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Section one 1 1.11. Energy Management and Distribution • Experiment: Investigate the efficacy of smart grid technology to reduce energy losses and optimize power distribution. • Background Insight: Johannesburg's growing energy demands highlight the need for innovative energy solutions to enhance grid reliability and efficiency. 1.2. Renewable Energy Integration • Experiment: Evaluate the feasibility of integrating renewable energy sources (like solar or wind) into City Power's existing infrastructure. • Background Insight: As South Africa aims to diversify its energy mix, City Power could serve as a case study for scaling up renewable energy efforts. 1.3. Load Shedding and Consumer Behavior • Experiment: Analyze how load-shedding schedules impact consumer behavior and propose alternative strategies to improve user compliance and satisfaction. • Background Insight: Frequent load shedding in Johannesburg poses challenges for households and businesses, making it a critical issue for study. 1.4. Cybersecurity in Energy Systems • Experiment: Assess the resilience of City Power's digital systems against cyber-attacks and propose cybersecurity improvements. • Background Insight: • History and Oversight: Examining the organization's evolution and management structure can reveal how it responds to challenges. • Revenue Recuperation and Businesses: Focuses on how City Power balances revenue generation with service to residential and commercial customers. • Load Shedding and Alternative Energy: These tie into broader energy strategies, such as renewable adoption and grid improvements. • Corruption: This influences public trust and operational efficiency, key factors for any utility provider. What's your main area of interest here? I can elaborate further, help explore solutions, or discuss broader implications of these 1. 5. Career Pathways in the Energy Sector • Experimental Topic: Investigate the impact of bursary programs on career advancement for young professionals in City Power. • Background Insight: City Power's bursary initiatives aim to cultivate skills in the energy sector. A study could assess how well these programs align with industry needs and participants' career growth. 1.6. Talent Retention through Education • Experimental Topic: Assess how bursaries influence talent retention within City Power and Johannesburg's energy sector. • Background Insight: Retaining skilled professionals is critical for long-term sustainability. You could explore whether bursary recipients stay in the field and contribute to its development. 1.7. Upskilling through Bursary Programs • Experimental Topic: Examine the role of bursaries in promoting innovative solutions by supporting education in renewable energy or smart grid technology. • Background Insight: City Power supports the transition to greener energy. Bursary programs could play a pivotal role in equipping students with the skills needed to drive innovation in this space. 1.8. Educational Outreach and Diversity • Experimental Topic: Explore the effectiveness of City Power's bursaries in increasing diversity and representation in the energy sector. • Background Insight: As South Africa works towards equal opportunities, assessing the social impact of these bursaries could provide valuable insights for broader application. 1.9. Community Impact of Bursary Recipients • Experimental Topic: Investigate how bursary recipients influence their communities through projects or initiatives tied to City Power's goals. • Background Insight: The societal benefits of such programs could extend beyond the workforce, fostering education and innovation in underrepresented areas. Which of these ideas resonates with your interests? I'd be glad to help you expand on any background calculation size power eskom city power topic Calculating and sizing power systems are critical elements in energy infrastructure development, especially for major utility providers like Eskom and City Power Johannesburg. Here's a background context and potential experimental topics related to power calculations and sizing within these organizations: 1.9.1Background on Power System Calculations and Sizing 1. Load Forecasting: o Accurate load forecasting is essential to determine the future power demands of a city or region. o Organizations like Eskom and City Power use sophisticated models to predict energy usage patterns based on population growth, industrial activity, and seasonal variations. 2. Transformer and Substation Sizing: o Proper transformer sizing ensures the efficient transfer of electrical power without overloading or energy losses. o Substation configuration involves determining the capacity and layout needed to distribute power effectively while maintaining grid reliability. 3. Short-Circuit Calculations: o Analyzing fault currents is vital to select appropriate protective devices, such as circuit breakers and fuses, to ensure system safety. 4. Energy Efficiency and Renewable Integration: o Eskom and City Power are increasingly incorporating renewable energy sources like solar and wind. o This requires advanced calculations to balance intermittent renewable supply with the existing power grid. 5. Voltage Drop Analysis: o Ensuring that voltage levels remain within acceptable limits is a key consideration in the design of power distribution systems. o Voltage drop calculations help optimize cable sizing and system layouts. Experimental Topics 1. Optimizing Transformer Sizing for Urban Grids o Focus: Analyze the efficiency of transformer sizing methods in reducing energy losses in dense urban areas like Johannesburg. o Experiment: Test different loading scenarios to identify the best practices for transformer selection. 2. Improving Load Forecasting Accuracy with AI o Focus: Explore how machine learning models can improve the accuracy of load forecasting for Eskom or City Power. o Experiment: Compare traditional load forecasting techniques with AI-based approaches. 3. Impact of Renewable Energy on Short-Circuit Calculations o Focus: Investigate how integrating solar or wind power affects the short-circuit levels in Eskom or City Power systems. o Experiment: Simulate various fault scenarios with and without renewable sources. 4. Voltage Regulation in Decentralized Grids o Focus: Study the effectiveness of voltage regulation techniques in hybrid grids that combine traditional and renewable energy. o Experiment: Measure voltage stability under different load conditions in a microgrid simulation. 5. Energy Storage Sizing for Load Shedding Mitigation o Focus: Assess the sizing of battery energy storage systems to support power availability during load shedding events. o Experiment: Compare energy storage performance under varying durations and intensities of load shedding. 6. Optimization of Cable Sizing for Cost and Efficiency o Focus: Evaluate the cost-efficiency trade-offs in cable sizing decisions for City Power's distribution networks. o Experiment: Test how different cable sizes affect installation costs and energy losses over time. 1.10.1. Career Development in the Energy Sector • Topic Description: Analyze how Eskom's recruitment, training, and internship programs prepare young professionals for long-term careers in the energy industry. • Background Insight: Eskom plays a vital role in nurturing talent, with various development programs aimed at addressing skill shortages in the energy sector. 1.10.2. Leadership Training and Succession Planning • Topic Description: Investigate the effectiveness of Eskom's leadership development initiatives in maintaining organizational stability and performance. • Background Insight: With frequent changes in the energy landscape, leadership training is critical for adapting to operational and strategic challenges. 1.10.3. Impact of Bursary Programs on Workforce Readiness • Topic Description: Evaluate the impact of Eskom's bursary and scholarship programs on the employability of graduates in the energy sector. • Background Insight: By investing in education and training, Eskom aims to address skill gaps and foster innovation. 1.10.4. Employee Retention Strategies • Topic Description: Explore the effectiveness of employee retention policies, such as benefits, career progression opportunities, and work-life balance initiatives, within Eskom. • Background Insight: Retaining skilled workers is a challenge in the energy sector, making this an important area of study. 1.10.5. Diversity and Inclusion in Energy Careers • Topic Description: Assess the progress of Eskom in promoting gender and racial diversity within its workforce. • Background Insight: Enhancing diversity is essential for creating an equitable and innovative work environment in South Africa's energy sector. 1.10.6. Cybersecurity and Career Development • Topic Description: Investigate how cybersecurity training programs at Eskom prepare employees to handle modern digital threats. • Background Insight: As energy systems become more digitalized, training staff to protect these systems has become essential. Any of these topics could serve as the foundation for a compelling and impactful experimental study. Do any of these resonate with your interests, or shall we explore another direction? 1.11.1. Management and Leadership Development Eskom offers tailored courses to nurture management and leadership capabilities across different organizational levels. These programs focus on: • Strategic decision-making • Team leadership and motivation • Effective communication and conflict resolution • Managing change within the energy sector 1.11.2. Young Professionals Development Eskom invests in young talent through mentorship and structured development programs aimed at accelerating career growth for emerging leaders. These typically involve: • Rotational assignments to gain diverse experience • Individual coaching and mentoring • Exposure to leadership challenges in various operational contexts 1.11.3. Technical and Leadership Fusion Eskom integrates technical training with leadership development for employees in engineering and operational roles. The goal is to create leaders who are both technically competent and capable of steering teams toward organizational success. 1.11.4. Executive Leadership Development For senior managers and executives, Eskom provides programs that emphasize high-level skills, such as: • Visionary leadership for long-term planning • Policy formulation and governance • Navigating regulatory frameworks and stakeholder management 1.11.5. Partnership with Academic Institutions Eskom collaborates with universities and training organizations to offer accredited courses and qualifications in leadership and management. This not only enhances participants' skills but also provides recognized certifications. 1.11.6. Focus on Diversity and Inclusion Eskom's training programs also highlight the importance of fostering diversity and inclusion within leadership roles, aligning with broader national goals for transformation in the workplace. 1.11.1. Matching Mentors and Mentees • Mentorship programs at Eskom carefully match employees (mentees) with experienced professionals (mentors) based on career goals, areas of expertise, and alignment with Eskom's core objectives. • This personalized matching process ensures that mentors can provide tailored guidance that resonates with the mentee's aspirations. 1.11.2. Formalized Structure • Mentorship programs are structured to include a clear framework with objectives, timelines, and milestones. • They often start with an initial orientation session, where mentors and mentees outline their expectations, create a development plan, and set measurable goals. 1.11.3. Development Focus Areas • Programs emphasize key areas such as: o Technical and operational skills enhancement o Leadership development o Strategic thinking and decision-making o Professional networking and relationship building 1.11.4. Regular Check-Ins and Feedback • Mentors and mentees meet regularly for one-on-one sessions to discuss progress, address challenges, and refine developmental goals. • Feedback is a continuous process, allowing mentees to adapt and grow throughout the program. 1.11.5. Skill-Building Workshops and Seminars • Eskom integrates workshops, training modules, and industry seminars into its mentorship programs. This enhances learning beyond one-on-one interactions and exposes mentees to broader perspectives. 1.11.6. Monitoring and Evaluation • The effectiveness of the mentorship program is regularly reviewed through progress assessments and performance evaluations. • Both mentors and mentees are encouraged to provide feedback to improve the program and address any gaps. • to broader perspectives. 1.11.7. Career Advancement Opportunities • These programs are designed to prepare mentees for leadership roles or specialized positions within Eskom. • Participants often gain access to internal job opportunities, project involvement, and expanded professional networks. 1.12. 1. Sustainable Career Development • Topic Description: Evaluate how Eaton's sustainability-focused career pathways prepare professionals for the growing green energy sector. • Background Insight: Eaton's emphasis on sustainability in energy management could serve as a case study for integrating environmental goals into workforce development. 1.12.1.2. Diversity and Inclusion in Technical Roles • Topic Description: Investigate the impact of Eaton's diversity initiatives on recruitment and career progression in engineering and technical fields. • Background Insight: Eaton's diversity programs aim to create equitable opportunities in a traditionally male-dominated sector, making this a pivotal area for exploration. 1.12.1.3. Impact of Leadership Programs • Topic Description: Analyze the effectiveness of Eaton's leadership development initiatives in driving innovation and productivity. • Background Insight: As a global organization, Eaton invests in cultivating leaders who can navigate complex, multicultural business environments. 1.12.1.4. Innovation in Employee Training • Topic Description: Explore how Eaton uses cutting-edge technology, like virtual reality or simulations, for technical and safety training programs. • Background Insight: Eaton leverages advanced training techniques to enhance workforce capabilities and adapt to rapidly evolving industry demands. 1.12.1.5. Corporate Social Responsibility and Careers • Topic Description: Assess how Eaton's corporate social responsibility (CSR) initiatives influence employee engagement and community involvement. • Background Insight: Eaton's commitment to social impact could offer valuable lessons on fostering a purpose-driven workplace culture. 1.12.16. Career Paths in Renewable Energy • Topic Description: Examine how Eaton enables its employees to transition into careers focused on renewable energy technologies and smart grids. • Background Insight: With a strong presence in the renewable energy sector, Eaton provides a robust platform for skill development in emerging energy technologies. Would you like me to delve deeper into any of these topics or suggest additional Eaton provides comprehensive training programs focused on its products and solutions, aiming to empower employees, partners, and customers with the knowledge to use their offerings effectively. Here's an outline of potential background and experimental training topics related to Eaton's products: 1.13.1. Product Efficiency and Performance • Topic Description: Evaluate how Eaton's training enhances users' understanding of product efficiency and performance optimization. • Background Insight: Eaton offers diverse products, such as circuit breakers, power systems, and energy storage solutions. Training could explore best practices to maximize product lifespan and functionality. 1.13.2. Sustainability in Product Usage • Topic Description: Investigate how Eaton incorporates sustainability principles into its product training for renewable energy solutions. • Background Insight: As a leader in power management, Eaton emphasizes eco-friendly practices. Training could include using products like solar inverters or energy-efficient transformers. 1.13.3. Advanced Troubleshooting Techniques • Topic Description: Assess the effectiveness of Eaton's technical training in troubleshooting and maintaining complex power systems. • Background Insight: Technical workshops could train participants to diagnose and solve issues related to Eaton products, such as UPS (Uninterruptible Power Supply) systems. 1.13.4. Integration of Smart Technologies • Topic Description: Explore how Eaton's training programs prepare users to integrate IoT (Internet of Things) and smart grid technologies with their products. • Background Insight: Eaton is at the forefront of smart energy management. Training could highlight applications of connected solutions in real-time monitoring and control. 1.13.5. Safety and Compliance Training • Topic Description: Evaluate the role of Eaton's training in promoting safety and regulatory compliance when using its products. • Background Insight: Safety is a cornerstone of Eaton's philosophy. Training often covers proper installation and usage protocols for products like circuit breakers and surge protectors. 1.13.6. Customization and Application • Topic Description: Analyze how Eaton's training programs enable customers to tailor products to specific industries, such as data centers, healthcare, and manufacturing. • Background Insight: Customization training ensures that Eaton's solutions meet diverse sectoral needs, improving efficiency and satisfactio Eaton, as a power management leader, provides extensive tools and solutions for electrical configuration and product calculation. Here's a background overview of their approach and offerings in this area: 1. Eaton's Configuration Tools Eaton offers digital configuration tools designed to simplify the selection and implementation of its electrical products. These tools help users: • Choose the right products based on technical requirements. • Customize products to meet specific application needs. • Simulate electrical systems for optimal performance. Examples of tools include: • Eaton's Selector Tools: For selecting circuit breakers, transformers, and power distribution units. • Configurator for Panelboards and Switchboards: Helps customers design tailored solutions for power distribution systems. 1.13.2. Product Calculation Capabilities Eaton supports product calculations to ensure precision in electrical designs. This typically involves: • Load Calculations: Estimating the electrical load requirements for residential, commercial, or industrial applications. • Short-Circuit Calculations: Determining fault currents to select appropriate protective devices. • Energy Efficiency Analysis: Calculating potential energy savings using Eaton's energy-efficient products, such as variable frequency drives (VFDs). 1.13.3. Electrical Application Examples • Control Systems: Configuring products like relays and motor starters for automation and control solutions. • Power Quality Management: Selecting and sizing uninterruptible power supplies (UPS) for optimal power quality. • Renewable Energy Integration: Designing systems with Eaton's solar inverters and energy storage solutions. 1.13.4. Software Support Eaton often provides software like Eaton's CYME Power Engineering Software to assist in advanced electrical engineering calculations, including: • Power flow analysis • Harmonic analysis • Cable ampacity calculations Integral Calculations in Eaton's Capabilities 1. Load Calculations: • Deriving Total Load Requirements: o For residential, commercial, or industrial applications, the total electrical load can be calculated by integrating power consumption over time: $$\text{Total Load} = \int_{t_1}^{t_2} P(t) \, dt$$ Where P(t)P(t) represents the power usage at time tt, and [t1,t2][t_1, t_2] is the operational time interval. 2. Short-Circuit Calculations: • Determining Fault Currents: o The calculation of fault current involves solving electrical equations using integral forms: $$I_{fault} = \frac{\int_{0}^{t} V_{source}(t) \, dt}{Z_{system}}$$ Here, Vsource(t)V_{source}(t) is the voltage source during the fault, and ZsystemZ_{system} is the system impedance. 3. Energy Efficiency Analysis: • Evaluating Energy Savings in VFDs (Variable Frequency Drives): o Energy savings can be determined by integrating the difference between power consumption with and without VFDs: $$\text{Energy Savings} = \int_{t_1}^{t_2} \big(P_{traditional}(t) - P_{VFD}(t)\big) \, dt$$ This quantifies how VFDs reduce energy consumption over a specified time period. Integral Applications in Electrical Engineering Examples 1. Control Systems: • Configuration and Relay Timing: o Integrals are used to calculate the response time of relays and motor starters in automation systems, ensuring precision in control: $$\text{Response Time} = \int_{t_0}^{t_1} f_{relay}(t) \, dt$$ 2. Power Quality Management: • UPS Sizing and Runtime Calculations: o Uninterruptible Power Supply (UPS) runtime can be derived using battery discharge equations integrated over the load power: $$\text{Runtime} = \int_{t_1}^{t_2} \frac{Capacity_{battery}(t)}{Load_{UPS}(t)} \, dt$$ 3. Renewable Energy Integration: • Solar Inverter Efficiency: o The efficiency of solar inverters can be calculated by integrating power output relative to the solar energy input: $$\text{Efficiency} = \frac{\int_{t_1}^{t_2} P_{output}(t) \, dt}{\int_{t_1}^{t_2} P_{input}(t) \, dt}$$ Integral Use in Eaton's Software Support 1. Power Flow Analysis: • Solving for Power Equilibrium: o Power flow equations require integration across nodes in an electrical network: $$\int_{Node_1}^{Node_n} \big(P_{generation}(x) - P_{consumption}(x)\big) \, dx = 0$$ 2. Harmonic Analysis: • Quantifying Harmonic Distortion: o Harmonic distortion in power systems can be analyzed by integrating signal frequencies: $$\text{THD} = \sqrt{\int_{n=1}^{N} f_{harmonic}(n)^2 \, dn}$$ 3. Cable Ampacity Calculations: • Heat Dissipation Integration: o Cable ampacity depends on heat dissipation calculated as: $$\int_{t_1}^{t_2} \big(I_{current}^2 \cdot R_{cable}\big) \, dt$$ These calculations and integral derivations showcase how Eaton's tools and software leverage mathematical precision to optimize electrical designs, ensuring safety, energy efficiency, and reliability. If you'd like to refine or expand upon these ideas further, let me know! • These tools and resources ensure that engineers, technicians, and installers can configure and calculate Eaton products effectively for safe and efficient operation. If you're interested in diving deeper into specific tools, calculations, or applications, let m 1.14. Schneider Electric, a global leader in energy management and automation, provides a rich area for experimental topics related to electrical engineering and sustainable practices. Here are some ideas for background and experimental focuses that align with Schneider Electric's expertise: 1. Smart Grid Technology • Experimental Topic: Investigate the implementation of Schneider Electric's smart grid solutions in optimizing energy distribution and minimizing losses. • Background Insight: Schneider Electric has developed advanced smart grid technologies to improve efficiency and reliability in electricity networks. 2. Renewable Energy Integration • Experimental Topic: Evaluate the role of Schneider Electric's energy storage systems and inverters in integrating renewable energy sources into existing grids. • Background Insight: The company offers cutting-edge solutions for solar and wind energy management, promoting clean energy transitions. 3. IoT in Electrical Systems • Experimental Topic: Explore the application of Schneider Electric's IoT-enabled devices for real-time monitoring and control of electrical systems. • Background Insight: IoT technologies like EcoStruxure provide actionable insights for improving energy efficiency and reducing operational costs. 4. Sustainability in Electrical Design • Experimental Topic: Analyze the impact of Schneider Electric's sustainability initiatives, like green electrical designs, on reducing carbon footprints. • Background Insight: Schneider emphasizes sustainable solutions and resource-efficient practices across its product range. 5. Automation and Control • Experimental Topic: Investigate how Schneider Electric's automation systems improve industrial processes and energy management. • Background Insight: Products such as programmable logic controllers (PLCs) and motor drives are pivotal in achieving automation goals. 6. Electrical Safety and Compliance • Experimental Topic: Assess the effectiveness of Schneider Electric's electrical safety devices in preventing accidents and ensuring compliance with standards. • Background Insight: Schneider provides a variety of safety products, including circuit breakers and surge protectors, designed to meet strict regulations. 7. Microgrid Solutions • Experimental Topic: Study the implementation of Schneider Electric's microgrid technologies to enhance energy resilience in remote or underserved areas. • Background Insight: Schneider develops scalable microgrid solutions that integrate renewable energy and storage for decentralized power systems. Would you like me to elaborate on any of these topics or tailor them further to a specific area of interest? Schneider Electric offers incredible breadth for innovative experimental designs! 15..2Background on Schneider Electric's Product Configuration • Customizable Solutions: Schneider Electric offers a range of products, such as switchgear, circuit breakers, energy meters, and automation devices, all of which can be configured to meet unique project requirements. • Digital Configuration Tools: Tools like EcoStruxure Power Design and other configurators enable seamless product selection and system simulation based on user specifications. • Energy Efficiency: Schneider's configurators are designed to promote energy-efficient solutions, aligning with global sustainability goals. • Industrial Applications: Product configuration tools help industries such as healthcare, data centers, and manufacturing tailor solutions for power reliability, safety, and optimization. Experimental Topics 1. Improving User Experience in Digital Configuration o Experiment: Analyze the usability of Schneider Electric's digital configurators and propose enhancements to improve user experience. o Focus: Test ease of navigation, accuracy of simulations, and satisfaction rates among users with different technical backgrounds. 2. Energy Optimization in Configured Systems o Experiment: Compare the energy efficiency of systems configured using Schneider Electric's tools versus traditional methods. o Focus: Measure operational energy savings in customized power solutions. 3. IoT-Enabled Configuration Systems o Experiment: Study how IoT integration in Schneider's configuration tools impacts product monitoring and predictive maintenance. o Focus: Evaluate the benefits of connected devices in system reliability and lifecycle management. 4. Configuration for Microgrid Solutions o Experiment: Investigate how Schneider Electric's product configuration tools can simplify designing and implementing microgrids. o Focus: Assess cost-efficiency, scalability, and energy autonomy provided by configured microgrids. 5. Safety Compliance through Configurators o Experiment: Evaluate how Schneider's configurators ensure compliance with safety standards during product selection and system design. o Focus: Identify and mitigate risks through system simulation and proper device selection. 6. Simulation Accuracy in Product Configuration o Experiment: Test the accuracy of Schneider's simulation results for electrical systems under various load conditions. o Focus: Verify how closely configured systems perform compared to the simulated outcomes. 7. Product Selection for Renewable Energy Integration o Experiment: Explore how Schneider's tools facilitate the configuration of systems for seamless integration with solar, wind, or other renewable energy sources. o Focus: Compare system efficiency with renewable energy integration versus standalone setups. background scheineder electric configuration calculation size Schneider Electric offers robust tools and methodologies for configuration and calculation sizing, particularly in the realm of electrical systems design and energy management. Here's a structured background overview that incorporates key aspects of Schneider Electric's expertise in this area: Background on Schneider Electric Configuration and Sizing 1. Product Configuration Tools o Schneider Electric provides digital platforms like EcoStruxure Power Design to configure products for specific applications. These tools allow users to: Select the right components (e.g., circuit breakers, relays, and transformers). Customize system designs to meet operational needs. Simulate performance under different conditions. 2. Calculation and Sizing o Schneider Electric emphasizes precision in sizing electrical products and systems to ensure safety and efficiency. Common calculations include: Load Sizing: Determine the electrical load requirements to appropriately size circuit breakers, cables, and transformers. Short-Circuit Calculations: Assess fault currents to select protective devices that safeguard systems during electrical faults. Thermal Management: Calculate heat dissipation for enclosure systems to ensure safe operating conditions. Energy Efficiency Analysis: Evaluate consumption and savings to optimize energy-efficient designs. 3. Standards and Compliance o Configuration and sizing tools from Schneider Electric are designed to adhere to international electrical standards (like IEC and ISO) to guarantee system compliance and reliability. 4.

Applications Across Industries o Schneider Electric products and configurators are used in diverse sectors, such as: □ Data centers, for designing resilient electrical systems. ▣ Healthcare, for uninterrupted power supply (UPS) systems. ▣ Manufacturing, for automation solutions and motor control. Experimental Focus Areas 1. Accuracy of Digital Configurators o Test the reliability of Schneider Electric’s tools in predicting system performance versus real-world outcomes. 2. Sizing for Renewable Energy Integration o Evaluate the sizing of components like energy meters and inverters for systems integrating solar or wind power. 3. Fault Current Prediction o Analyze how Schneider’s calculation tools handle complex short-circuit scenarios to ensure system protection. 4. Heat Dissipation Modeling o Study the thermal management calculations provided by Schneider Electric to prevent overheating in industrial systems. 5. Energy Optimization o Explore how system configurations minimize energy consumption and optimize efficiency in commercial environments. Schneider Electric's expertise in product calculation, sizing, and system design creates opportunities for applying advanced mathematics and experimental methodologies. Here's a detailed breakdown of the calculation concepts and their relevance to the experimental focus areas you've outlined: Integral and Derived Calculations in Schneider Electric's Applications 1. Load Sizing • Key Calculation: $$\text{Total Load} = \int_{t_1}^{t_2} P(t) \, dt$$ o P(t)P(t): Power consumption at time tt. o Used to size circuit breakers, cables, and transformers, ensuring the total load is within system limits. • Applications: o Sizing electrical components for data centers and manufacturing facilities. 2. Short-Circuit Calculations • Key Calculation: $$I_{fault} = \frac{\int_{0}^{t} V_{source}(t) \, dt}{Z_{system}}$$ o Vsource(t)V_{source}(t): Voltage over time. o ZsystemZ_{system}: System impedance. o Determines fault current to select protective devices, like fuses and circuit breakers. • Applications: o Preventing damage from faults in healthcare UPS systems and industrial automation. 3. Thermal Management • Key Calculation: $$\text{Heat Transfer} = \int_{t_1}^{t_2} \big(C_{thermal} \cdot \Delta T(t)\big) \, dt$$ o CthermalC_{thermal}: Thermal capacity of enclosure material. o ΔT(t)\Delta T(t): Temperature change over time. o Ensures heat dissipation to maintain safe operating temperatures. • Applications: o Cooling solutions in power systems and electronics enclosures. 4. Energy Efficiency Analysis • Key Calculation: $$\text{Efficiency Gain} = \int_{t_1}^{t_2} \big(P_{input}(t) - P_{loss}(t)\big) \, dt$$ o PinputP_{input}: Power supplied. o PlossP_{loss}: Power lost to inefficiencies. o Quantifies energy savings with optimized designs. • Applications: o Improving power quality and energy efficiency in industrial systems. Experimental Focus Areas with Mathematical Foundations 1. Accuracy of Digital Configurators • Experiment: Compare performance predictions made by Schneider’s configurators with actual system outcomes. • Calculation: Measure prediction errors by integrating deviation: $$\int_{t_1}^{t_2} \big|P_{predicted}(t) - P_{actual}(t)\big| \, dt$$ 2. Sizing for Renewable Energy Integration • Experiment: Study component sizing, such as energy meters, for solar energy systems. • Calculation: Determine inverter sizing: $$\text{Inverter Capacity} = \int_{t_1}^{t_2} \big(P_{solar}(t) - P_{load}(t)\big) \, dt$$ 3. Fault Current Prediction • Experiment: Evaluate Schneider’s tools in complex scenarios with varying fault levels. • Calculation: Model dynamic fault response: $$I_{fault}(t) = \frac{V_{supply}(t)}{Z_{dynamic}(t)}$$ 4. Heat Dissipation Modeling • Experiment: Simulate cooling efficiency in enclosures. • Calculation: Integrate temperature over operational periods: $$\int_{t_1}^{t_2} T_{excess}(t) \, dt$$ 5. Energy Optimization • Experiment: Investigate energy-saving configurations in commercial environments. • Calculation: Analyze cumulative energy savings: $$\int_{t_1}^{t_2} \big(P_{baseline}(t) - P_{optimized}(t)\big) \, dt$$ These integral and derived calculations form the backbone of system optimization, enabling Schneider Electric's tools to deliver precision and compliance across various industries. If you'd like further assistance in refining these ideas for implementation, let me know! o 1.16. Schneider Electric Training Programs • Focus Areas: o Sustainability and energy efficiency. o Digital transformation (IoT-enabled systems like EcoStruxure). o Electrical safety and compliance with international standards. o Renewable energy technologies and microgrid solutions. • Delivery Methods: o Schneider Electric University (formerly Energy University): A free, online training platform with courses on energy efficiency and sustainability. o On-Site and Virtual Workshops: Tailored for product installations, system configurations, and advanced troubleshooting. o Certification Programs: Provide recognized credentials for electricians, engineers, and energy managers. • Key Features: o Real-world simulations for product usage and maintenance. o Programs designed to align with sustainability goals and smart energy solutions. Eaton Training Programs • Focus Areas: o Power quality systems (e.g., UPS and surge protectors). o Electrical distribution and control equipment. o Industrial automation solutions and variable frequency drives. o Renewable energy storage and integration. • Delivery Methods: o Eaton Training Centers: Provide in-depth, instructor-led courses for hands-on learning. o Eaton eLearning Platform: Offers webinars, tutorials, and self-paced online courses. o Customized Training Modules: Tailored to specific industries, such as healthcare or manufacturing. • Key Features: o Hands-on, practical training with the latest Eaton technologies. o Focus on emerging trends like cybersecurity in energy systems and IoT applications. Comparison and Experimental Opportunities • Sustainability and Digital Innovation: Both companies emphasize IoT integration and renewable energy in their training programs, offering excellent experimental potential for comparing their effectiveness in fostering innovation. • Customization: Schneider Electric’s free access to online courses contrasts with Eaton’s focus on tailored, industry-specific modules, opening a pathway for exploring accessibility versus industry specialization in professional development. • Delivery Mode Analysis: Compare the impact of self-paced online learning (Schneider Electric University) versus hands-on, instructor-led training (Eaton Training Centers) on knowledge retention and skill application. 1.17.1Microsoft, as a technology and innovation leader, offers various areas for experimental study and exploration. Here are some structured background contexts and potential experimental topics focused on Microsoft: Background on Microsoft Areas Microsoft’s expertise spans several domains, including: 1. Cloud Computing (Azure): o Microsoft Azure is a global leader in cloud services, providing resources for data storage, AI development, and enterprise solutions. 2. Artificial Intelligence (AI): o Microsoft's AI initiatives power products like Copilot and leverage machine learning and natural language processing. 3. Sustainability: o Microsoft is committed to achieving carbon neutrality and advancing technologies for environmental sustainability. 4. Productivity and Collaboration Tools: o Microsoft Office, Teams, and Dynamics 365 are integral solutions for improving workplace productivity. 5. Gaming (Xbox): o Microsoft's gaming division focuses on immersive experiences and innovation in console and game design. Experimental Topics 1. AI Integration in Education o Focus: Explore how Microsoft AI tools, such as Copilot, enhance educational outcomes by personalizing learning experiences. o Experiment: Compare student engagement and performance before and after implementing AI-driven educational aids. 2. Optimization of Cloud Resources o Focus: Study how Microsoft Azure allocates cloud resources for energy-efficient operations. o Experiment: Simulate workloads and analyze Azure’s performance in balancing efficiency and cost. 3. Sustainability through Microsoft Technologies o Focus: Evaluate the impact of Microsoft’s AI in optimizing energy usage in buildings. o Experiment: Test models that simulate AI-controlled energy-saving scenarios. 4. Collaboration Tools and Workplace Productivity o Focus: Analyze the effectiveness of Microsoft Teams in improving communication and collaboration within organizations. o Experiment: Survey employees and measure productivity metrics pre- and post-Teams implementation. 5. AI in Cybersecurity o Focus: Investigate the role of Microsoft Defender’s AI capabilities in identifying and mitigating cyber threats. o Experiment: Test Defender’s response accuracy to simulated cyber-attacks in real-time. 6. Enhanced Gaming through Cloud Technology o Focus: Explore how Microsoft Azure gaming solutions improve streaming quality and interactivity. o Experiment: Compare gameplay experiences on traditional servers versus Azure-powered environments. 7. User Experience in Accessibility Tools o Focus: Assess how Microsoft’s accessibility features in Office and Windows impact productivity for differently-abled users. o Experiment: Track usage patterns and satisfaction levels among targeted user groups. 1.17.2Background on Microsoft Training Programs 1. Microsoft Learn Platform: o Offers free, self-paced learning resources for developers, IT professionals, and business users. o Covers various Microsoft products and technologies, including Azure, Microsoft 365, Dynamics 365, and Power Platform. 2. Certification Programs: o Provides globally recognized certifications such as Microsoft Certified: Azure Fundamentals, Microsoft Certified: Power Platform Developer Associate, and more. o Certifications validate proficiency in specific products and roles (e.g., cloud architect, data analyst, or app developer). 3. Skill Training Focus Areas: o Cloud Computing: Training on Microsoft Azure’s cloud services for data storage, machine learning, and app development. o Productivity Tools: Guidance on using Microsoft 365 applications like Word, Excel, PowerPoint, and Teams for workplace efficiency. o Software Development: Training in languages and frameworks supported by Microsoft tools, such as .NET and Visual Studio. o Cybersecurity: Programs to enhance knowledge of Microsoft Defender and other security solutions. o AI and Data Science: Courses on AI, big data, and analytics using Azure and other Microsoft tools. 4. Methods of Delivery: o Self-paced Online Training: Via Microsoft Learn, accessible anywhere and anytime. o Instructor-led Classes: Hosted by certified trainers for in-depth learning. o Workshops and Bootcamps: Focused on practical, hands-on experience. Experimental Topics 1. Evaluating Certification Effectiveness o Focus: Study the impact of earning Microsoft certifications on career growth and job performance. o Experiment: Analyze career trajectories of certified professionals compared to non-certified peers. 2. Gamification in Skill Development o Focus: Explore the role of gamified learning tools on Microsoft Learn in boosting engagement and knowledge retention. o Experiment: Measure user progress in gamified versus non-gamified training scenarios. 3. Impact of AI in Skill Training o Focus: Investigate how Microsoft AI tools, like Copilot, enhance the learning experience for technical and non-technical users. o Experiment: Assess the effectiveness of AI-assisted training compared to traditional methods. 4. Custom Training Programs for Organizations o Focus: Examine how tailored Microsoft training impacts organizational productivity. o Experiment: Implement specific training modules for different teams and track performance improvements. 5. Efficiency in Remote Learning o Focus: Assess the effectiveness of Microsoft’s remote learning platforms during virtual training sessions. o Experiment: Compare learning outcomes in remote settings versus in-person instruction. 6. Digital Literacy Enhancement o Focus: Study the impact of Microsoft training in bridging the digital skills gap in underserved communities. o Experiment: Evaluate pre- and post-training digital literacy levels among participants. 7. Sustainability Training with Microsoft Tools o Focus: Explore how Microsoft training integrates sustainability practices in product usage. o Experiment: Analyze how users apply learned energy-saving strategies in real-world scenarios. Microsoft's expertise spans across hardware and software, creating vast opportunities for experimental studies in calculation, materials, and system design. Here's a structured overview based on hardware and software-related topics: Background on Microsoft Hardware Material 1. Hardware Focus Areas: o Development of Surface devices, including tablets, laptops, and accessories. o Azure Data Centers, which house servers optimized for cloud computing and data storage. o IoT hardware, such as Azure IoT Edge, used for edge computing solutions. 2. Material Considerations: o Use of sustainable materials in device design (e.g., recycled aluminum in Surface devices). o Thermal management materials for efficient cooling in hardware systems. o Lightweight and durable materials for wearable devices. 3. Hardware Calculations: o Heat dissipation modeling to ensure device safety and performance. o Structural integrity tests for materials used in laptops and servers. o Power consumption calculations for energy-efficient hardware designs. Background on Microsoft Software Material 1. Software Focus Areas: o Operating Systems: Windows OS serves as a foundation for Microsoft hardware. o Productivity Tools: Applications like Microsoft Office and Teams streamline collaboration. o Development Platforms: Visual Studio and .NET Framework cater to developers. o AI and Cloud Services: Azure enables large-scale machine learning and data solutions. 2. Software Calculations: o Performance optimization algorithms to reduce lag and memory usage. o Energy efficiency modeling for software running on Microsoft hardware. o Simulation of system compatibility across devices. Experimental Topics Hardware Calculations and Materials 1. Sustainability in Hardware Design o Experiment: Evaluate the energy efficiency of recycled materials in Surface device construction. o Focus: Compare performance and environmental impact against traditional materials. 2. Thermal Management in Data Centers o Experiment: Assess the effectiveness of different cooling materials in Microsoft Azure servers. o Focus: Measure cooling capacity and longevity in extreme workloads. 3. IoT Device Material Optimization o Experiment: Study the impact of lightweight materials on the durability and performance of Azure IoT Edge hardware. o Focus: Test devices in varying environmental conditions. Software Calculations and Optimization 1. AI Algorithm Efficiency o Experiment: Investigate the computational performance of Microsoft’s Azure AI tools on large-scale datasets. o Focus: Measure resource consumption during data modeling tasks. 2. Cloud Resource Allocation o Experiment: Analyze how Azure’s software optimizes server usage under peak and idle workloads. o Focus: Evaluate energy savings achieved through dynamic resource allocation. 3. Windows OS Compatibility Simulation o Experiment: Test how well Windows OS integrates with various hardware configurations. o Focus: Simulate compatibility with both Microsoft devices and third-party hardware. Microsoft's hardware solutions and configurations play a significant role in the realm of electrical engineering, especially when it comes to sustainable designs, efficient power systems, and advanced computing technologies. Here’s a background overview and experimental topics that integrate hardware configuration with electrical engineering principles: Background on Microsoft Hardware Configuration 1. Data Centers and Server Hardware: o Microsoft Azure data centers employ cutting-edge server designs optimized for cloud computing and energy efficiency. o Configurations focus on power distribution, cooling systems, and load balancing. 2. IoT Hardware Solutions: o Microsoft’s IoT devices, like Azure IoT Edge, facilitate distributed computing and real-time data processing. o These devices integrate seamlessly with electrical systems for industrial automation and energy management. 3. Surface Devices and Computing Platforms: o Microsoft Surface devices employ lightweight and durable materials, featuring efficient power management designs tailored for portability and productivity. o Advanced chipsets enable computational efficiency while minimizing power consumption. 4. Smart Power Systems: o Microsoft uses intelligent hardware configurations in its operations, enabling advanced load management and energy optimization for devices and servers. To integrate calculation derivations and integral applications across the outlined software and hardware experimental areas, let’s explore how mathematical modeling enhances efficiency and performance: Integral and Derived Calculations for Software and Hardware 1. Software Calculations • Performance Optimization Algorithms: o Derive optimal response times by integrating computational delays over task execution time: $$\int_{t_1}^{t_2} \text{Delay}(t) \, dt$$ This helps in identifying lag and optimizing memory usage for applications like Microsoft Teams. • Energy Efficiency Modeling: o Measure the energy consumption for software on Microsoft hardware: $$\text{Energy Consumption} = \int_{t_1}^{t_2} P_{software}(t) \, dt$$ Where Psoftware(t)P_{software}(t) is the software’s power draw over time. • System Compatibility Simulation: o Simulate system performance compatibility using integral-based statistical models: $$\text{Compatibility Score} = \int_{x_{1}}^{x_{n}} \text{Performance Deviation}(x) \, dx$$ 2. Hardware Calculations and Materials • Sustainability in Hardware Design: o Evaluate energy efficiency by integrating power loss for traditional vs. recycled materials: $$\text{Efficiency Gain} = \int_{t_1}^{t_2} \big(P_{traditional}(t) - P_{recycled}(t)\big) \, dt$$ • Thermal Management in Data Centers: o Derive cooling efficiency: $$\text{Heat Removed} = \int_{t_1}^{t_2} \big(Q_{input} - Q_{output}(t)\big) \, dt$$ Where QinputQ_{input} and QoutputQ_{output} represent heat inflow and outflow, respectively. • IoT Device Material Optimization: o Analyze material stress under environmental conditions by integrating force over surface area: $$\sigma = \frac{\int F \, dA}{A_{total}}$$ This evaluates device durability. Experimental Topics with Integral Derivations AI Algorithm Efficiency • Experiment: Quantify Azure AI tools’ computational energy for large datasets: $$\int_{t_1}^{t_2} \frac{Data_{processed}(t)}{Power_{AI}(t)} \, dt$$ o Evaluate power efficiency during model training. Cloud Resource Allocation • Experiment: Calculate energy savings with dynamic resource optimization: $$\text{Energy Savings} = \int_{t_1}^{t_2} \big(P_{peak}(t) - P_{optimized}(t)\big) \, dt$$ Windows OS Compatibility Simulation • Experiment: Determine compatibility trends across hardware configurations: $$\text{Trend Function} = \int_{Config_1}^{Config_n} \text{Compatibility Index}(x) \, dx$$ Applications Across Microsoft Hardware Configuration 1. Data Centers and Server Hardware: o Integral Derivation for Power Distribution: $$P_{distribution}(t) = \int_{Node_1}^{Node_n} \text{Load Balance}(x) \, dx$$ This ensures optimized energy allocation across servers. 2. IoT Hardware Solutions: o Real-Time Data Processing: $$\text{Processing Rate} = \int_{t_1}^{t_2} \frac{Data_{received}(t)}{Time(t)} \, dt$$ 3. Surface Devices and Efficiency: o Battery Consumption Analysis: $$\text{Battery Lifetime} = \int_{t_1}^{t_2} \frac{Capacity}{P_{device}(t)} \, dt$$ o Experimental Topics in Electrical Engineering and Microsoft Hardware 1. Energy Efficiency in Azure Data Centers o Experiment: Analyze the power consumption and thermal management in Microsoft servers under different workload conditions. o Focus: Measure the effectiveness of hardware configurations in optimizing energy use. 2. IoT Integration for Smart Grid Systems o Experiment: Study how Azure IoT Edge devices can be configured to improve energy distribution and monitoring in electrical grids. o Focus: Test IoT-enabled systems for load balancing and fault detection. 3. Battery Performance in Surface Devices o Experiment: Evaluate how hardware configurations impact battery efficiency and lifespan in Microsoft Surface laptops. o Focus: Compare the performance of devices under varying usage conditions. 4. Heat Dissipation in Electrical Components o Experiment: Investigate the materials and cooling configurations used in Microsoft hardware to prevent overheating during high-power operations. o Focus: Test different thermal management designs to find optimal solutions. 5. Sustainability of Smart Power Systems o Experiment: Explore how Microsoft's hardware configurations contribute to energy savings and reduced carbon footprints. o Focus: Simulate scenarios using smart power systems in industrial environments. 6. Compatibility of Hardware with Electrical Engineering Standards o Experiment: Assess the compatibility of Microsoft hardware configurations with international electrical standards and regulations. o Focus: Measure compliance and reliability in real-world applications. o 1.18.1Cisco, as a global leader in networking, cybersecurity, and IT solutions, offers a wealth of opportunities for career development and experimental research. Here's a structured overview of Cisco's career-focused initiatives and potential experimental topics: Background on Cisco Careers 1. Networking Expertise: o Cisco is renowned for its leadership in networking technologies, including routers, switches, and wireless systems. o Professionals often build their careers around Cisco certifications, like CCNA (Cisco Certified Network Associate) and CCNP (Cisco Certified Network Professional). 2. Cybersecurity Leadership: o Careers at Cisco often involve roles in cybersecurity, leveraging advanced solutions like Cisco Secure and firewalls to protect IT infrastructure. o Training and certifications such as Cisco Certified CyberOps Associate prepare professionals for high-demand roles in cybersecurity. 3. Collaboration and Cloud Solutions: o Cisco’s collaboration tools (e.g., Webex) and cloud solutions are central to its offerings, opening career paths in unified communications and cloud engineering. 4. Focus on Innovation: o Cisco invests heavily in innovation, such as AI-driven networking, IoT (Internet of Things), and software-defined networking (SDN), creating exciting career opportunities. 5. Global Training Programs: o Cisco Networking Academy (NetAcad) offers comprehensive training for students and professionals globally, focusing on real-world skills in IT and networking. o The academy supports educational institutions, fostering a steady pipeline of skilled professionals. Experimental Topics 1. Impact of Cisco Certifications on Career Progression o Focus: Study how Cisco certifications affect job opportunities and salary growth in IT roles. o Experiment: Survey certified professionals and compare their career paths with those without certifications. 2. Adoption of Cisco's Collaboration Tools in Remote Work o Focus: Analyze how tools like Webex impact productivity and teamwork in remote job environments. o Experiment: Conduct a case study on organizations using Cisco collaboration tools to measure outcomes. 3. Role of AI in Network Automation o Focus: Explore how Cisco’s AI-driven solutions improve efficiency and reduce manual interventions in network management. o Experiment: Simulate network configurations with and without AI to compare performance metrics. 4. Cybersecurity Skills and Threat Management o Focus: Investigate the effectiveness of Cisco’s cybersecurity training in preparing professionals to handle modern cyber threats. o Experiment: Assess trainee performance in simulated threat scenarios before and after the training. 5. Diversity in Cisco Networking Academy o Focus: Evaluate how Cisco NetAcad promotes diversity and inclusion in the IT industry. o Experiment: Analyze demographic data and outcomes of NetAcad participants to identify trends and impacts. 6. IoT and Career Skills Development o Focus: Study how Cisco’s IoT training programs influence career opportunities in smart city and industry automation sectors. o Experiment: Assess skill acquisition and employability among participants in IoT-specific courses. 7. Environmental Sustainability in Cisco Careers o Focus: Analyze how Cisco’s emphasis on green networking and energy-efficient technologies shapes career opportunities. o Experiment: isco is a powerhouse in networking, security, and IT solutions, making it an essential subject for exploring hardware calculations, configurations, and their applications in electrical engineering. Here's a breakdown of the background and experimental topics related to Cisco hardware and electrical systems: Background on Cisco Hardware and Configuration in Electrical Engineering 1. Networking Hardware: o Cisco’s routers, switches, and wireless access points serve as the backbone of modern electrical and networking systems. o These devices play a crucial role in managing power, data flow, and communication across industrial and residential setups. 2. Power and Energy Management: o Cisco integrates smart features into its networking devices, enabling power efficiency, dynamic resource allocation, and uninterrupted operations. o Electrical engineers use configurations like PoE (Power over Ethernet) to streamline energy distribution for connected devices. 3. IoT Solutions: o Cisco IoT hardware facilitates real-time monitoring and control in smart grids and industrial automation. o These devices are engineered to operate under various electrical conditions, ensuring reliability and scalability. 4. System Design and Configuration: o Cisco hardware configurations involve system compatibility checks, load management, and network optimization. o Electrical engineers must calculate and configure devices to ensure seamless integration within larger infrastructures. 5. Energy Efficiency and Sustainability: o Cisco incorporates advanced hardware calculations to minimize energy consumption and reduce environmental impact. o This aligns with global goals for sustainability in electrical and networking systems. Experimental Topics Hardware Calculations 1. Efficiency of Power Over Ethernet (PoE) Systems o Experiment: Test energy consumption and performance optimization in PoE-enabled Cisco devices under varying loads. o Focus: Assess power delivery efficiency for connected devices like cameras and IoT sensors. 2. Load Balancing in Electrical Grids o Experiment: Analyze how Cisco networking equipment manages data and power loads in smart grids. o Focus: Measure system stability and efficiency during peak and idle periods. 3. Heat Dissipation in Cisco Hardware o Experiment: Study the thermal management capabilities of Cisco devices to prevent overheating in electrical systems. o Focus: Test different cooling configurations and materials. Hardware Configuration 4. Optimization of IoT-Enabled Electrical Systems o Experiment: Configure Cisco IoT hardware for industrial automation and monitor its impact on electrical system efficiency. o Focus: Compare outcomes with traditional non-IoT systems. 5. Network Traffic Impact on Energy Consumption o Experiment: Measure the correlation between network traffic and power usage in Cisco networking hardware. o Focus: Simulate high and low traffic conditions to evaluate energy-saving features. 6. Compatibility of Cisco Devices with Electrical Standards o Experiment: Test Cisco hardware configurations against national and international electrical engineering standards. o Focus: Ensure compliance and reliability under diverse conditions. Electrical System Integration 7. Smart Grid Performance with Cisco Hardware o Experiment: Investigate the role of Cisco networking devices in optimizing energy distribution within smart grids. o Focus: Study how configurations improve fault detection and load management. 8. Renewable Energy Integration o Experiment: Configure Cisco hardware to monitor and control systems with renewable energy sources like solar panels. o Focus: Analyze the efficiency of hardware configurations in hybrid energy setups. o ISC² (International Information Systems Security Certification Consortium) focuses on cybersecurity career advancement, offering world-renowned certifications and exams for professionals in the field. Here’s a structured background and experimental topics related to ISC² security, careers, and certifications: Background on ISC² Security Career Certifications 1. Prominent Certifications: o CISSP (Certified Information Systems Security Professional): ▣ Recognized as the gold standard for cybersecurity leadership roles. o CCSP (Certified Cloud Security Professional): ▣ Focused on cloud security expertise. o SSCP (Systems Security Certified Practitioner): ▣ Tailored for entry-level cybersecurity practitioners. o CSSLP (Certified Secure Software Lifecycle Professional): □ Specializes in secure software development. 2. Exam Structure and Content: o Exams typically include multiple-choice questions alongside advanced scenario-based queries. o Topics are based on ISC²'s Common Body of Knowledge (CBK), which provides a framework for security concepts like risk management, cryptography, asset protection, and governance. 3. Career Impact: o ISC² certifications open doors to high-demand roles in security analysis, cybersecurity management, cloud architecture, and software development security. o Professionals with certifications often enjoy higher salaries, greater career mobility, and recognition as subject matter experts. 4. Global Reach and Training: o ISC² offers training materials, study guides, and exam preparation resources. o The certifications are respected globally, making them valuable for building international careers. Experimental Topics Related to ISC² Security and Careers 1. Impact of ISC² Certifications on Career Progression o Experiment: Analyze how achieving ISC² certifications influences job opportunities, salary increments, and career growth. o Focus: Survey professionals who have attained certifications versus those without. 2. Exam Preparation Techniques and Success Rates o Experiment: Evaluate the effectiveness of different preparation methods (e.g., ISC² online training versus self-study) on exam pass rates. o Focus: Compare the pass rates of candidates using official ISC² resources to those relying on third-party materials. 3. Certification Adoption in Small vs. Large Organizations o Experiment: Study how small businesses versus large enterprises benefit from employees holding ISC² certifications. o Focus: Track how certified staff contribute to improved cybersecurity frameworks. 4. Skills Acquired Through Certification o Experiment: Investigate the practical application of skills learned during ISC² certification training in resolving real-world security challenges. o Focus: Assess the implementation of risk management strategies by certified professionals. 5. Cloud Security Knowledge Through CCSP Certification o Experiment: Explore how CCSP-certified professionals enhance cloud security in enterprise environments. o Focus: Test their ability to mitigate data breaches in cloud systems compared to non-certified individuals. 6. Diversity and Accessibility in ISC² Certification Programs o Experiment: Analyze demographic trends in ISC² certification candidates and assess barriers to entry for underrepresented groups. o Focus: Identify steps ISC² could take to improve accessibility and inclusivity. 7. Global Demand for Cybersecurity Certifications o Experiment: Examine the geographic distribution of professionals pursuing ISC² certifications and correlate it with cybersecurity demand in different regions. o Focus: Highlight areas of high certification adoption versus emerging markets. background experimental isc certificate calculation ISC² certifications, such as CISSP, CCSP, and SSCP, require a solid understanding of complex systems and methodologies, including various calculations related to security, risk management, and resource allocation. Here's a breakdown of the background and potential experimental topics involving certificate-related calculations: Background on ISC² Certificate Calculation Needs 1. Risk Assessment and Management: o ISC² certifications emphasize risk calculation, including identifying potential threats, evaluating their likelihood, and measuring impact levels. o Calculations may include quantifying residual risk and cost-benefit analysis of security measures. 2. Resource Allocation in Security Operations: o Determining the efficient use of resources such as time, personnel, and budget is a core skill for ISC²-certified professionals. o Tasks include calculating the Return on Security Investment (ROSI) and prioritizing mitigation strategies. 3. Cryptography and Key Management: o Encryption methods rely on mathematical calculations, including key generation, hashing, and validating algorithms for secure communication. o ISC² certifications test understanding of cryptographic standards and practices. 4. Security Metrics and Performance Evaluation: o Certified professionals must calculate performance metrics like incident response times, system uptime, and vulnerability patching rates. o These metrics are critical in monitoring and optimizing security frameworks. 5. Cloud Security Calculations: o For certifications like CCSP, candidates must calculate cloud storage costs, bandwidth requirements, and scalability factors while ensuring secure configurations. Experimental Topics Related to ISC² Calculations 1. Evaluating the Accuracy of Risk Calculations in Decision-Making o Focus: Assess how well ISC²-certified professionals calculate and interpret risk levels to influence security policies. o Experiment: Simulate various security scenarios and compare decision outcomes based on different risk calculations. 2. Optimization of Resource Allocation Using ROSI o Focus: Study the effectiveness of Return on Security Investment (ROSI) calculations in justifying security investments. o Experiment: Measure the efficiency of resource usage and outcomes in organizations applying ROSI-based strategies. 3. Cryptographic Performance Analysis o Focus: Investigate the efficiency of ISC²-recommended cryptographic algorithms under different conditions. o Experiment: Test encryption/decryption times and evaluate their implications for secure system design. 4. Application of Cloud Security Calculations o Focus: Analyze the impact of accurate cloud cost and performance calculations in securing enterprise systems. o Experiment: Compare cloud storage and security effectiveness with and without ISC²-certified guidance. 5. Quantifying Security Metrics for System Resilience o Focus: Study how well ISC²-certified professionals use calculated metrics to maintain system availability during cyber incidents. o Experiment: Track response times and system recovery rates in simulated breach scenarios. 6. Vulnerability Scoring and Patch Prioritization o Focus: Explore how vulnerability calculation methods like CVSS (Common Vulnerability Scoring System) improve patch management strategies. o Experiment: Evaluate system security before and after implementing prioritized patches. The convergence of electrical engineering, hardware systems, and data security presents a compelling field of study under the umbrella of ISC (Information Systems and Cybersecurity). Below is a structured background overview and potential experimental topics at this intersection: Background on ISC, Electrical Hardware, and Data Security 1. Electrical Hardware in IT and Data Systems: o Electrical hardware like servers, routers, and IoT devices forms the backbone of modern IT infrastructure, directly influencing power consumption, efficiency, and reliability. o Hardware security considerations include encryption modules, secure boot mechanisms, and tamper-resistant designs to protect sensitive data. 2. Data Security in Electrical Systems: o Electrical grids, substations, and industrial control systems (ICS) increasingly incorporate networked hardware, making them vulnerable to cyberattacks. o Cybersecurity frameworks, such as those provided by ISC² certifications, emphasize securing communication between devices and safeguarding system integrity. 3. Interdependencies in Electrical and IT Systems: o Power management in data centers relies on efficient electrical designs to support critical operations while ensuring secure data storage and transmission. o Electrical systems in smart grids or IoT applications depend on data encryption, access control, and threat detection to protect functionality. 4. ISC² and Electrical Systems: o ISC² certifications, such as CISSP (Certified Information Systems Security Professional) or CCSP (Certified Cloud Security Professional), include knowledge areas covering hardware and infrastructure security, ideal for professionals working with electrical and data systems. Experimental Topics Electrical Hardware and Data Security 1. Securing Power Distribution in Data Centers o Experiment: Analyze the effectiveness of various hardware security measures (e.g., encrypted power management units) in protecting power distribution systems. o Focus: Simulate potential cyberattacks and evaluate system resilience. 2. IoT Device Vulnerabilities in Electrical Networks o Experiment: Investigate security gaps in IoT-enabled electrical systems and propose hardware-level solutions. o Focus: Test encryption and secure boot implementations in networked devices. 3. Energy-Efficient Cryptographic Hardware o Experiment: Design and test cryptographic modules that minimize energy consumption for secure data transfer in electrical systems. o Focus: Compare energy efficiency and computational performance of different encryption techniques. Electrical Systems and Cyber Threat Detection 4. Anomaly Detection in Industrial Control Systems o Experiment: Develop hardware-based intrusion detection systems (IDS) for monitoring anomalies in ICS used in power distribution. o Focus: Evaluate IDS accuracy in identifying unauthorized access or system disruptions. 5. Cybersecurity Frameworks for Smart Grids o Experiment: Analyze the implementation of ISC²-based security principles in safeguarding smart grid hardware and data communication. o Focus: Measure the impact of applied frameworks on grid stability and data integrity. Integration of Hardware, Electrical Systems, and Security 6. Resilience Testing of Electrical Hardware o Experiment: Test the durability and security of electrical hardware under simulated physical and cyberattacks. o Focus: Assess tamper-resistant designs and their effectiveness in maintaining system integrity. 7. Hardware-Based Security for Renewable Energy Systems o Experiment: Investigate the role of hardware security modules in protecting data generated and transmitted by solar or wind energy systems. o Focus: Compare hardware reliability and data protection efficiency across various renewable setups. 4. Anomaly Detection in Industrial Control Systems Developing hardware-based IDS (Intrusion Detection Systems) involves monitoring and analyzing data flows within power distribution systems. The integral calculations could be related to: 1. Signal Processing and Filtering: o Use integration to process incoming data signals and identify abnormalities. o For example, calculate the cumulative energy signals over a given time: $$\int_{t_1}^{t_2} E(t) \, dt$$ Here, E(t)E(t) represents the energy signals within the control system during time interval [t1,t2][t_1, t_2]. 2. Threshold-Based Detection: o Derive anomalies by integrating deviations from standard operational parameters: $$\int_{t_1}^{t_2} \big(E_{observed}(t) - E_{expected}(t)\big)^2 \, dt$$ This helps quantify discrepancies between observed and expected energy patterns. 3. Accuracy Evaluation Metrics: o Evaluate IDS accuracy using ROC (Receiver Operating Characteristic) curves, which involve integral calculations to determine areas under the curve (AUC) for false positive/negative rates: $$\text{AUC} = \int_{x_{false}}^{x_{true}} f(x) \, dx$$ 5. Cybersecurity Frameworks for Smart Grids Analyzing the implementation of ISC² security principles in smart grids involves modeling and evaluating stability and data integrity. Integral calculations could be applied to: 1. Grid Stability Analysis: o Integrate power flow equations across the grid to ensure equilibrium: $$\int_{t_1}^{t_2} \big(P_{input}(t) - P_{output}(t)\big) \, dt$$ Where PinputP_{input} and PoutputP_{output} represent power inflow and outflow over time. 2. Encryption and Data Security Metrics: o Measure encrypted data efficiency via integral calculations related to computational performance: $$\int_{t_1}^{t_2} \frac{Data_{processed}(t)}{Time(t)} \, dt$$ This quantifies encryption throughput over time. 3. Framework Impact on Integrity: o Assess the cumulative impact of security frameworks by integrating data loss rates: $$\int_{t_1}^{t_2} Loss_{data}(t) \, dt$$ 4. Grid Communication Latency: o Integrate latency values across communication nodes to optimize response times: $$\int_{node_1}^{node_n} \text{Latency}(x) \, dx$$ Where Latency(x)\text{Latency}(x) represents transmission delays at node xx. Salesforce, a leader in CRM (Customer Relationship Management), along with Trailblazer learning programs and Tableau data analytics tools, provides exciting avenues for experimentation and innovation. Here’s an overview and experimental topics: Background on Salesforce and Trailblazer 1. Salesforce CRM Ecosystem: o Salesforce CRM is used for customer engagement, sales automation, and enterprise resource planning. o Features tools like Sales Cloud, Marketing Cloud, and Service Cloud for end-to-end business solutions. 2. Trailblazer Learning Program: o Trailhead, Salesforce's learning platform, provides modular learning paths for developing skills in Salesforce tools, data management, and application development. o Focuses on gamified learning and personalized certifications. 3. Tableau Analytics: o Salesforce Tableau enables advanced data visualization, analytics, and storytelling through interactive dashboards. o Widely used across industries like finance, healthcare, and retail for business intelligence. Experimental Topics Salesforce CRM Focus 1. Personalized Customer Engagement Algorithms o Experiment: Test Salesforce's AI-driven insights to improve customer satisfaction metrics. o Focus: Measure the effectiveness of automated personalization strategies in different sectors. 2. Sales Workflow Optimization o Experiment: Study how Salesforce tools streamline sales cycles in various industries. o Focus: Measure reductions in lead conversion time and effort. Trailblazer Learning Program 3. Effectiveness of Gamified Learning o Experiment: Analyze the impact of Trailhead’s gamification elements on knowledge retention. o Focus: Compare results with traditional learning methods. 4. Skill Progression with Trailhead Certifications o Experiment: Evaluate career advancements based on Trailhead certification achievements. o Focus: Measure employment and salary growth over time. Tableau Analytics 5. Impact of Data Visualization on Decision-Making o Experiment: Investigate how Tableau dashboards enhance understanding and improve business decisions. o Focus: Compare success rates of decisions made with and without Tableau visualization. 6. Integration of Tableau with Salesforce CRM o Experiment: Study how the integration improves predictive analytics for customer behavior. o Focus: Track ROI on predictive analytics adoption. 7. Efficiency of AI Analytics in Tableau o Experiment: Analyze the accuracy and insights of AI-powered features in Tableau. o Focus: Measure prediction reliability on business trends and outcomes. 1.20.1 Background on Salesforce Training and Products 1. Salesforce Training Ecosystem: o Trailhead Learning Platform: Offers gamified courses tailored to Salesforce tools, including Sales Cloud, Service Cloud, Marketing Cloud, and more. It is designed to help learners gain certifications and skills for implementing Salesforce solutions. o Corporate Training Programs: Organizations can use Salesforce tools for customer relationship management (CRM), workflow automation, and data-driven decision-making. 2. Tableau Analytics Integration: o Tableau is a part of Salesforce and specializes in advanced data analytics and visualization. It enables businesses to create interactive dashboards, analyze trends, and predict outcomes effectively. o Training in Tableau covers topics like data connections, visualization techniques, and dashboard storytelling. 3. Industry Applications: o Salesforce and Tableau serve industries such as finance, healthcare, retail, and technology. Training programs often focus on tailoring solutions to meet sector-specific needs, such as customer journey mapping or real-time analytics. Experimental Topics Training Programs 1. Effectiveness of Gamification in Trailhead o Experiment: Measure the impact of Trailhead’s gamification features (badges, points, interactive modules) on learning outcomes. o Focus: Compare knowledge retention and application between gamified and traditional training methods. 2. Skill Advancement from Certifications o Experiment: Evaluate how Trailblazer certifications contribute to individual career growth and organizational success. o Focus: Track skill utilization in real-world Salesforce product implementations. Product Integration 3. Impact of Salesforce-Tableau Integration on CRM Analytics o Experiment: Study how Tableau dashboards improve Salesforce CRM data visualization and decision-making capabilities. o Focus: Monitor changes in user satisfaction and business outcomes post-integration. 4. Data Visualization in Marketing Campaigns o Experiment: Assess the effectiveness of Tableau-generated dashboards in optimizing marketing strategies. o Focus: Compare ROI and campaign efficiency for visualized vs. non-visualized strategies. Product Performance and Innovation 5. AI-driven Insights in Tableau Analytics o Experiment: Analyze the accuracy and usability of Tableau’s AI-powered prediction models. o Focus: Measure improvements in forecasting business trends. 6. Customization of Salesforce Tools for Industry-Specific Applications o Experiment: Develop tailored Salesforce configurations for a specific industry, such as healthcare or retail, and measure business impacts. o Focus: Study ease of adoption and operational enhancements from tailored setups. Background on Salesforce, Trailblazer, and Tableau 1. Salesforce Ecosystem: o Salesforce is a leading CRM platform offering tools for customer engagement, sales automation, and data management. o It supports advanced configurations, enabling seamless integration with hardware systems like IoT devices and providing real-time data collection. 2. Trailblazer Program: o Trailhead Learning Platform delivers gamified training on Salesforce products, ensuring skill development for professionals handling software and hardware integration. o Certifications from Trailhead cover Salesforce tools, Tableau analytics, and related technical skills. 3. Tableau Analytics: o Tableau excels in data visualization and analytics, offering tools for configuring dashboards and performing advanced calculations across various datasets. o Widely used for analyzing hardware performance and system behavior in industries such as energy, automation, and manufacturing. 4. Electrical Hardware and System Relevance: o Salesforce and Tableau can integrate with IoT devices for monitoring electrical systems, providing operational insights for maintenance, energy usage, and fault detection. o Through automation workflows, Salesforce tools can manage the lifecycle of electrical assets, while Tableau visualizes their performance trends. Configuration and Calculation Examples 1. Electrical Load Management: • Salesforce Configuration: o Use Salesforce IoT integrations to monitor electrical hardware data, such as load balancing and power usage metrics. o Automate workflows to trigger alerts for system anomalies. • Tableau Visualization and Calculation: o Create dashboards to visualize electrical load distribution: $$\text{Total Load} = \int_{t_1}^{t_2} P(t) \, dt$$ Where P(t)P(t) represents power usage over time. 2. Data Integration for Fault Detection: • Salesforce Configuration: o Configure Salesforce systems to gather fault data from connected devices. o Create reports to track historical fault occurrences and resolutions. • Tableau Analytics: o Analyze fault trends using Tableau's machine learning models. o Calculate fault impact: $$\text{Impact Score} = \int_{t_1}^{t_2} \big(F_{severity}(t) \cdot F_{duration}(t)\big) \, dt$$ 3. Energy Efficiency Optimization: • Salesforce Automation: o Automate processes to manage energy-saving initiatives, such as optimizing IoT device usage during off-peak hours. • Tableau Analysis: o Measure energy savings: $$\text{Energy Saved} = \int_{t_1}^{t_2} \big(P_{initial}(t) - P_{optimized}(t)\big) \, dt$$ This tracks power consumption before and after optimization efforts. Experimental Topics 1. Salesforce and IoT for Electrical Hardware Monitoring: o Experiment with integrating Salesforce IoT Cloud to monitor hardware operations in real-time. o Focus on anomaly detection and automated fault reporting workflows. 2. Tableau in Energy Efficiency Analysis: o Explore how Tableau dashboards can improve visibility of energy consumption patterns in industrial settings. o Experiment with integrating predictive analytics to forecast energy demands. 3. Skill Training via Trailhead for Smart Systems: o Analyze how Trailhead training improves the ability of professionals to configure Salesforce and Tableau for electrical hardware projects. o Experiment with measuring skill acquisition rates versus project outcomes. 1.21.1 The Metropolitan Police Service (Met Police) in the UK is one of the most prominent law enforcement agencies, and experimental studies in policing, governance, and technology implementation offer numerous possibilities. Here's a detailed background and potential research topics focusing on "block marks," which may refer to policing strategies, community markers, or system blockages in law enforcement operations: Background on the Met Police UK 1. Law Enforcement Mission: o The Met Police operates to maintain public safety and order in Greater London. Its scope includes crime prevention, response, and counterterrorism efforts. o The organization works closely with community policing strategies to engage with diverse populations. 2. Technology Integration: o The Met Police has been adopting advanced technologies, including body-worn cameras, data analytics, and predictive policing models. o Blocked operations or system inefficiencies are challenges the department aims to address through technology and reform. 3. Community Engagement: o Programs focus on building trust between the police and local communities through collaborative problem-solving and transparency initiatives. 4. Operational Challenges: o Budget constraints, resource allocation, and accountability are ongoing issues. o "Block marks" could symbolize procedural or systemic blockages, including administrative hurdles, data flow interruptions, or social challenges like distrust in policing. Experimental Topics Technology Implementation 1. Effectiveness of Predictive Policing Models o Experiment: Evaluate how predictive algorithms help identify high-crime areas and allocate resources effectively. o Focus: Measure the accuracy of crime prevention in areas flagged by predictive systems. 2. Body-Worn Cameras and Trust Building o Experiment: Assess the impact of body-worn cameras on transparency and citizen trust. o Focus: Compare complaint rates and community feedback pre- and post-implementation. 3. Data Flow Blockage in Law Enforcement Systems o Experiment: Investigate the causes and impacts of system inefficiencies in data sharing between departments. o Focus: Propose solutions for seamless information sharing across units. Community Engagement 4. Community Perception of Police Presence o Experiment: Study how block-based police patrols influence community perceptions of safety. o Focus: Compare areas with intensive patrols to those with minimal coverage. 5. Addressing Distrust through Restorative Practices o Experiment: Examine the outcomes of restorative justice programs on reducing community-police tensions. o Focus: Track recidivism and satisfaction rates post-program implementation. Operational Effectiveness 6. Resource Allocation in High-Density Blocks o Experiment: Test strategies for optimizing resource distribution in densely populated urban blocks. o Focus: Analyze crime rates and response times with varying allocation models. 7. Policing Blockages in Emergency Response o Experiment: Evaluate the impact of administrative or procedural blockages on emergency response times. o Focus: Implement process improvements and measure performance changes. The Metropolitan Police Service (Met Police) in the UK plays a crucial role in law enforcement, community safety, and professional career development. Exploring their training programs and career paths provides meaningful insights into law enforcement innovation. Below is a structured background and potential experimental topics related to Met Police careers, training, and the concept of "blockmark," which may relate to operational blocks, procedural benchmarks, or performance indicators: Background on Met Police Training and Careers 1. Career Development: o The Met Police offers a range of entry points for aspiring officers and staff, such as the Police Constable Degree Apprenticeship (PCDA), Direct Entry, and graduate schemes. o Career progression involves specialized roles like counterterrorism, cybercrime, and armed policing. 2. Training Programs: o Comprehensive training is provided at the Met Police Training School, combining theory and practical simulations. o Key areas include public order management, investigative techniques, and community engagement. 3. Operational Benchmarks ("Blockmarks"): o Blockmarks may refer to procedural standards or checkpoints for evaluating officer performance and operational efficiency. o These benchmarks ensure accountability, compliance with protocols, and alignment with the Met’s mission. 4. Use of Technology: o Advanced technology, like data analytics and AI, is increasingly integrated into police work, supporting crime mapping, predictive policing, and resource allocation. o Training programs now incorporate technological skills to prepare officers for modern challenges. Experimental Topics Training Programs 1. Effectiveness of Simulation-Based Training o Experiment: Compare the success rates of officers trained using real-world simulations versus traditional classroom methods. o Focus: Assess retention of practical skills like de-escalation and crowd control. 2. Evaluation of Community Policing Training o Experiment: Study how training focused on community engagement impacts public trust in policing. o Focus: Compare trust levels in communities served by officers trained in these techniques to those who weren’t. 3. Career Progression and Training Accessibility o Experiment: Investigate whether training accessibility influences career progression for officers across different demographics. o Focus: Analyze how diversity and inclusion policies impact training outcomes and promotions. Operational Blockmarks 4. Performance Metrics in Crime Prevention o Experiment: Study the effectiveness of procedural benchmarks in preventing specific types of crimes. o Focus: Track crime reduction rates in areas with strict adherence to blockmarks. 5. Technology Training Impact on Performance o Experiment: Evaluate the impact of training officers in predictive policing technologies on operational efficiency. o Focus: Measure response times and crime-solving rates pre- and post-implementation. 6. Blockmarks for Officer Well-Being o Experiment: Test the inclusion of mental health and well-being blockmarks in officer evaluations. o Focus: Analyze changes in job satisfaction and performance among officers. These topics provide opportunities to explore the effectiveness of Met Police training programs, blockmark benchmarks, and their impact on officer careers and community The Metropolitan Police Service (Met Police) in the UK utilizes a combination of advanced hardware, software, and data systems to enhance its operations, and exploring their configurations and calculations in this context can reveal opportunities for optimization. Here's a structured background and experimental ideas for calculations, sizing, and configurations involving the Met Police’s use of data, hardware, and software systems. Background on the Met Police’s Use of Technology 1. Hardware Systems: o Key Infrastructure: Includes communication devices (e.g., radios, CCTV systems), servers for data storage, and control room technology. o IoT and Sensors: The Met uses IoT-enabled devices like traffic sensors and surveillance tools for real-time monitoring. o Scaling and Sizing: Proper hardware sizing ensures efficient data processing, secure storage, and fast retrieval for operations. 2. Software Systems: o Data Management Tools: Systems like HOLMES (Home Office Large Major Enquiry System) are used for managing large investigations. o Predictive Policing: Software tools analyze historical crime data to predict and prevent incidents. o Configuration Capabilities: Customized applications manage workflows, resource allocation, and crime reporting. 3. Data Utilization: o Operational Data: Includes crime statistics, incident reports, and officer performance metrics. o Analysis and Visualization: Data is visualized using tools like dashboards, enabling actionable insights. o Security Compliance: Ensures adherence to data protection regulations like GDPR. 4. Challenges and Opportunities: o Balancing hardware scalability with cost-effectiveness. o Configuring software systems to adapt to diverse policing needs. o Ensuring interoperability among devices and platforms. Experimental Topics Hardware Configuration and Sizing 1. Optimizing Server Capacity for Crime Data Management o Experiment: Determine the optimal server size for secure and efficient storage of incident reports. o Calculation: Use data flow equations to model storage requirements over time: $$\text{Capacity} = \int_{t_1}^{t_2} \text{Data_{input}}(t) - \text{Data_{archived}}(t) \, dt$$ 2. IoT Network Sizing for Urban Surveillance o Experiment: Analyze the capacity of IoT devices to handle dense urban traffic monitoring. o Focus: Evaluate real-time data transmission accuracy and latency. 3. Energy Efficiency of Control Room Hardware o Experiment: Investigate the power consumption of hardware used in police control rooms. o Focus: Compare energy usage under normal and peak loads to identify inefficiencies. Software Configuration and Data Analysis 4. Crime Prediction Accuracy of Software Tools o Experiment: Test predictive policing software by comparing its forecasts against real incident trends. o Calculation: Measure prediction accuracy: $$\text{Accuracy} = \int_{t_1}^{t_2} \big|\text{Predicted Crimes}(t) - \text{Actual Crimes}(t)\big| \, dt$$ 5. Optimizing Software Workflow Configurations o Experiment: Study how workflow customization in software impacts officer response times. o Focus: Configure workflows to reduce response delays in emergency scenarios. 6. Visualizing Crime Data for Decision-Making o Experiment: Assess the impact of data visualization dashboards on operational planning. o Focus: Compare planning outcomes with and without visualization tools. Data System Integration 7. Interoperability of Hardware and Software Platforms o Experiment: Analyze the compatibility of various hardware devices with police software applications. o Focus: Test data flow continuity and error rates in integrated systems. 8. Scaling Data Storage for Long-Term Investigations o Experiment: Determine the scalability of existing data storage systems for prolonged investigations. o Calculation: Predict future storage needs: $$\text{Future Storage} = \int_{t_0}^{t_{future}} \text{Data_{input}}(t) \, dt$$ The integral calculations embedded within the experimental topics related to hardware systems, software systems, and data utilization offer insightful opportunities for precision and optimization in the Met Police's operational environment. Here's how these integrals would apply, along with specific examples tailored for electrical engineering relevance: Integral Calculations for Hardware Systems 1. Optimizing Server Capacity for Crime Data Management • Key Integral: $$\text{Capacity} = \int_{t_1}^{t_2} \text{Data_{input}}(t) - \text{Data_{archived}}(t) \, dt$$ o Application: This integral calculates the required server storage by analyzing incoming and archived data over time. o Electrical Engineering Perspective: Ensures that server hardware power consumption is optimized, avoiding overloading or underutilization of storage systems. 2. IoT Network Sizing for Urban Surveillance • Key Integral: $$\text{Network Load} = \int_{t_1}^{t_2} \text{Data_{transmitted}}(t) \, dt$$ o Application: Analyzes the total volume of data transmitted by IoT devices in a specific time frame. o Electrical Engineering Perspective: Ensures bandwidth allocation in networked surveillance systems aligns with power supply and scalability requirements. 3. Energy Efficiency in Control Room Hardware • Key Integral: $$\text{Energy Consumption} = \int_{t_1}^{t_2} \text{Power}(t) \, dt$$ o Application: Evaluates the energy consumed by control room devices under varying workloads. o Electrical Engineering Perspective: Helps design efficient electrical systems to minimize energy wastage during peak operations. Integral Calculations for Software Systems 1. Crime Prediction Accuracy • Key Integral: $$\text{Accuracy} = \int_{t_1}^{t_2} \big|\text{Predicted Crimes}(t) - \text{Actual Crimes}(t)\big| \, dt$$ o Application: Calculates the deviation between predicted and actual crime trends. o Electrical Engineering Perspective: Informs power requirements for running predictive algorithms efficiently on computational hardware. 2. Optimizing Software Workflow Configurations • Key Integral: $$\text{Workflow Efficiency} = \int_{t_1}^{t_2} \frac{\text{Tasks Completed}}{\text{Time Taken}} \, dt$$ o Application: Measures how effectively workflows are executed in emergency response systems. o Electrical Engineering Perspective: Helps configure power redundancy in electrical setups supporting critical software applications. 3. Visualizing Crime Data for Decision-Making • Key Integral: $$\text{Visualization Impact} = \int_{t_1}^{t_2} \text{Decision Speed}(t) \cdot \text{Accuracy}(t) \, dt$$ o Application: Quantifies improvements in decision-making facilitated by data visualization dashboards. o Electrical Engineering Perspective: Optimizes energy efficiency of display systems used for visualization. Integral Calculations for Data System Integration 1. Interoperability of Hardware and Software Platforms • Key Integral: $$\text{Data Flow Continuity} = \int_{Device_1}^{Device_n} \text{Error Rate}(x) \, dx$$ o Application: Monitors error rates across multiple hardware and software systems to ensure seamless integration. o Electrical Engineering Perspective: Enhances fault tolerance in interconnected electrical and data systems. 2. Scaling Data Storage for Long-Term Investigations • Key Integral: $$\text{Future Storage} = \int_{t_0}^{t_{future}} \text{Data_{input}}(t) \, dt$$ o Application: Predicts storage requirements for ongoing investigations. o Electrical Engineering Perspective: Ensures electrical infrastructure scalability for high-capacity data servers. 1.22.1 The Department of Higher Education and Training (DHET) in South Africa oversees various education and training initiatives, including NATED and NCV programs, as well as institutions accredited by SAQA (South African Qualifications Authority) and QCTO (Quality Council for Trades and Occupations). Here's a structured background and experimental topics in education and career development: Background on DHET and Associated Entities 1. DHET (Department of Higher Education and Training): o Responsible for post-school education, including universities, TVET colleges, and community education. o Focuses on developing skills to meet labor market demands through vocational and technical education. 2. NATED (National Accredited Technical Education Diploma) Programs: o Designed for TVET (Technical and Vocational Education and Training) colleges, focusing on practical and theoretical training in fields like engineering, business, and tourism. o

Includes levels N1 to N6, preparing learners for industry entry or further studies. 3. NCV (National Certificate Vocational): o Offers vocational education for grades 10–12 in technical and practical disciplines, providing an alternative to traditional schooling. o Equips learners with skills for specific trades and occupations. 4. SAQA (South African Qualifications Authority): o Responsible for ensuring qualifications meet national standards and are aligned to the National Qualifications Framework (NQF). o Accredits providers of education and training. 5. QCTO (Quality Council for Trades and Occupations): o Focuses on developing occupational qualifications aligned to workplace needs. o Ensures training is relevant to industry demands and promotes skills transferability. Experimental Topics Education and Training 1. Effectiveness of NATED Programs in Industry Readiness o Experiment: Study how NATED graduates transition into the workforce compared to non-NATED learners. o Focus: Analyze employability rates and skill applicability. 2. NCV Learner Satisfaction and Career Trajectory o Experiment: Evaluate the satisfaction levels of NCV learners and their career paths post-graduation. o Focus: Compare outcomes in specific vocational fields like engineering or hospitality. 3. Impact of SAQA Accreditation on TVET Colleges o Experiment: Assess the influence of SAQA-accredited qualifications on the reputation and outcomes of TVET institutions. o Focus: Examine learner performance and progression rates. Occupational and Career Development 4. Role of QCTO in Developing Workplace-Relevant Skills o Experiment: Analyze the effectiveness of QCTO qualifications in meeting industry standards. o Focus: Measure alignment between occupational training and actual job requirements. 5. Career Pathways Through Vocational Qualifications o Experiment: Investigate the career trajectories of learners with NATED, NCV, or QCTO certifications. o Focus: Compare long-term career growth and earnings potential across qualification types. 6. Digital Integration in Vocational Training o Experiment: Explore how digital tools enhance learning in DHET-backed programs. o Focus: Evaluate improvements in student engagement and practical skill development. Innovative Areas for Exploration 1. Blended Learning Models for TVET Colleges o Experiment with hybrid teaching methods (online and practical) to expand accessibility to NATED and NCV programs. 2. Sustainability in Vocational Curricula o Develop environmentally-focused modules in engineering or construction programs and measure learner understanding. 3. Community Impact of DHET-Funded Initiatives o Examine how vocational qualifications address unemployment rates and improve local economies. The Department of Higher Education and Training (DHET) in South Africa oversees various education and training initiatives, such as NATED (National Accredited Technical Education Diploma) and NCV (National Certificate Vocational) programs, as well as qualifications certified by SAQA (South African Qualifications Authority) and QCTO (Quality Council for Trades and Occupations). Combining these with data configuration, training, and engineering (particularly electrical engineering) creates exciting opportunities for educational and professional exploration. Here's a comprehensive overview and experimental ideas: Background on DHET Education, Career Pathways, and Technical Training 1. DHET and Vocational Education: o DHET drives post-school education and skill development through TVET (Technical and Vocational Education and Training) colleges. o Programs like NATED (N1-N6) and NCV (levels 2-4) train learners in engineering disciplines, including electrical engineering, mechanics, and construction. o Focuses on bridging the skills gap in South Africa to meet labor market demands. 2. SAQA-Accredited Qualifications: o SAQA aligns qualifications with the National Qualifications Framework (NQF) to ensure standardization and quality. o Electrical engineering qualifications emphasize theoretical knowledge and practical experience, catering to industry needs. 3. QCTO's Role in Occupational Training: o The QCTO emphasizes competency-based qualifications tailored to specific jobs or industries. o Electrical engineering training under QCTO integrates academic rigor with workplace training, ensuring graduates are job-ready. 4. Engineering and Electrical Systems: o Electrical engineering programs cover installation, maintenance, power systems, and renewable energy integration. o Topics like electrical design, load analysis, circuit configuration, and compliance with safety standards form the foundation. 5. Data Configuration in Education and Industry: o Modern education integrates data analytics and software tools for efficient curriculum management and technical training. o Engineering industries rely on data systems to optimize design, configuration, and operational processes. Experimental Topics NATED and NCV Programs in Electrical Engineering 1. Effectiveness of Practical Training in NATED Programs o Experiment: Evaluate how practical sessions in NATED engineering programs prepare students for real-world electrical projects. o Focus: Compare problem-solving skills in students trained through theoretical versus practical methods. 2. Skills Transferability in NCV Graduates o Experiment: Assess the ability of NCV graduates in electrical engineering to apply vocational skills across different industries. o Focus: Analyze adaptability to emerging technologies like renewable energy systems. 3. Digital Tools for Learning Enhancement o Experiment: Explore how integrating simulation software improves student outcomes in electrical engineering courses. o Focus: Compare learning effectiveness between traditional lab setups and digital simulations. Let's explore how integral calculations and derivations play a crucial role in the educational and practical contexts outlined for DHET programs, particularly in electrical engineering, with NATED, NCV, and SAQA/QCTO frameworks. Here's a breakdown of the calculations and their applications within these phases: Integral Calculations in Engineering Education 1. Load Analysis in Electrical Training • Key Calculation: Determining the total electrical load in practical sessions for designing and troubleshooting circuits: $$\text{Total Load} = \int_{t_1}^{t_2} P(t) \, dt$$ o P(t)P(t): Power consumption at time tt. o Application: Students calculate real-world power demands in circuits, developing practical design skills. 2. Circuit Design and Efficiency • Key Calculation: Calculating energy efficiency of electrical systems: $$ \text{Efficiency} = \frac{\int_{t_1}^{t_2} P_{output}(t) \, dt}{\int_{t_1}^{t_2} P_{input}(t) \, dt}$$ o Poutput(t)P_{output}(t): Useful power output. o Pinput(t)P_{input}(t): Total power input. o Application: Emphasizes practical understanding of energy conservation in renewable energy projects. 3. Simulation of Renewable Energy Systems • Key Calculation: Modeling energy generation: $$\text{Energy Produced} = \int_{t_1}^{t_2} P_{generated}(t) \, dt$$ o Application: Students use software to simulate solar or wind energy contributions to grid systems. Integral Calculations in Data Configuration 1. Curriculum Optimization Using Data • Key Calculation: Tracking curriculum success: $$\text{Performance Metrics} = \int_{t_1}^{t_2} \text{Learning Outcomes}(t) \, dt$$ o Application: Data analytics evaluate how students perform on theoretical and practical modules over time. 2. Resource Allocation in TVET Labs • Key Calculation: Optimizing resource usage: $$\text{Resource Utilization} = \int_{t_1}^{t_2} \text{Equipment Usage}(t) \, dt$$ o Application: Predicts material or lab equipment needs based on student interactions. Integral Derivations for Engineering Systems 1. Electrical Circuit Phase Calculations • Derivation: Determine phase angles in alternating current (AC) circuits: $$\phi = \arccos \left(\frac{\int_{t_1}^{t_2} V(t) \cdot I(t) \, dt}{\sqrt{\int_{t_1}^{t_2} V^2(t) \, dt \cdot \int_{t_1}^{t_2} I^2(t) \, dt}} \right)$$ o V(t)V(t): Voltage as a function of time. o I(t)I(t): Current as a function of time. o Application: Enhances learners' grasp of real-time analysis for AC systems. 2. Heat Dissipation in Electrical Systems • Derivation: Evaluate system safety through thermal modeling: $$Q = \int_{t_1}^{t_2} I^2(t) \cdot R \, dt$$ o I(t)I(t): Current through the system. o RR: Resistance. o Application: Helps students learn to prevent overheating in engineering applications. Experimental Integration into NATED and NCV Programs Effectiveness of Practical Training in NATED Programs • Experiment: Measure students' improvement in efficiency calculations and circuit performance using practical labs. • Focus: Compare their problem-solving rates in controlled theoretical versus simulated environments. Skills Transferability in NCV Graduates • Experiment: Study how students transition to advanced renewable energy projects after completing calculations like: $$\text{Renewable Efficiency} = \frac{\int_{t_1}^{t_2} P_{renewable}(t) \, dt}{\int_{t_1}^{t_2} P_{total}(t) \, dt}$$ Digital Tools for Learning Enhancement • Experiment: Evaluate the role of software simulations in building students' circuit design skills, using integrals for load analysis. 1.23.1 Sci-Bono Discovery Centre and Kheta both play crucial roles in South Africa's educational landscape, aligning with the DHET's (Department of Higher Education and Training) mission to promote skills development, particularly through NATED and NCV programs. Here's a structured background and experimental career-oriented topics linked to these initiatives: Background on Sci-Bono and Kheta 1. Sci-Bono Discovery Centre: o A flagship science center in Johannesburg supporting STEM (Science, Technology, Engineering, and Mathematics) education and skills development. o Works in collaboration with DHET to offer resources, workshops, and career guidance for TVET learners, particularly in NATED and NCV programs. o Promotes practical learning environments through hands-on activities and exposure to technology. 2. Kheta Career Guidance Initiative: o An online and mobile platform providing career advice and educational resources for South African students. o Focuses on aligning students' skills with labor market demands. o Offers information on vocational paths, university admissions, and technical career options tied to NATED and NCV qualifications. 3. NATED (National Accredited Technical Education Diploma): o A program designed for TVET colleges to bridge theoretical knowledge and workplace experience. o Levels N1–N6 prepare learners for careers in fields like electrical engineering, mechanical engineering, and business management. 4. NCV (National Certificate Vocational): o A vocational alternative to traditional secondary schooling, offering practical education in specialized trades like engineering, tourism, or IT systems. o Career-oriented, equipping learners with workplace-ready skills. Experimental Topics Sci-Bono's Role in Skills Development 1. Impact of Sci-Bono Workshops on Career Readiness o Experiment: Evaluate the effectiveness of Sci-Bono's hands-on STEM workshops for preparing learners in NATED engineering programs. o Focus: Compare practical competency levels of learners who attended Sci-Bono sessions versus those who didn't. 2. Effectiveness of Sci-Bono's Technical Exhibits o Experiment: Study how technical exhibits influence interest and skill development in NCV learners pursuing STEM-related careers. o Focus: Analyze exhibit engagement rates and resulting career choices. Kheta Career Guidance Initiative 3. Role of Kheta in Career Decision-Making o Experiment: Investigate how Kheta's career resources impact the accuracy of career path decisions among NATED learners. o Focus: Track learner satisfaction and alignment of chosen fields with market opportunities. 4. Digital Career Counseling for NCV Learners o Experiment: Assess the influence of Kheta's mobile and online career tools on NCV learner progression. o Focus: Compare job placement rates among users of Kheta's platform versus traditional counseling methods. NATED and NCV Programs 5. Workplace Integration of NATED Graduates o Experiment: Study how well NATED learners adapt to real-world technical roles after completing programs. o Focus: Measure employer feedback and graduate retention rates. 6. Skills Transfer in NCV Vocational Graduates o Experiment: Examine how NCV graduates apply their training in industries like renewable energy or IT systems. o Focus: Analyze adaptability to emerging technology-based trades. Innovative Areas for Exploration 1. Digital Learning Modules for NATED and NCV o Develop online training modules tailored to STEM-focused careers and assess their impact on learner engagement. 2. Sustainability Education Integration o Pilot eco-conscious learning programs in Sci-Bono and NCV curricula and track learner awareness of green careers. 3. Career Mentorship Programs o Investigate the effectiveness of mentorship initiatives facilitated by Kheta and Sci-Bono in accelerating career readiness. bacground experimental configuration material background experimental sciebono kheta DHET's NATED and NCV programs career topics Exploring Sci-Bono, Kheta, and DHET's NATED and NCV programs together offers a powerful perspective on education, technical training, and career development in South Africa. Below is a detailed background overview and experimental ideas that focus on configuration, materials, and career topics linked to these initiatives: Background on Sci-Bono, Kheta, DHET NATED, and NCV Programs 1. Sci-Bono Discovery Centre: o Sci-Bono is a prominent hub for STEM education and career exploration in Johannesburg, providing learners with access to advanced workshops, technical exhibits, and practical skills development programs. o The center frequently collaborates with DHET to integrate practical learning into NATED and NCV curricula. 2. Kheta Career Guidance: o Kheta is a digital platform aimed at supporting students with career advice, aligning education choices with labor market demands. o It offers resources to help students understand vocational qualifications like NATED and NCV, enabling informed career paths in engineering and other technical fields. 3. NATED Programs: o These are structured technical education courses for levels N1-N6, primarily offered by TVET colleges. o Focuses on bridging theoretical knowledge with workplace readiness, with specializations in engineering disciplines, such as electrical engineering, mechanics, and business management. 4. NCV Programs: o An alternative to traditional schooling, these programs provide vocational certificates (levels 2-4) for technical trades such as engineering, IT, and hospitality. o NCV combines academic learning with hands-on training, preparing learners for specialized careers. 5. Engineering and Materials Configuration: o Both NATED and NCV programs emphasize understanding materials and configurations for electrical systems, construction projects, and mechanical designs. o Learners develop skills in system design, configuration, and troubleshooting, addressing material properties and energy efficiency. Experimental Topics Sci-Bono Discovery Centre 1. Impact of Sci-Bono Technical Workshops o Experiment: Study how hands-on workshops at Sci-Bono influence learners' mastery of engineering concepts. o Focus: Compare skills development in workshop attendees versus classroom-only learners. 2. STEM Exhibit Engagement o Experiment: Analyze how engagement with Sci-Bono STEM exhibits improves interest in technical careers. o Focus: Track the career choices of learners exposed to STEM-focused activities. Kheta Career Guidance 3. Effectiveness of Kheta's Career Path Tools o Experiment: Evaluate the success of Kheta's digital tools in guiding NATED learners toward optimal career paths. o Focus: Compare decision accuracy and satisfaction between digital platform users and traditional counseling methods. 4. Kheta's Role in NCV Job Placement o Experiment: Assess how Kheta resources support NCV graduates in finding jobs aligned with their qualifications. o Focus: Track placement rates and employer feedback. NATED and NCV Career Topics 5. Material Configuration Skills in NATED Programs o Experiment: Investigate how NATED learners apply material configuration principles in engineering systems. o Focus: Measure proficiency in energy-efficient designs and material compatibility. 6. Adaptability of NCV Graduates in Emerging Industries o Experiment: Study the ability of NCV graduates to transition into new technological fields like renewable energy or IoT-enabled systems. o Focus: Analyze their skills in implementing modern configurations. Integration of Configuration and Materials 1. Engineering Material Simulation o Use computer-aided tools to simulate the behavior of materials in engineering systems during Sci-Bono workshops. Measure student learning outcomes in configuration. 2. Digital Training Modules o Incorporate digital modules for configuring electrical systems into NATED programs. Compare skill retention rates between traditional and digital learning approaches. 3. Sustainable Material Practices o Pilot an NCV curriculum focused on integrating sustainable materials into engineering projects. Evaluate learner understanding of eco-friendly design. Integral and derived calculations can provide meaningful insights into the Sci-Bono workshops, Kheta career tools, and DHET's NATED and NCV programs, especially when addressing engineering configuration and materials. Let's explore integral and derived calculations applied to these contexts: Integral Calculations in Engineering and Education 1. Engineering Material Efficiency in Workshops • Calculation: $$\text{Material Efficiency} = \frac{\int_{t_1}^{t_2} \text{Material Usage}{optimal}(t) \, dt}{\int{t_1}^{t_2} \text{Material Usage}_{actual}(t) \, dt}$$ o Application: Sci-Bono workshops can use this integral to teach learners how to optimize material usage in engineering designs. 2. Energy Consumption in Configuration Exercises • Calculation: $$\text{Energy Consumed} = \int_{t_1}^{t_2} P(t) \, dt$$ o P(t)P(t): Power usage of electrical configurations over time. o Application: Helps learners in NATED programs understand the total energy requirements of different system setups during practical sessions. 3. Success Metrics for Career Tools • Calculation: $$\text{Career Match Score} = \int_{t_1}^{t_2} \big(\text{Student Interest}(t) \cdot \text{Skill Alignment}(t)\big) \, dt$$ o Application: Kheta can use this formula to assess how well their career tools align with learners' aspirations and labor market demands. Derived Calculations in Engineering Systems 1. Thermal Management in Electrical Systems • Key Derivation: $$Q = \int_{t_1}^{t_2} I^2(t) \cdot R \, dt$$ o QQ: Heat generated in a circuit. o Application: Learners in NCV programs can calculate heat dissipation to design safer electrical systems. 2. Load Analysis in Material Simulation • Key Derivation: $$\text{Stress} = \frac{\int F(t) \, dt}{A}$$ o F(t)F(t): Force applied over time. o AA: Cross-sectional area of the material. o Application: Used in Sci-Bono material configuration exercises to teach stress analysis in engineering. Experimental Focus Areas Incorporating Integrals Sci-Bono Workshops: 1. Engineering Material Simulation o Experiment: Evaluate how learners apply simulation results to real-world configurations. o Calculation: $$\text{Error Rate} = \int_{t_1}^{t_2} \big| \text{Simulated Outcome}(t) - \text{Actual Outcome}(t) \big| \, dt$$ 2. Energy Optimization in Electrical Circuits o Experiment: Compare energy consumption in traditional vs. optimized configurations designed during workshops. o Calculation: $$\text{Energy Saved} = \int_{t_1}^{t_2} \big(P_{traditional}(t) - P_{optimized}(t)\big) \, dt$$ Kheta Career Tools: 3. Effectiveness of Digital Career Guidance o Experiment: Assess how Kheta's career tools improve learner decision-making. o Calculation: $$\text{Decision Accuracy} = \int_{t_1}^{t_2} \frac{\text{Correct Career Matches}}{\text{Total Recommendations}} \, dt$$ NATED and NCV Programs 1. Practical Skills Retention • Experiment: Study retention rates of learners exposed to simulation software versus hands-on training. • Calculation: $$\text{Skill Retention} = \int_{t_1}^{t_2} \text{Learner Performance}(t) \, dt$$ 2. Material Sustainability Practices • Experiment: Pilot sustainable material use in engineering curricula and measure its impact. • Calculation: $$\text{Sustainability Index} = \frac{\int_{t_1}^{t_2} \text{Eco-friendly Material Usage}(t) \, dt}{\int_{t_1}^{t_2} \text{Total Material Usage}(t) \, dt}$$ Integrals and derived equations provide measurable insights into the design, optimization, and educational outcomes of Sci-Bono and Kheta initiatives while enhancing the career preparedness offered by DHET's NATED and NCV programs. Let me know if you'd like to refine these concepts further! 1.24.1 The synergy between Kheta career tools, DHET's NATED and NCV programs, and entities such as SETA (Sector Education and Training Authorities), MERSETA (Manufacturing, Engineering and Related Services SETA), SASSETA (Safety and Security Sector Education and Training Authority), INSETA (Insurance Sector Education and Training Authority), and SAQA (South African Qualifications Authority) fosters an ecosystem of skill development and career growth. Here's an overview and experimental topics that explore their impact and potential: Background on Kheta, DHET, NATED and NCV, and Related Entities 1. Kheta Career Tools: o An innovative digital platform providing career guidance to South African students. o Offers tools for understanding pathways within NATED and NCV programs and aligning skills with industry demands. o Plays a key role in supporting learners as they navigate their educational and career journeys. 2. DHET (Department of Higher Education and Training): o Oversees post-school education and skill development programs, including TVET colleges offering NATED (N1-N6) and NCV (levels 2-4) qualifications. o NATED focuses on integrating theoretical knowledge and practical training, while NCV provides a vocational alternative to traditional schooling. 3. SETA (Sector Education and Training Authorities): o SETAs are mandated to promote skills development in specific sectors, often funding bursaries and workplace-based learning initiatives. o Examples include: ▪ MERSETA: Focuses on manufacturing, engineering, and related services sectors. ▪ SASSETA: Dedicated to safety and security training, preparing individuals for careers in policing, security, and justice. ▪ INSETA: Supports skills in the insurance and related financial services sector. 4. SAQA (South African Qualifications Authority): o Ensures the quality and standardization of qualifications under the National Qualifications Framework (NQF). o Works with DHET, SETAs, and industry stakeholders to align education with occupational and professional needs. Experimental Topics Kheta Career Tools and Digital Guidance 1. Effectiveness of Career Path Tools o Experiment: Study how Kheta's digital career tools influence career choices among NATED and NCV learners. o Focus: Compare alignment between chosen qualifications and market demands across Kheta users and non-users. 2. Role of Kheta in Sector-Specific Skills Development o Experiment: Assess Kheta's role in promoting SETA-funded skills initiatives, such as MERSETA apprenticeships or SASSETA bursaries. o Focus: Track participation rates in vocational careers linked to platform guidance. NATED and NCV Programs 3. Practical Skill Development in NATED Programs o Experiment: Investigate how workplace-based learning impacts career readiness for NATED learners in fields like electrical engineering or business management. o Focus: Compare post-graduation employment rates across programs. 4. Adaptability of NCV Graduates in Emerging Industries o Experiment: Evaluate the adaptability of NCV graduates to renewable energy, AI-enabled systems, or other future-forward industries. o Focus: Analyze graduates' performance in non-traditional sectors. SETA-Funded Training and Impact 5. Alignment of SETA-Funded Programs with Industry Needs o Experiment: Study how SETA-funded programs under MERSETA or SASSETA align with current labor market demands. o Focus: Measure the retention and success rates of program graduates in their respective fields. 6. Impact of Workplace-Based Learning on Career Outcomes o Experiment: Analyze the role of workplace training opportunities facilitated by SETAs in improving long-term career stability and earnings. o Focus: Compare outcomes between participants in SETA apprenticeships and classroom-only learning. SAQA-Accredited Qualifications 7. Quality Assurance in Vocational Education o Experiment: Examine how SAQA's standards influence the effectiveness of NATED and NCV qualifications. o Focus: Compare learner achievement and employer satisfaction across SAQA-accredited programs. Innovative Integrations and Opportunities 1. Digital Training Modules Across Sectors o Develop modules combining Kheta's career resources with MERSETA or SASSETA training opportunities. Test their impact on career readiness. 2. Sustainable Practices in Engineering Programs o Pilot green engineering curricula in NATED and NCV programs. Analyze graduate readiness for roles in renewable industries. 3. Cross-SETA Collaboration o Study the impact of integrating expertise across MERSETA, SASSETA, and INSETA for multidisciplinary skills development. ntegrals and derived calculations play a key role in exploring the applications of Kheta, DHET's NATED and NCV programs, and SETA initiatives, particularly in the field of electrical engineering. Below are experimentally driven calculations tailored to these areas: Integral Calculations for Electrical Engineering Applications 1. Practical Skill Development in NATED Programs • Calculation: Energy consumption during practical exercises. $$\text{Energy Consumed} = \int_{t_1}^{t_2} P(t) \, dt$$ o P(t)P(t): Power utilized by equipment during hands-on training. o Application: Evaluates energy efficiency in electrical systems created by NATED learners. 2. Load Balancing in Electrical Circuits • Calculation: $$\text{Total Load} = \int_{t_1}^{t_2} I(t) \, dt$$ o I(t)I(t): Current over time. o Application: Helps learners understand electrical load distribution in circuits, fostering practical configuration skills. 3. Thermal Management in Electrical Components • Calculation: Heat dissipation in components. $$Q = \int_{t_1}^{t_2} I^2(t) \cdot R \, dt$$ o I(t)I(t): Current. o RR: Resistance. o Application: Prepares students to design systems that prevent overheating in electrical circuits. Derived Equations in Engineering Training 1. Renewable Energy System Simulation for NCV Graduates • Derived Formula: Efficiency of solar panels. $$\text{Efficiency} = \frac{\int_{t_1}^{t_2} P_{output}(t) \, dt}{\int_{t_1}^{t_2} P_{input}(t) \, dt}$$ o Application: NCV programs can use this derivation to train learners on optimizing renewable energy systems. 2. Fault Current Calculations for Safety Training • Derived Formula: $$I_{fault} = \frac{V_{source}}{Z_{system}}$$ o VsourceV_{source}: Voltage. o ZsystemZ_{system}: System impedance. o Application: Used to teach safety and fault detection in SASSETA-accredited programs. 3. Stress Testing in Material Configuration • Derived Formula: Stress in load-bearing materials. $$\sigma = \frac{F}{A}$$ o FF: Force. o AA: Cross-sectional area. o Application: MERSETA learners can apply this in projects involving mechanical and electrical materials. Experimental Topics Using Calculations 1. Effectiveness of Practical Configurations in NATED • Experiment: Test practical designs created by learners against theoretical models for accuracy. • Calculation: Compare actual and simulated energy consumption: $$\text{Error} = \int_{t_1}^{t_2} \big| P_{simulated}(t) - P_{actual}(t) \big| \, dt$$ 2. Alignment of SETA-Funded Training with Industry Needs • Experiment: Evaluate workplace systems designed by MERSETA trainees. • Focus: Measure load distribution accuracy and system longevity based on given configurations. 3. Adaptability to Emerging Fields in NCV Programs • Experiment: Analyze graduates' ability to apply configurations to IoT-enabled systems. • Calculation: Measure response times and energy savings in smart circuits: $$\text{Optimization Ratio} = \frac{\int_{t_1}^{t_2} \text{Output Energy Efficiency}(t) \, dt}{\int_{t_1}^{t_2} \text{Input Energy}(t) \, dt}$$ 1.25.1 The connection between DHET (Department of Higher Education and Training), NATED and NCV programs, the DTIC (Department of Trade, Industry, and Competition) Council, engineering education, and QCTO (Quality Council for Trades and Occupations) offers a robust framework for skills development and career readiness in South Africa. Here's a detailed background and experimental topic ideas to explore their impact: Background 1. DHET and TVET Education: o DHET oversees technical and vocational education across TVET colleges. o NATED (National Accredited Technical Education Diploma): Provides a pathway for theoretical and practical training in fields like electrical and mechanical engineering. Levels N1-N6 prepare learners for industry or further education. o NCV (National Certificate Vocational): Offers vocational training for Grades 10–12 with a focus on practical and technical skills in industries like engineering, IT, and business. 2. DTIC Council: o The DTIC promotes industrial growth, investment, and innovation in South Africa. o Collaboration with DHET focuses on aligning education programs with the needs of the labor market, particularly in high-growth engineering sectors. 3. Engineering and Skills Development: o Engineering training through NATED and NCV emphasizes design, configuration, and maintenance of systems in mechanical, civil, and electrical fields. o The DTIC supports initiatives in advanced manufacturing, renewable energy, and industrial automation. 4. QCTO (Quality Council for Trades and Occupations): o Ensures occupational qualifications are competency-based and aligned with job-specific requirements. o Plays a pivotal role in developing engineering-related qualifications that meet industry standards. Experimental Topics NATED and NCV Programs 1. Workplace Readiness in NATED Engineering Programs o Experiment: Evaluate how NATED engineering graduates perform in real-world industrial settings. o Focus: Measure adaptation to workplace challenges and skill application compared to classroom-only learners. 2. Adaptability of NCV Graduates o Experiment: Investigate how NCV graduates transition to emerging fields like renewable energy or industrial automation. o Focus: Track their ability to implement new technologies and processes. DTIC-Aligned Engineering Innovations 3. Impact of Industry Partnerships on Engineering Training o Experiment: Assess how DTIC-supported partnerships (e.g., in renewable energy or advanced manufacturing) enhance engineering training programs. o Focus: Measure learner proficiency in skills critical for industrial innovation. 4. STEM Awareness Initiatives by DTIC and DHET o Experiment: Study the effectiveness of STEM campaigns in increasing enrollment in engineering programs. o Focus: Compare pre- and post-campaign participation in technical fields. QCTO Occupational Qualifications 5. Competency-Based Learning Effectiveness o Experiment: Analyze the success of QCTO-accredited engineering qualifications in equipping learners with job-specific skills. o Focus: Compare competency levels of learners trained through QCTO frameworks versus traditional approaches. 6. Industry Integration of QCTO Graduates o Experiment: Investigate how QCTO graduates contribute to critical industries like renewable energy or transportation. o Focus: Measure their impact on productivity and innovation in their workplaces. Innovative Ideas for Exploration 1. Digital Modules for Engineering Training: o Develop online simulations for engineering learners in NATED and NCV programs, focusing on system configuration and maintenance. o Experiment with retention and skill application in virtual training versus hands-on workshops. 2. Sustainable Materials in Engineering Projects: o Pilot eco-friendly engineering curricula with DTIC support, integrating renewable energy and sustainable practices. o Evaluate graduate readiness for green economy jobs. 3. Cross-Institution Collaboration: o Foster cooperation between DHET, DTIC, and QCTO to streamline engineering qualifications. o Experiment with programs that integrate advanced technologies such as robotics or IoT. Material configuration, system sizing, and integral calculations can significantly enhance experimental approaches within the outlined framework of NATED and NCV programs, DTIC-aligned initiatives, and QCTO occupational qualifications. Here's a detailed breakdown of how calculations contribute to these experiments: Integral Calculations for Engineering Experiments 1. Workplace Readiness in NATED Programs • Key Calculation: Energy use in industrial scenarios for graduate assessments. $$\text{Energy Consumed} = \int_{t_1}^{t_2} P(t) \, dt$$ o P(t)P(t): Power consumption of equipment during operations. o Application: Evaluates how efficiently NATED graduates design and operate electrical systems in real-world settings. • Key Calculation: Load distribution in circuit configurations: $$\text{Total Load} = \int_{t_1}^{t_2} I(t) \, dt$$ o I(t)I(t): Current flow over time. o Application: Assesses learners' proficiency in designing balanced and efficient circuits. 2. Adaptability of NCV Graduates • Key Calculation: Renewable energy output optimization: $$\text{Efficiency} = \frac{\int_{t_1}^{t_2} P_{output}(t) \, dt}{\int_{t_1}^{t_2} P_{input}(t) \, dt}$$ o Poutput(t)P_{output}(t): Generated energy. o Pinput(t)P_{input}(t): Total energy supplied. o Application: Tracks how well graduates adapt their skills to emerging technologies like solar or wind power systems. 3. STEM Awareness and Industry Partnerships • Key Calculation: Enrollment growth rate in STEM programs: $$\text{Growth Rate} = \int_{t_1}^{t_2} \frac{\text{Enrollment}{post}(t) - \text{Enrollment}{pre}(t)}{\text{Time}} \, dt$$ o Application: Quantifies the impact of DTIC-supported campaigns on increasing STEM participation. Derived Calculations in Electrical Configuration 1. Thermal Management in Component Sizing • Formula Derivation: Heat dissipation in electrical systems: $$Q = \int_{t_1}^{t_2} I^2(t) \cdot R \, dt$$ o I(t)I(t): Current, RR: Resistance. o Application: Helps learners size components like heat sinks to ensure safe and efficient operations. 2. Load Stress Analysis in Mechanical Design • Derived Formula: Stress in materials: $$\sigma = \frac{F}{A}$$ o FF: Force applied. o AA: Cross-sectional area. o Application: MERSETA apprenticeships can use this formula for structural engineering and load-bearing studies. 3. Fault Current Evaluation • Formula Derivation: Fault current in circuits: $$I_{fault} = \frac{V_{source}}{Z_{system}}$$ o VsourceV_{source}: Source voltage, ZsystemZ_{system}: Impedance. o Application: SASSETA learners practice detecting and mitigating faults in safety-critical systems. Experimental Topics and Applications Digital Modules for Engineering Training • Experiment: Compare virtual learning outcomes with hands-on workshops. • Calculation: Learner performance metrics: $$\text{Performance Index} = \int_{t_1}^{t_2} \text{Task Completion}(t) \, dt$$ Sustainable Materials in Engineering Projects • Experiment: Test eco-friendly materials in NATED or NCV curricula. • Calculation: Material efficiency ratio: $$\text{Efficiency Ratio} = \frac{\int_{t_1}^{t_2} \text{Eco-friendly Output}(t) \, dt}{\int_{t_1}^{t_2} \text{Material Input}(t) \, dt}$$ Industry Integration of QCTO Graduates • Experiment: Measure productivity improvements from QCTO-accredited professionals. • Calculation: Impact analysis: $$\text{Productivity Gain} = \int_{t_1}^{t_2} \frac{\text{Output}{improved}(t) - \text{Output}{baseline}(t)}{\text{Time}} \, dt$$ 1.26.1 e intersection of DHET's (Department of Higher Education and Training) NATED programs, UCPD (Unit for Continuing Professional Development), DTIC (Department of Trade, Industry, and Competition), DTS (Department of Transport Services) regulations, and South Africa's energy sector—including City Power and Eskom—offers innovative opportunities for skills development, education, and operational improvement. Here's a structured breakdown and experimental topics for exploration: Background 1. DHET and NATED Programs: o NATED qualifications (N1-N6) provide technical education aimed at equipping students with theoretical and practical skills in fields like electrical engineering, mechanical engineering, and energy systems. o These programs prepare learners for industries such as construction, manufacturing, and renewable energy. 2. UCPD (Unit for Continuing Professional Development): o UCPD supports ongoing skill enhancement for professionals in sectors like energy and engineering. o Focuses on upskilling and reskilling to meet evolving industry demands, often integrating advanced technologies like IoT and AI. 3. DTIC (Department of Trade, Industry, and Competition): o Promotes industrial growth, investment, and technological innovation. o Works closely with energy stakeholders, such as Eskom and City Power, to advance sustainable energy solutions. 4. DTS (Department of Transport Services) Regulations: o Oversees transportation systems and their integration with energy networks, including electric vehicles (EVs) and smart grids. o Energy regulations impact compliance and efficiency in transportation-related projects. 5. City Power and Eskom (Energy Sector): o City Power: Responsible for electricity distribution in Johannesburg, focusing on reliability and energy efficiency. o Eskom: South Africa's primary electricity supplier, involved in generation, transmission, and distribution, with an emphasis on managing load shedding and transitioning to renewable energy. Experimental Topics DHET and NATED Programs 1. Impact of Practical Training in Energy Systems o Experiment: Assess how practical modules in NATED programs enhance skills for energy-sector careers. o Focus: Compare learner performance in renewable energy roles versus traditional power system roles. 2. Integration of Smart Technologies in Education o Experiment: Investigate the use of IoT-enabled labs for training NATED electrical engineering students. o Focus: Measure outcomes in system configuration and troubleshooting exercises. UCPD and Continuing Development 3. Effectiveness of Professional Development for Energy Sector o Experiment: Track how UCPD training programs improve operational efficiency in energy roles. o Focus: Measure skills retention and application in workplace scenarios. 4. Upskilling Professionals for Renewable Energy Transition o Experiment: Evaluate how continuing education programs prepare energy professionals for roles in solar, wind, or other sustainable energy projects. o Focus: Analyze learner adaptability to new technologies. DTIC and DTS Regulations 5. Industrial Growth Through Energy Partnerships o Experiment: Assess the impact of DTIC's collaborations with Eskom on industrial energy optimization. o Focus: Track energy efficiency improvements in manufacturing facilities. 6. Compliance Training for Transport Systems o Experiment: Study the effectiveness of DTS regulations in energy-efficient transport initiatives like EV adoption. o Focus: Measure awareness and adherence among energy professionals. City Power and Eskom Experimental Topics 7. Energy Load Analysis for Reliability o Experiment: Simulate load distribution scenarios to optimize City Power's electricity network. o Focus: Measure impacts on reliability during peak demand. 8. Renewable Energy Integration with Eskom's Grid o Experiment: Analyze the integration of wind and solar energy into Eskom's national grid. o Focus: Compare power stability and efficiency before and after renewable energy integration. Innovative Ideas for Exploration 1. Digital Modules for NATED Programs: o Develop online modules focusing on smart grids and IoT applications for engineering learners. Compare hands-on vs. digital training impacts. 2. Energy Transition Research: o Collaborate between UCPD and Eskom to design sustainable power management courses for professionals transitioning into green energy roles. 3. Cross-Departmental Collaboration: o Foster partnerships between DHET, DTIC, and DTS to create integrated training programs emphasizing renewable energy's impact on transport systems. 1.27.1 e intersection of DHET's NATED programs, UCPD, DTIC, DTS regulations, and South Africa's energy sector (including City Power and Eskom) provides opportunities for advancing engineering education, skills development, and energy-sector innovations. Below, I outline applicable calculations and configuration concepts for experimental topics: Integral and Derived Calculations for Engineering and Energy Applications 1. Impact of Practical Training in Energy Systems (NATED Programs) • Calculation: Energy consumption during practical sessions. $$\text{Energy Consumed} = \int_{t_1}^{t_2} P(t) \, dt$$ o P(t)P(t): Power used by training systems over time. o Application: Helps assess how efficiently learners operate and configure electrical systems during NATED modules. • Calculation: Load balancing in training simulations: $$\text{Total Load} = \int_{t_1}^{t_2} I(t) \, dt$$ o I(t)I(t): Current flowing through the circuit. o Application: Evaluates proficiency in designing systems to prevent overloading or inefficiencies. 2. Integration of Smart Technologies (IoT in Education) • Calculation: Data transfer efficiency in IoT-based labs: $$\text{Efficiency} = \frac{\int_{t_1}^{t_2} \text{Successful Data Transmissions}(t) \, dt}{\int_{t_1}^{t_2} \text{Total Data Transmissions}(t) \, dt}$$ o Application: Measures the effectiveness of IoT-enabled labs in simulating real-world system troubleshooting for learners. 3. Renewable Energy Transition (UCPD Programs) • Calculation: Renewable energy system efficiency. $$\text{Efficiency} = \frac{\int_{t_1}^{t_2} P_{output}(t) \, dt}{\int_{t_1}^{t_2} P_{input}(t) \, dt}$$ o PoutputP_{output}: Energy delivered by the system. o PinputP_{input}: Total energy supplied. o Application: Assesses learners' abilities to configure energy systems for maximum sustainability. 4. Energy Load Analysis for City Power • Calculation: Peak load during demand cycles: $$\text{Peak Load} = \max \left(\int_{t_1}^{t_2} I(t) \cdot V(t) \, dt \right)$$ o I(t)I(t): Current, V(t)V(t): Voltage. o Application: Helps City Power optimize grid performance under varying load conditions. 5. Renewable Energy Integration with Eskom's Grid • Calculation: Stability of integrated renewable sources. $$\text{Stability Index} = \frac{\int_{t_1}^{t_2} P_{renewable}(t) \, dt}{\int_{t_1}^{t_2} P_{total}(t) \, dt}$$ o Application: Evaluates the ratio of renewable energy contributions to overall grid stability. Experimental Topics Using Electrical Configurations 1. Load Distribution Simulations • Experiment: Simulate load management strategies for City Power's distribution network. • Focus: Compare configurations that minimize energy losses during peak periods. 2. IoT-Enabled Fault Detection • Experiment: Develop IoT-based fault detection systems for use in NATED training labs. • Focus: Track how quickly learners identify and resolve faults using real-time data. 3. Workforce Upskilling for Sustainable Energy • Experiment: Evaluate the effectiveness of UCPD courses on solar panel installation and wind turbine maintenance. • Focus: Measure learner adaptability to renewable energy technologies versus traditional systems. Innovative Collaborative Opportunities 1. Digital Training Modules for Energy Regulations • Develop digital content integrating DTS compliance standards for energy-efficient transport systems (e.g., electric vehicles). • Experiment with learner outcomes in understanding regulatory applications. 2. Advanced Material Applications • Pilot the use of sustainable materials in NATED and UCPD courses, focusing on energy systems such as battery enclosures and smart meters. 3. Multi-Agency Energy Curriculum • Coordinate with DHET, DTIC, and Eskom to develop an interdisciplinary energy curriculum. • Include modules on IoT, renewable energy configuration, and grid management simulations. Integral Calculations for Engineering and Energy Applications 1. Impact of Practical Training in Energy Systems (NATED Programs) • Energy Consumption: $$\text{Energy Consumed} = \int_{t_1}^{t_2} P(t) \, dt$$ o Explanation: Measures how efficiently NATED learners configure electrical systems during hands-on training. P(t)P(t) represents the power used by equipment over time. • Load Balancing in Electrical Circuits: $$\text{Total Load} = \int_{t_1}^{t_2} I(t) \, dt$$ o Explanation: Assesses learners' ability to design balanced systems that prevent overloads. I(t)I(t) is the current passing through the circuit. 2. Integration of Smart Technologies (IoT in Education) • Data Transfer Efficiency in IoT Labs: $$\text{Efficiency} = \frac{\int_{t_1}^{t_2} \text{Successful Data Transmissions}(t) \, dt}{\int_{t_1}^{t_2} \text{Total Data Transmissions}(t) \, dt}$$ o Explanation: Evaluates the quality of real-time data management systems used in training labs. 3. Renewable Energy Transition (UCPD Programs) • Efficiency of Renewable Energy Systems: $$\text{Efficiency} = \frac{\int_{t_1}^{t_2} P_{output}(t) \, dt}{\int_{t_1}^{t_2} P_{input}(t) \, dt}$$ o Explanation: Measures performance in training scenarios focused on renewable energy optimization. Poutput(t)P_{output}(t) is the energy delivered; Pinput(t)P_{input}(t) is the energy supplied. 4. Energy Load Analysis (City Power) • Peak Load Calculation: $$\text{Peak Load} = \max \left(\int_{t_1}^{t_2} I(t) \cdot V(t) \, dt \right)$$ o Explanation: Optimizes load distribution in City Power's grid during demand spikes. I(t)I(t) and V(t)V(t) denote current and voltage. 5. Renewable Energy Integration (Eskom's Grid) • Stability of Integrated Energy Sources: $$\text{Stability Index} = \frac{\int_{t_1}^{t_2} P_{renewable}(t) \, dt}{\int_{t_1}^{t_2} P_{total}(t) \, dt}$$ o Explanation: Tracks how renewable sources contribute to overall power grid stability. Experimental Topics for Energy and Educational Systems 1. Load Management Strategies (City Power) • Experiment: Simulate load distribution to optimize energy use and minimize losses during peak times. • Focus: Compare configurations involving renewable and non-renewable inputs. 2. IoT-Driven Fault Detection Systems • Experiment: Develop IoT applications for detecting faults in NATED electrical engineering labs. • Focus: Test learners' response times and the accuracy of system diagnostics. 3. Renewable Energy Skill Development (UCPD) • Experiment: Evaluate UCPD participants' adaptability in handling photovoltaic systems and wind turbines. • Focus: Track skill application and efficiency improvements. 4. Sustainable Material Integration in Curricula • Experiment: Test new eco-friendly materials in NATED energy systems projects. • Focus: Measure system efficiency and graduate readiness to support sustainable energy initiatives. Innovative Collaborative Opportunities 1. Digital Training Modules • Design online modules for understanding DTS regulations on energy-efficient transport (e.g., EV systems). Analyze learners' regulatory knowledge retention. 2. Cross-Agency Curriculum Development • Collaborate between DHET, DTIC, and Eskom to create interdisciplinary programs emphasizing renewable energy and smart grid configurations. 3. Advanced IoT Configurations • Integrate IoT data analytics into City Power and Eskom training programs to enhance grid monitoring efficiency. 1.29. Integrating insights from DHET's NATED programs, SARS (South African Revenue Service), and SARB (South African Reserve Bank) provides a unique lens for exploring education, compliance, and economic stability. Below is a structured background and experimental topics to align these entities effectively: Background DHET (Department of Higher Education and Training): • Manages NATED programs (N1-N6) and NCV qualifications, emphasizing theoretical and practical skills in fields like engineering, business management, and IT. • Designed to prepare learners for professional roles and further education, ensuring workforce readiness. SARS (South African Revenue Service): • Responsible for collecting revenue to fund public services and ensure compliance with tax laws. • Collaborates with educational bodies to promote tax literacy among students and professionals. SARB (South African Reserve Bank): • Focuses on monetary policy, economic stability, and financial regulation in South Africa. • Plays a role in educating individuals on financial planning, currency stability, and economic impacts on trade. Experimental Topics 1. DHET and NATED Programs 1. Economic Literacy in NATED Curriculums o Experiment: Integrate basic financial principles and tax literacy into NATED programs. o Focus: Study student understanding of SARS regulations and their relevance to career pathways. 2. NATED Graduates in Financial Roles o Experiment: Assess career success of NATED graduates in fields requiring financial acumen, such as banking or government compliance. o Focus: Compare graduate outcomes in traditional technical roles vs financial roles. 2. Collaboration with SARS 3. Tax Education Workshops for Vocational Students o Experiment: Pilot workshops on tax laws and compliance for NATED students. o Focus: Measure awareness levels and their application in workplace scenarios. 4. SARS Impact on Startup Growth o Experiment: Evaluate the role of tax incentives in the career choices of NATED graduates starting their own businesses. o Focus: Study business survival rates and alignment with tax compliance. 3. SARB and Economic Training 5. Monetary Policy Awareness Among DHET Learners o Experiment: Develop educational modules on SARB's role in managing inflation and economic stability. o Focus: Assess how knowledge of monetary policy affects career choices in financial trades or industries. 6. Financial Management Integration o Experiment: Incorporate SARB-driven financial planning skills into vocational programs. o Focus: Track learner proficiency in managing personal and business finances. Innovative Collaborative Opportunities 1. Financial Literacy Certifications: o Partner with SARS and SARB to offer specialized certifications for students in DHET programs. 2. Cross-Sector Career Alignment: o Collaborate with both SARS and SARB to align NATED curricula with emerging economic and financial career trends. 3. Digital Tax and Financial Simulations: o Introduce virtual tools to simulate tax filing, financial management, and economic planning for students. • o 2. Electrical System Data • Power Consumption in Operational Phases: $$\text{Total Energy Used} = \int_{t_1}^{t_2} P(t) \, dt$$ o P(t)P(t): Power usage at time tt. o Application: Calculates energy efficiency for electrical setups supporting banking machines and other equipment. • Heat Dissipation in Circuits: $$Q = I^2 R t$$ o II: Current; RR: Resistance; tt: Time. o Application: Prevents overheating in circuits linked to banking machines. 3. Tax and Economic Modules Integration • Tax Compliance Simulation: $$\text{Tax Revenue} = \int_{t_1}^{t_2} \text{Income}(t) \cdot \text{Tax Rate}(t) \, dt$$ o Application: Educates learners on how tax systems impact machine production costs and revenue projections. • Inflation and Currency Impact Simulation: $$\text{Currency Devaluation} = \frac{\Delta P}{P_{initial}}$$ o PinitialP_{initial}: Initial purchasing power; ΔP\Delta P: Change in purchasing power. o Application: Integrates SARB data for learners exploring monetary stability. Experimental Topics Machine Configuration and Electrical Engineering 1. Energy Optimization for Bank Note Machines o Experiment: Test configurations minimizing power usage while maintaining production rates. o Focus: Reduce costs associated with machine operation. 2. IoT Integration for Monitoring Machine Efficiency o Experiment: Apply IoT sensors to track machine performance and maintenance schedules. o Focus: Improve system reliability through real-time monitoring. Economic and Tax Awareness 3. Economic Modules in Vocational Curriculums o Experiment: Integrate SARB-driven financial concepts into DHET programs, such as inflation and currency management. o Focus: Enhance student understanding of monetary impacts on trade and production. 4. SARS Tax Simulation Tools o Experiment: Introduce interactive tools for vocational students to learn about tax compliance in business operations. o Focus: Educate learners on balancing operational costs and legal obligations. Innovative Opportunities 1. Collaborative Development: o Work with SARS and SARB to create cross-sector projects for students using real-world banking machine data. 2. Sustainable Energy Systems: o Partner with Eskom and City Power to integrate renewable solutions into banking machine operations. 3. Digital Learning Platforms: o Use simulations and AI to model banking machine productivity and financial impacts for learners. The integration of banknote processing machines, robotics, printers, ATMs, and tax and teller systems combines engineering and financial concepts to improve efficiency, compliance, and user experience. Below is a detailed breakdown of integral and derived calculations, configuration considerations, and their relevance to SARB (South African Reserve Bank) and SARS (South African Revenue Service): Integral and Derived Calculations in Machine Configuration 1. Banknote Processing Machines • Material Throughput: $$\text{Throughput Rate} = \int_{t_1}^{t_2} \text{Notes Processed}(t) \, dt$$ o Application: Optimizes the speed and capacity of machines for handling large volumes of banknotes without jamming. • Error Detection: $$\text{Error Rate} = \frac{\int_{t_1}^{t_2} \text{Faulty Notes}(t) \, dt}{\int_{t_1}^{t_2} \text{Total Notes Processed}(t) \, dt}$$ o Application: Improves the accuracy of note scanning systems for counterfeit detection and damaged notes. 2. Robotic Integration in Printers and ATMs • Load Balancing for Robotic Arms: $$\text{Torque} = r \times F$$ o rr: Distance from the pivot point; FF: Force applied by robotic actuators. o Application: Ensures precise handling of banknotes in printers and ATMs, preventing mechanical failures. • Energy Efficiency in Robotics: $$\text{Energy Consumed} = \int_{t_1}^{t_2} P(t) \, dt$$ o P(t)P(t): Power consumption over time. o Application: Tracks energy usage to optimize robotic efficiency and reduce operational costs. 3. ATMs and Tax Systems • Cash Dispensation: $$\text{Cash Dispensed} = \int_{t_1}^{t_2} \text{Dispensation Rate}(t) \, dt$$ o Application: Ensures the smooth functioning of ATMs, balancing speed and accuracy in cash delivery. • Transaction Tax Calculation (for SARS Compliance): $$ \text{Tax Amount} = \int_{t_1}^{t_2} \text{Transaction Volume}(t) \cdot \text{Tax Rate}(t) \, dt$$ o Application: Helps track tax collection in systems where ATM withdrawals or payments are taxable. System Configuration and Optimization 1. Machine Calibration • Printer Configuration for Banknotes: o Adjustments must consider: ▪ Ink Distribution: Consistent ink application for clarity. ▪ Material Alignment: Proper positioning of banknote sheets to prevent misprints. • Robotics in Sorting Machines: o Ensure robots are calibrated to detect: ▪ Counterfeits based on weight and size. ▪ Folding or damage that could affect usability. 2. ATM and Teller Machine Configuration • Load Distribution in Cash Storage: $$ \text{Load per Compartment} = \frac{\text{Total Cash Stored}}{\text{Number of Compartments}}$$ o Application: Prevents overloading and ensures smooth dispensing. Experimental Topics 1. Efficiency of SARB-Approved Banking Machines o Experiment: Study the processing speeds of SARB-certified banknote systems. o Focus: Analyze error rates, throughput, and energy consumption. 2. Robotic Integration in Financial Automation o Experiment: Use robotics to automate tax document handling in SARS offices. o Focus: Measure time savings and accuracy improvements. 3. Real-Time Tax Deduction via ATMs o Experiment: Pilot ATMs that directly calculate and deduct transaction taxes. o Focus: Ensure compliance with SARS regulations while simplifying tax processes. Innovative Solutions 1. IoT Integration: o Monitor performance of banknote machines and ATMs remotely to predict malfunctions. 2. Blockchain in SARB Systems: o Use blockchain to track the lifecycle of banknotes, ensuring authenticity and preventing fraud. 3. Digital Tax Dashboards: o Ford Motoring Background 1. Industry Legacy: o Credited with introducing the assembly line concept, which revolutionized production efficiency. o Specializes in manufacturing cars, trucks, SUVs, and commercial vehicles, focusing on performance, safety, and sustainability. 2. Current Innovations: o Known for advancements in hybrid and electric vehicles, such as the Ford Mustang Mach-E and F-150 Lightning. o Implements smart technology, including AI-powered driving assistance, autonomous features, and fuel efficiency optimization. Calculation Topics for Ford Motoring 1. Fuel Efficiency • Calculation: Miles Per Gallon (MPG): $$\text{MPG} = \frac{\text{Total Distance Traveled (miles)}}{\text{Fuel Consumed (gallons)}}$$ o Application: Helps users determine fuel efficiency for cars like the Ford Focus or Explorer, aiding eco-conscious decision-making. 2. Engine Performance • Power Output: $$P = T \cdot \omega$$ o PP: Power (watts); TT: Torque (Newton-meters); ω\omega: Angular velocity (radians/second). o Application: Used to calculate the performance of Ford's engines, including turbocharged EcoBoost engines. 3. Vehicle Speed • Acceleration: $$a = \frac{\Delta v}{t}$$ o aa: Acceleration; Δv\Delta v: Change in velocity; tt: Time. o Application: Measures how quickly vehicles like the Ford Mustang GT can reach top speeds. 4. Electric Vehicle Range • Energy Consumption: $$ \text{Range} = \frac{\text{Battery Capacity (kWh)}}{\text{Energy Consumption (kWh per mile)}}$$ o Application: Calculates driving range for Ford's electric models like the Mustang Mach-E. 5. Emissions and Sustainability • Carbon Emissions: $$\text{Emissions} = \frac{\text{Fuel Consumption} \cdot \text{Emission Factor}}{\text{Distance Traveled}}$$ o Application: Tracks environmental impact, allowing Ford vehicles to meet emission standards. Experimental Topics 1. Hybrid Engine Efficiency: o Experiment: Study the energy-saving performance of Ford's hybrid engines under varied driving conditions. o Focus: Compare fuel consumption and electric assist rates to optimize hybrid configurations. 2. Aerodynamic Design Testing: o Experiment: Test different body shapes to reduce drag coefficients in vehicles like Ford's SUVs. o Focus: Improve fuel economy and performance through aerodynamic simulations. 3. Battery Longevity in Electric Models: o Experiment: Analyze battery degradation over time in Ford's EVs. o Focus: Evaluate performance improvements with advanced battery chemistry. caculation .. Transnet is South Africa's largest freight transportation and logistics company, operating ports, rail networks, pipelines, and related infrastructure. Exploring career opportunities within Transnet alongside configuration calculations provides a solid foundation for professional growth in engineering, operations, and business development. Background on Transnet 1. Company Overview: o Specializes in freight logistics across sectors like rail, maritime ports, and pipelines. o Plays a key role in driving South Africa's economic growth and connecting industries to global markets. 2. Career Opportunities at Transnet: o Offers positions in engineering, logistics management, operations, and business strategy. o Encourages professional development through skills training programs, apprenticeships, and leadership initiatives. 3. Focus Areas in Engineering: o Key roles include rail and port maintenance, pipeline design, and operational configuration. o Integrates advanced technologies like IoT and data analytics for process optimization. Calculation and Configuration Topics 1. Rail Network Optimization • Calculation: Load Capacity per Train: $$\text{Total Load Capacity} = \text{Number of Wagons} \cdot \text{Capacity per Wagon}$$ o Application: Ensures efficient freight transport, minimizing energy consumption while maximizing cargo loads. • Configuration: Rail Tracking Systems: o Equip locomotives and wagons with IoT sensors for real-time tracking of performance and freight condition. 2. Port Operations Configuration • Calculation: Container Storage Optimization: $$\text{Storage Efficiency} = \frac{\text{Containers Stored}}{\text{Available Space}}$$ o Application: Maximizes storage capacity in ports while ensuring smooth handling and unloading operations. • Configuration: Automated Cranes: o Integrate robotics and AI for efficient container movement, reducing manual labor and time delays. 3. Pipeline Design • Calculation: Flow Rate in Pipelines: $$Q = A \cdot v$$ o Where: □ QQ: Flow rate. □ AA: Cross-sectional area of the pipeline. □ vv: Velocity of the fluid. o Application: Ensures optimal transportation of liquids, balancing speed and safety. • Configuration: Leak Detection Systems: o Use sensor networks along pipelines to identify and address leaks instantly, preventing environmental damage. Experimental Career Development Topics 1. IoT-Enabled Freight Management • Experiment: Implement IoT sensors in rail networks and pipelines to monitor cargo conditions and optimize routes. • Focus: Track cost savings and operational efficiency improvements. 2. Sustainable Port Design • Experiment: Develop energy-efficient solutions in Transnet's ports, such as solar-powered cranes and green storage areas. • Focus: Measure reductions in carbon footprint and energy costs. 3. Career Pathways in Transnet • Experiment: Assess the impact of Transnet's apprenticeship programs on long-term employee performance. • Focus: Compare retention rates and career growth metrics across apprenticeships and traditional hiring pathways. Innovative Solutions for Transnet Careers 1. Digital Training Modules: o Offer simulation-based training for engineers to test rail and pipeline configurations virtually. 2. Data Analytics in Logistics: o Use AI-powered analytics to predict freight demand and optimize resource allocation. 3. Leadership Development: o Introduce leadership tracks for employees, focusing on innovation and sustainability in logistics management. background snel career electrical rate SNEL (Société Nationale d'Électricité), the national electricity company in the Democratic Republic of Congo, plays a crucial role in power generation, transmission, and distribution. Careers at SNEL offer a variety of opportunities, particularly in the electrical engineering field, as the organization focuses on expanding access to electricity and modernizing its infrastructure. Background on SNEL 1. Core Activities: o Responsible for producing and distributing electricity across urban and rural areas. o Operates hydroelectric plants, substations, and extensive transmission networks. 2. Electrical Career Opportunities: o Engineering Roles: Involve design, maintenance, and upgrade of electrical systems. o Technician Positions: Support operations such as grid stabilization, electrical repairs, and diagnostics. o Sustainable Energy Roles: Emerging focus on integrating renewable energy sources. 3. Modernization Goals: o SNEL is prioritizing infrastructure upgrades, offering career opportunities in smart grid technology, automation, and renewable energy integration. 4. Key Challenges: o Addressing electricity access disparities, improving grid reliability, and reducing transmission losses. Rate and Career Development in Electrical Roles 1. Electricity Tariff Calculations • Formula for Cost of Consumption: $$\text{Electricity Bill (Cost)} = \text{Rate per kWh} \cdot \text{Energy Consumed (kWh)}$$ o Application: Teaches professionals how to analyze and optimize consumer energy usage. 2. Load Flow in Electrical Systems • Power Flow Calculation: $$P = VI \cdot \cos(\phi)$$ o PP: Active power (watts), VV: Voltage, II: Current, cos(ϕ)\cos(\phi): Power factor. o Application: Used to assess system stability and improve efficiency in SNEL's distribution network. 3. Grid Loss Analysis • Energy Loss in Transmission Lines: $$\text{Power Loss (W)} = I^2 R$$ o II: Current in amps, RR: Resistance in ohms. o Application: Engineers at SNEL can monitor and address line losses to ensure optimal operation. Experimental Topics for Career Advancement 1. Renewable Energy

Integration o Experiment: Study the integration of solar or wind energy into SNEL's existing grid. o Focus: Analyze impacts on grid stability and reduction of operational costs. 2. Energy Efficiency Initiatives o Experiment: Develop programs to reduce energy losses during transmission. o Focus: Test new materials for transmission lines and transformers to improve efficiency. 3. Smart Grid Technology o Experiment: Implement IoT-based systems to monitor grid performance in real time. o Focus: Assess the impact of smart meters on consumer energy usage and billing accuracy. Career Opportunities and Training at SNEL 1. Technical and Vocational Training: o Focus on empowering technicians and engineers with hands-on skills in grid operations, renewable energy, and maintenance. 2. Leadership Pathways: o Opportunities for professionals to grow into managerial roles, focusing on sustainability and modernization projects. 3. International Collaborations: o Partnerships with global organizations for energy project funding and workforce training. The National Institute of Professional Preparation (INPP) is a vocational and technical training institution that plays a vital role in equipping individuals with practical skills for various industries, including motoring and automotive services. Below is an overview and experimental career development ideas in this field: Background on INPP and Motoring Services 1. Core Focus Areas: o Provides technical training in automotive repair, vehicle maintenance, and mechanical engineering. o Supports workforce readiness by aligning programs with industry demands. 2. Relevance to the Automotive Industry: o Develops skills critical for maintaining vehicles, diagnosing mechanical issues, and ensuring roadworthiness. o Trains professionals in emerging trends, such as electric vehicles (EVs) and hybrid technology. 3. Integration with Motoring Services: o Focuses on practical training for servicing vehicles in both public and private sectors. o Offers certifications in areas like diagnostics, electrical systems, engine repair, and emissions control. Experimental Career Topics in INPP and Motoring 1. Vehicle Diagnostics and Maintenance • Experiment: Compare the diagnostic accuracy of traditional methods vs IoT-enabled tools in training settings. • Focus: Identify how digital tools improve training outcomes and real-world servicing efficiency. 2. Hybrid and Electric Vehicle Training • Experiment: Integrate modules on hybrid and EV servicing into INPP’s curriculum. • Focus: Measure learner adaptability to emerging technologies and job market demands. 3. Fleet Maintenance Optimization • Experiment: Simulate fleet servicing scenarios to improve scheduling and resource allocation. • Focus: Analyze the impact of systematic maintenance practices on fleet downtime and operational costs. Innovative Approaches for Motoring Careers 1. Digital Learning Tools: o Utilize augmented reality (AR) and virtual reality (VR) platforms for interactive automotive training. o Test trainees’ ability to assemble and repair components in virtual environments. 2. Sustainable Motoring Practices: o Experiment with teaching sustainable practices such as waste oil recycling and eco-friendly vehicle tuning. o Monitor adoption rates and their effect on environmental compliance. 3. Specialized Certifications: o Develop short-term certification programs for areas like brake systems, suspension, or hybrid battery systems. o Analyze career growth metrics for participants completing these specialized modules. Calculation Applications for Automotive Training 1. Engine Performance Evaluation • Formula: Power Output: $$P = T \cdot \omega$$ o PP: Power; TT: Torque; ω\omega: Angular velocity. o Application: Teaches trainees to calculate and optimize engine performance during maintenance. 2. Fuel Efficiency Calculations • Formula: Fuel Efficiency: $$\text{Efficiency} = \frac{\text{Distance Covered (km)}}{\text{Fuel Used (liters)}}$$ o Application: Evaluates a vehicle’s consumption rate and identifies potential efficiency improvements. 3. Brake Performance Assessment • Formula: Braking Force: $$F = m \cdot a$$ o FF: Force; mm: Mass; aa: Acceleration. o Application: Ensures safe braking functionality during inspections. Career Opportunities in Motoring 1. Technical Roles: o Automotive mechanics, electrical technicians, and diagnostic specialists. 2. Advanced Careers: o Electric vehicle consultants, fleet managers, or trainers in motoring academies. 3. Entrepreneurial Ventures: o 1.29.1 Background on Alison 1. Platform Overview: o Alison offers a vast library of free online courses, focusing on professional development, workplace skills, and industry-specific knowledge. o Includes certifications in areas such as IT, business, engineering, healthcare, and language learning. 2. Career Development Focus: o The platform helps learners gain competitive skills to increase employability. o Courses are tailored for both beginners and professionals seeking advancement or career changes. 3. Global Accessibility: o Courses are self-paced, accessible from anywhere, and typically designed to require minimal prior knowledge. o Target audience includes students, working professionals, and entrepreneurs looking for affordable learning opportunities. 4. Alignment with Career Goals: o Alison's offerings align with contemporary career trends, such as data analytics, sustainability, cybersecurity, and digital marketing. o The platform also supports foundational learning for skills required in various industries, making it an important resource for career planning. Experimental Career Topics Skill Acquisition and Certification 1. Effectiveness of Free Certifications o Experiment: Study how completing Alison’s free certification courses impacts employability. o Focus: Compare hiring rates of individuals with Alison certifications against those without. 2. Skill Retention from Online Courses o Experiment: Evaluate the retention of skills gained from Alison’s self-paced courses over time. o Focus: Measure how well learners apply acquired knowledge in real-world scenarios. Professional Development 3. Career Advancement with Alison o Experiment: Investigate how Alison’s courses support individuals in advancing to leadership roles. o Focus: Analyze career progression metrics, including promotions and salary increases. 4. Adaptability to Industry Trends o Experiment: Study how Alison’s course offerings prepare learners for emerging industries like renewable energy or AI development. o Focus: Track job placements in future-forward sectors. Learning Effectiveness 5. Impact of Self-Paced Learning o Experiment: Compare learning outcomes from Alison’s self-paced model to traditional structured learning formats. o Focus: Assess learner engagement and completion rates. 6. Global Reach and Accessibility o Experiment: Analyze how Alison’s platform enables learning in regions with limited access to traditional education. o Focus: Measure the platform’s impact on skill development in underserved communities. Innovative Topics to Explore 1. Blended Career Pathways: o Combine Alison’s online modules with hands-on training (e.g., internships or apprenticeships) to evaluate hybrid learning effectiveness. 2. Language Learning for Global Careers: o Experiment with the role of Alison’s language courses in preparing learners for international job markets. 3. Alison and Emerging Technologies: o 1.30.1 e intersection of DHET's NATED and NCV programs, UCPD (Unit for Continuing Professional Development), and electrical engineering provides a solid framework for education, skills development, and innovation. Adding experimental approaches in areas such as assessment methods, engineering applications, and career readiness creates opportunities to enhance outcomes. Here's a structured overview and experimental topic ideas involving the use of "exempters" and marking answer sheets in electrical engineering education: Background 1. DHET and Technical Education: o NATED (National Accredited Technical Education Diploma): Offers levels N1-N6, focusing on both theoretical and practical skills in fields like electrical engineering, mechanics, and construction. o NCV (National Certificate Vocational): Provides vocational training for secondary-level learners (grades 10-12), preparing them for hands-on roles in fields like electrical systems and technology. 2. UCPD (Unit for Continuing Professional Development): o Focuses on upskilling professionals in technical fields, such as electrical engineering, through advanced training and certification. o Often integrates industry-relevant technologies like IoT, AI applications in energy systems, and renewable energy solutions. 3. Electrical Engineering Examinations: o Assessment in NATED and NCV programs typically includes both theoretical evaluations and practical exercises. o Marking answer sheets, especially in technical exams, involves assessing the accuracy of calculations, configurations, and the application of engineering principles. 4. Role of Exempters in Evaluation: o "Exempters" (possibly referring to automatic grading systems or processes for exempting errors) can simplify the marking of complex engineering calculations, circuit designs, and material configurations. o They play a crucial role in maintaining accuracy and fairness, while reducing the manual workload for examiners. Experimental Topics 1. Exam Assessment Methods 1. Automated Marking of Answer Sheets o Experiment: Test the accuracy and efficiency of automated systems in grading theoretical and practical electrical engineering exams. o Focus: Compare results with manual marking to ensure consistency and reliability. 2. Error Tolerance Levels in Engineering Calculations o Experiment: Analyze the impact of "exempted" minor calculation errors on overall grading outcomes. o Focus: Study how error thresholds can be optimized without compromising the integrity of assessments. 2. Training and Professional Development 3. UCPD Programs for Advanced Marking Techniques o Experiment: Investigate how UCPD training for educators in using digital exempters enhances grading accuracy. o Focus: Measure improvements in the speed and precision of assessments. 4. Skill Transfer Through Adaptive Learning Tools o Experiment: Test the effectiveness of adaptive learning platforms in preparing learners for technical engineering assessments. o Focus: Compare knowledge retention between traditional study methods and adaptive software. 3. Engineering Applications in Exams 5. Practical Assessment of Circuit Configurations o Experiment: Develop practical exams where learners design circuits, with results evaluated by automated or semi-automated exempters. o Focus: Assess learner proficiency in circuit optimization and fault detection. 6. Material Selection and System Design in Assessment o Experiment: Include tasks requiring the analysis of material properties (e.g., conductors, insulators) in marking schemes. o Focus: Evaluate the ability of learners to justify their choices based on energy efficiency and safety criteria. Innovative Topics in Assessment and Engineering 1. Use of IoT for Practical Exams • Experiment: Integrate IoT-based devices into practical exams to capture real-time data from circuit operations. • Focus: Use data analytics tools to evaluate system performance designed by learners. 2. AI in Marking and Grading Systems • Experiment: Leverage AI-driven marking systems to assess open-ended answers and engineering diagrams. • Focus: Measure improvements in subjective and objective assessment accuracy. 3. Standardization of Assessment Tools • Experiment: Develop standardized templates for marking answer sheets across different institutions offering NATED and NCV programs. • Focus: Ensure consistency in grading practices while accounting for institution-specific variations. Integral and derived calculations for a material cone, when intersecting with the goals of DHET's NATED and NCV programs, UCPD initiatives, and electrical engineering, provide an intriguing exploration of education, assessment, and real-world applications. Here’s a deeper dive into how these concepts can blend to enhance outcomes: Integral and Derived Calculations in Material Cone Applications 1. Volume of a Material Cone (Theoretical Basis) • Integral Calculation: The volume (VV) of a cone can be derived using: $$V = \int_0^h \pi \left(\frac{r}{h}z\right)^2 \, dz$$ o rr: Base radius of the cone. o hh: Height of the cone. o Derived Formula: Using the integral: $$V = \frac{1}{3} \pi r^2 h$$ o Application: Learners in NATED programs can calculate material requirements for projects, such as conical components in electrical insulators. 2. Surface Area of a Material Cone • Integral Calculation: The surface area (AA) of a cone, excluding the base, is given by: $$A = \int_0^{2\pi} \int_0^L r \, dL \, d\theta$$ o rr: Radius, LL: Slant height. o Derived Formula: $$A = \pi r \sqrt{r^2 + h^2}$$ o Application: Useful in projects to determine the conductive material needed for electrical systems. Experimental Topics Using Material Cone Calculations 1. Application in Electrical Insulator Design • Experiment: Calculate the optimal cone size for electrical insulators to minimize material cost while maximizing performance. • Focus: Analyze trade-offs between material volume and insulation effectiveness. 2. Heat Dissipation in Conical Components • Experiment: Study how cone-shaped materials dissipate heat in electrical circuits. • Calculation: Heat dissipation can be evaluated using: $$Q = \int_0^h \pi \left(\frac{r}{h}z\right)^2 k \Delta T \, dz$$ o kk: Thermal conductivity, ΔT\Delta T: Temperature gradient. • Focus: Train learners to understand thermal modeling in practical systems. Integration with UCPD and Assessment Tools 1. Automated Assessment of Cone Calculations • Experiment: Develop a digital tool to mark assessments involving material cone calculations. • Focus: Compare the accuracy and efficiency of automated grading (using integrals and derived formulas) versus manual marking. 2. Use of IoT Sensors in Practical Cone Applications • Experiment: Equip learners with IoT tools to monitor stress or temperature changes in conical electrical components. • Focus: Evaluate learners’ ability to configure systems based on real-time IoT data. Career-Focused Innovation 1. Preparing Learners for Industry-Specific Roles • Combine material cone calculations with real-world engineering applications in industries like power distribution (City Power, Eskom) or manufacturing. 2. Promoting Advanced Training • Introduce UCPD modules to deepen knowledge of conical geometries in advanced systems like antennas or transformers. Addressing issues like irregularities in transcripts, backlogs in certifications (e.g., SITA-linked NN Diplomas), and alignment with SAQA standards in DHET’s NATED and NCV programs requires targeted solutions. Here's a structured overview with experimental topics that can tackle these challenges: Background 1. DHET (Department of Higher Education and Training): o Manages NATED (National Accredited Technical Education Diploma) and NCV (National Certificate Vocational) programs. o NATED: Offers technical education in levels N1-N6, combining theory and practical workplace skills in fields like electrical and mechanical engineering. o NCV: Vocational training for Grades 10–12, emphasizing hands-on career readiness in trades like technology, business, and engineering. 2. Transcripts and Irregularities: o Material Transcripts: Errors, omissions, or delays in finalizing transcripts for NATED or NCV graduates disrupt progress. o Complaints: Students and institutions often raise concerns over transcript delays or inaccuracies. 3. Backlogs and NN Diplomas: o Certification delays (e.g., from SITA) create backlogs that hinder students’ career progression. o NN Diplomas represent an example where procedural inefficiencies impact final certification and workforce entry. 4. SAQA and Compliance: o Ensures qualifications meet national standards through the National Qualifications Framework (NQF). o Delays in the finalization of SAQA certifications affect educational integrity and recognition. Experimental Topics 1. Addressing Transcript Irregularities 1. Automated Transcript Processing o Experiment: Test the impact of digital platforms for automated transcript generation and validation. o Focus: Measure reductions in errors and processing time compared to manual methods. 2. Complaint Resolution System o Experiment: Develop a centralized portal for tracking and resolving student complaints related to transcripts or diplomas. o Focus: Analyze response times and student satisfaction levels. 2. Tackling Backlogs in NN Diplomas 3. Workflow Optimization for SITA Backlogs o Experiment: Pilot streamlined workflows or allocate additional resources to clear certification backlogs. o Focus: Compare processing times before and after workflow adjustments. 4. Provisional Certification Recognition o Experiment: Introduce provisional certifications for learners impacted by backlogs. o Focus: Evaluate the impact of provisional documents on employment and career progression. 3. Enhancing SAQA Compliance 5. Blockchain-Based Certification Verification o Experiment: Implement blockchain technology to securely verify and finalize SAQA certifications. o Focus: Compare traditional verification timelines with blockchain-enabled processes. 6. Impact Assessment of Certification Delays o Experiment: Study the impact of delayed certifications on graduate employment rates. o Focus: Identify industries most affected by backlog challenges and propose priority resolutions. Innovative Solutions 1. Standardized Transcript Templates: o Design uniform templates for NATED and NCV programs to reduce errors and speed up approvals. 2. Digital Qualification Portals: o Build a national platform for tracking transcript, diploma, and certification progress, accessible to both students and employers. 3. Collaborative Task Forces: o Create cross-agency teams with DHET, SITA, and SAQA to address systemic inefficiencies and ensure alignment with industry demands. enrich the structured topics presented, let’s explore calculation-based approaches tied to the size, configuration, and materials involved in electrical applications for engineering programs. These approaches align with addressing educational and systemic inefficiencies while introducing practical experimental opportunities. Calculation and Engineering Configuration for Material Efficiency 1. Material Volume in Electrical System Components • Calculation: Determine material usage for a cylindrical insulator. $$\text{Volume} = \pi r^2 h$$ o rr: Radius, hh: Height. o Application: Helps students calculate material requirements, minimizing waste in NATED or NCV practicals. 2. Electrical Load Sizing for Practical Training • Calculation: Total energy consumption during lab sessions. $$\text{Energy Consumed} = \int_{t_1}^{t_2} P(t) \, dt$$ o P(t)P(t): Power usage over time. o Application: Ensures lab equipment and electrical installations meet training needs without overloading circuits. 3. Optimization of Circuit Designs in Exams • Calculation: Resistance in a wire used for training setups. $$R = \rho \frac{L}{A}$$ o ρ\rho: Resistivity, LL: Length of wire, AA: Cross-sectional area. o Application: Teaches learners to optimize circuits for energy efficiency and material use. Experimental Topics Using Calculations 1. Automated Material Optimization Systems • Experiment: Implement AI tools for predicting material requirements in practical exercises. • Focus: Measure reductions in material waste when integrated into NATED coursework. 2. Dynamic Circuit Configuration in NCV Labs • Experiment: Develop adjustable circuits for hands-on fault detection and repair training. • Focus: Track learner speed and accuracy in diagnosing faults under exam conditions. 3. Streamlining Transcript Verification • Experiment: Test blockchain systems for generating and validating material-transcript calculations. • Focus: Compare error rates and approval speeds between traditional and digital methods. Combining Educational and Certification Challenges 1. Digital Platforms for Certification Delays: o Collaborate with SITA to introduce automated backlogs trackers and project completion validation tools. o Add progress visualizations for NN Diploma candidates. 2. IoT-Based Practical Assessments: o Use IoT sensors to log student performance during system configurations, ensuring compliance with SAQA’s standards. nriching your structured topics with a focus on maintenance of NN Diplomas, professional trade development over 5–10 years, and calculation-based approaches can build sustainable career pathways. Below is an integration of these elements into your framework: Extended Calculation-Based Approaches for Electrical Engineering 1. Material Durability and Maintenance over Time • Calculation: Predict wear-and-tear for electrical system components. $$\text{Degradation Rate} = \frac{\Delta M}{\Delta t}$$ o ΔM\Delta M: Material loss due to usage, Δt\Delta t: Time interval. o Application: Guides NN Diploma learners in scheduling maintenance or replacement of components like insulators or cables. 2. Energy Efficiency Audits over 5–10 Years • Calculation: Cumulative energy usage in long-term lab or industrial projects. $$\text{Total Energy} = \int_{t_1}^{t_{10}} P(t) \, dt$$ o P(t)P(t): Power consumption at a given time. o Application: Trains professionals to monitor and optimize energy efficiency, crucial in developing renewable systems. 3. Maintenance Optimization in Circuit Design • Calculation: Resistance drift due to prolonged usage. $$R_{new} = R_{initial} + \Delta R(t)$$ o ΔR(t)\Delta R(t): Resistance change over time. o Application: Prepares learners to predict and manage aging circuits in practical systems. Experimental Career Development Topics 1. Maintenance Strategies for NN Diploma Recipients • Experiment: Introduce structured maintenance training into electrical engineering courses. • Focus: Assess how maintenance expertise improves long-term reliability of electrical installations in professional settings. 2. 5-Year Career Growth Metrics • Experiment: Analyze trade career progression (e.g., NATED graduates) based on hands-on and theoretical skills acquired. • Focus: Evaluate salary growth, professional certifications (e.g., UCPD courses), and project success. 3. Digital Platforms for Trade Maintenance • Experiment: Implement IoT-enabled platforms to monitor professional trade outcomes over a 10-year span. • Focus: Track system performance logs, repair schedules, and energy audits. Solutions for Certification and Systemic Improvements 1. Backlog Management in NN Diplomas: o Use predictive models to prioritize backlog resolution by urgency and economic impact on careers. 2. SAQA Compliance with Maintenance Records: o Require periodic updates on system maintenance history as part of SAQA certification finalization. 3. Professional Trade Upskilling: o Introduce advanced training modules focusing on large-scale infrastructure maintenance (e.g., power grids). Adding calculations and considerations for body insurance qualifications, consumer protection phases, and transit award processes provides deeper value to your framework. Here’s how these dimensions could further integrate into the provided experimental approaches and enrich the structured topics: Calculation and Consumer-Focused Approaches 1. Actuarial Calculations for Body Insurance • Integral Calculation: Estimating premiums based on risk factors over time. $$\text{Premium Cost} = \int_{t_1}^{t_n} \text{Risk Factor}(t) \cdot \text{Coverage Amount}(t) \, dt$$ o Application: Guides learners in understanding the mathematics behind insurance policies for electrical engineering professionals. 2. Consumer Energy Efficiency in Transit Phases • Cumulative Energy Savings: $$\text{Total Savings} = \int_{t_1}^{t_n} \big(P_{baseline}(t) - P_{optimized}(t)\big) \, dt$$ o PbaselineP_{baseline}: Energy usage in conventional systems, PoptimizedP_{optimized}: Usage in improved systems. o Application: Evaluates the benefits of efficient energy systems for consumers and transit infrastructure. 3. Qualification Metrics for Trade and Awards • Calculation: Scoring phase for qualification and transit awards: $$\text{Qualification Score} = \frac{\int_{t_1}^{t_n} \text{Skill Application}(t) \, dt}{\int_{t_1}^{t_n} \text{Training Opportunity}(t) \, dt}$$ o Application: Helps standardize and assess trade qualifications and certifications over time. Experimental Career Development Topics 1. Awarding NN Diploma Recipients with Maintenance Qualifications • Experiment: Pilot new award systems for outstanding performance in long-term maintenance projects. • Focus: Assess how recognition motivates consistent skill application in practical scenarios. 2. Insurance as a Support Mechanism in Electrical Engineering Careers • Experiment: Introduce micro-insurance options for tools and training in trade professions. • Focus: Measure the uptake and impact on professional resilience during equipment failures. 3. Consumer Protection in Career Development • Experiment: Develop awareness programs for trade professionals to educate them about rights and resources related to certification delays or insurance disputes. • Focus: Track knowledge improvements and their impact on resolving administrative challenges. Innovative Solutions 1. Digital Platforms for Award Management: o Implement portals to nominate and score candidates for trade or NN diploma transit awards using automated scoring algorithms. 2. IoT in Insurance Applications: o Leverage IoT devices to assess and track insurable risks in engineering workplaces, linking real-time data to actuarial models. 3. Collaborative Consumer Advocacy: o Partner with SAQA and trade organizations to address consumer-level issues in certification processes, ensuring fair treatment in backlogs and complaints. 1.30.1 Combining insights into material irregularities, transcript delays, and backlogs with the dynamics of City Power, Eskom, and global industry leaders like Eaton, Schneider, and Microsoft, reveals exciting possibilities for resolving systemic inefficiencies and advancing professional career pathways in NATED DHET programs. Here’s a structured approach to address these topics effectively: Background and Key Issues 1. DHET (Department of Higher Education and Training): o Focuses on delivering practical and theoretical education through NATED programs (N1-N6) and NCV certificates. o Challenges often include transcript irregularities, certification delays, and alignment with industry demands. 2. City Power and Eskom: o Critical players in South Africa’s energy sector, emphasizing reliable power distribution and transitioning to sustainable energy. o Collaboration with industries like Eaton and Schneider enables advancements in electrical engineering and energy systems. 3. Material and Transcript Irregularities: o Errors or omissions in materials or certifications delay student progression in vocational programs. o Backlogs in diploma validation hinder integration into industry roles. 4. Trade and Industrial Collaboration: o Eaton and Schneider specialize in energy management and industrial automation, creating opportunities to integrate students into advanced engineering roles. o Microsoft brings digital innovations like AI, IoT, and cloud platforms to improve educational and industrial workflows. Experimental Topics 1. Addressing Transcript and Certification Delays 1. Blockchain Technology for Certification Validation o Experiment: Implement blockchain to track and verify transcripts and certification processes for NATED and NCV programs. o Focus: Reduce delays and improve transparency for students transitioning to industry roles. 2. Digital Portals for Backlog Management o Experiment: Introduce automated progress trackers for NN Diplomas and certification backlogs. o Focus: Measure processing efficiency across DHET institutions. 2. Material and System Configuration 3. Energy Optimization with Eaton and Schneider o Experiment: Develop hands-on student projects using Eaton’s energy-efficient systems and Schneider’s automation solutions. o Focus: Enhance practical understanding of material usage in sustainable energy applications. 4. IoT and AI-Enabled Maintenance with Microsoft o Experiment: Pilot IoT-based platforms for monitoring irregularities in electrical systems during vocational training. o Focus: Track fault detection and resolution efficiency for NATED learners. 3. Professional Career Development 5. Trade Growth Metrics for Industry Integration o Experiment: Analyze career progression of NATED graduates employed in City Power or Eskom-supported roles. o Focus: Evaluate salary growth, certifications, and project success over a 5–10 year span. 6. Collaborative Training Models o Experiment: Develop cross-industry training programs integrating Eaton, Schneider, and Microsoft technologies with DHET curricula. o Focus: Assess improvements in workforce readiness for modern trade professions. Innovative Collaborative Opportunities 1. SAQA-Compliant Maintenance Modules: o Introduce new SAQA-approved courses focusing on maintaining industrial systems powered by Eaton and Schneider technology. 2. Blazer-Level Digital Tools from Microsoft: o Leverage Microsoft’s Blazer tools for transcript generation, backlog tracking, and personalized career mapping for learners. 3. City Power and Eskom Green Energy Awards: o Recognize outstanding vocational projects in renewable energy and industrial efficiency, encouraging student innovation. xpanding on these topics with integral and derivative calculations provides mathematical precision for addressing irregularities, optimizing configurations, and advancing collaboration with industry leaders in trade and industrial development. Here's how these calculations can be structured: Integral and Derived Calculations for Addressing Issues 1. Material Requirements for Energy Systems • Volume of Material in Cylindrical Components: $$\text{Volume} = \pi r^2 h$$ o Application: Calculates material needs for components like insulators, ensuring minimized waste in projects involving Eaton or Schneider systems. o Optimization: Students optimize material usage based on real-world requirements in NATED labs. 2. Cumulative Energy Usage in Industrial Systems • Energy Efficiency Calculation: $$\text{Total Energy Used} = \int_{t_1}^{t_2} P(t) \, dt$$ o P(t)P(t): Power consumption at time tt. o Application: Trains students to measure and analyze energy usage in City Power or Eskom-supported setups. 3. System Resistance Over Time • Derivation: Resistance Variation: $$R_{new} = R_{initial} + \Delta R(t)$$ o ΔR(t)\Delta R(t): Incremental resistance change over time. o Application: Helps learners in vocational training predict long-term efficiency of electrical systems and identify points of failure. Experimental Topics Using Calculations 1. Blockchain Efficiency in Certification Validation • Experiment: Measure performance improvements using blockchain: $$\text{Validation Time Saved} = \int_{t_1}^{t_2} \big(\text{Traditional Process}(t) - \text{Blockchain Process}(t)\big) \, dt$$ o Focus: Highlights benefits of blockchain for reducing transcript and diploma validation backlogs. 2. IoT and AI-Powered Maintenance in Training • Energy Savings with Smart Sensors: $$\text{Savings} = \int_{t_1}^{t_2} \big(P_{baseline}(t) - P_{optimized}(t)\big) \, dt$$ o PbaselineP_{baseline}: Initial power use; PoptimizedP_{optimized}: Optimized power use with IoT tools. o Application: Introduces students to real-time energy monitoring, aligning with Microsoft’s digital initiatives. 3. Career Development Metrics Over 5–10 Years • Growth Index Calculation: $$\text{Career Growth} = \frac{\int_{t_1}^{t_{10}} \text{Certifications Completed}(t) \, dt}{\int_{t_1}^{t_{10}} \text{Available Opportunities}(t) \, dt}$$ o Focus: Tracks trade progress among NATED graduates in roles linked to City Power, Eskom, and global partners. Innovative Collaborative Opportunities 1. Eaton and Schneider Industry Integration: o Develop simulations for students to assess load balancing and energy distribution systems. o Train learners on maintenance solutions for energy automation. 2. Digital Career Tools via Microsoft: o Incorporate Microsoft’s advanced analytics tools to create dashboards visualizing certification and growth trends in trade professions. 3. Green Energy Awards with City Power and Eskom: o Use derived metrics like energy savings and material efficiency to select student projects for recognition in renewable energy. 1.31.1 Atlantic International University (AIU) is known for its flexible and personalized approach to education, offering programs designed for self-paced learning and tailored career development. Here's an overview along with potential experimental career development topics that align with AIU's structure: Background on Atlantic International University (AIU) 1. Learning Philosophy: o AIU emphasizes a personalized learning approach, focusing on integrating students' career goals with their educational journey. o Programs are designed to be flexible, encouraging self-directed learning with guidance from faculty advisors. 2. Academic Offerings: o Offers undergraduate, master’s, and doctoral programs across disciplines like business, education, engineering, health sciences, and social studies. o Focuses on a combination of theoretical knowledge and practical application, preparing learners for global career opportunities. 3. Career-Oriented Education: o AIU's customized curriculums are aligned with individual career objectives, making it ideal for working professionals seeking to upskill or transition to new fields. o Students are encouraged to integrate ongoing professional experiences into their studies. 4. Global Accessibility: o Online platforms make programs accessible worldwide, supporting diverse learners in remote or underserved regions. Experimental Topics for Career Development 1. Personalized Learning Impact • Experiment: Analyze how personalized AIU curriculums influence career growth among students. • Focus: Compare career advancement (promotions, salary increases) between AIU graduates and traditional university graduates. 2. Self-Paced Learning Outcomes • Experiment: Measure skill retention and application in self-paced learners versus those in structured, time-bound courses. • Focus: Study how the flexibility of AIU’s learning approach affects long-term professional development. 3. Career Alignment with AIU Curriculums • Experiment: Investigate the alignment between AIU’s tailor-made programs and job market demands. • Focus: Track graduates’ success in securing roles directly linked to their personalized curriculum. 4. Cross-Disciplinary Learning Benefits • Experiment: Explore how AIU’s interdisciplinary approach (e.g., combining engineering with management) enhances career opportunities. • Focus: Study outcomes for graduates entering fields that require multidisciplinary knowledge. 5. Global Career Mobility • Experiment: Examine the role of AIU qualifications in supporting international career transitions. • Focus: Compare employment rates of AIU graduates in global markets to those with local qualifications only. Innovative Areas for Exploration 1. Digital Portfolios: o Encourage students to create digital portfolios showcasing projects, coursework, and certifications, and assess their impact on job applications. 2. AIU and Emerging Technologies: o Develop curriculums focusing on AI, IoT, or blockchain to prepare students for future-forward industries. 3. Industry-Specific Partnerships: o Collaborate with global companies to provide practical case studies and internships linked to AIU coursework. calculation size configuartion electrical material Here are some calculations and considerations related to size, configuration, and electrical material for various engineering applications: 1. Calculating Material Volume • Formula for Volume of Cylindrical Electrical Components: $$\text{Volume} = \pi r^2 h$$ o Where: □ rr: Radius of the cylinder. □ hh: Height or length of the component. o Application: Used to determine the material needed for insulation sleeves, cable coatings, or conductive rods, minimizing waste. 2. Sizing Electrical Wires • Formula for Resistance of a Wire: $$R = \rho \frac{L}{A}$$ o Where: □ RR: Resistance in ohms. □ ρ\rho: Resistivity of the material (depends on the type of conductor, e.g., copper or aluminum). □ LL: Length of the wire. □ AA: Cross-sectional area of the wire. o Application: Ensures the wire is appropriately sized for minimal energy losses and safe operation in electrical systems. 3. Power Capacity in Conductive Materials • Power Handling: $$P = IV$$ o Where: □ PP: Power in watts. □ II: Current in amperes. □ VV: Voltage in volts. o Application: Determines the material's capacity to carry a certain electrical load, ensuring the configuration meets system demands. 4. Heat Dissipation in Electrical Components • Heat Dissipation Calculation: $$Q = I^2 R t$$ o Where: □ QQ: Heat energy in joules. □ II: Current in amperes. □ RR: Resistance in ohms. □ tt: Time in seconds. o Application: Predicts heat buildup in conductors and ensures adequate cooling or material selection to avoid overheating. 5. Configuring Electrical Load for Safety • Load Balancing: $$\text{Total Load} = \int_{t_1}^{t_2} P(t) \, dt$$ o Where: □ P(t)P(t): Power drawn by the system as a function of time. o Application: Used to distribute loads in an electrical grid (e.g., for City Power or Eskom), preventing overloads and ensuring system reliability. 6. Optimizing Conductive Material for Renewable Systems • Efficiency of Renewable Energy Systems: $$\text{Efficiency} = \frac{P_{output}}{P_{input}} \times 100\%$$ o Where: □ PoutputP_{output}: Delivered power. □ PinputP_{input}: Consumed power. o Application: Ensures materials and configurations in solar panels, wind turbines, or power grids are optimized for maximum efficiency. Experimental Applications • Simulation of Electrical System Behavior: Use modeling software to test configurations for load distribution or heat dissipation. • IoT Sensors for Real-Time Monitoring: Apply IoT-enabled tools to track resistance drift and power usage, providing feedback on system health. Bibliographic Overview: Calculating and Sizing Power Systems 1. Utility Providers and Power System Requirements: o Eskom and City Power Johannesburg: Responsible for energy generation, transmission, and distribution across South Africa. These organizations manage large-scale power systems with significant focus on system reliability and sustainability. □ Power system calculations in these entities include load flow analysis, energy loss estimation, and fault current evaluations to ensure system stability and efficiency. □ Application Example: Load shedding management uses optimized sizing calculations to balance supply and demand. Educational and Developmental Entities 2. DHET and NATED Programs: o DHET (Department of Higher Education and Training): Oversees technical education through NATED (National Accredited Technical Education Diploma) and NCV programs. □ Focused on training skilled professionals in electrical engineering and energy systems. □ Students learn methodologies such as calculating total load demand: $$P_{\text{Total}} = \sum_{i=1}^{n} P_{\text{i}}$$ □ PiP_{\text{i}}: Load power demand for individual systems. 3. Sci-Bono Discovery Centre: o Promotes STEM education through hands-on experiences in energy systems, focusing on teaching power infrastructure fundamentals. o Provides platforms for students to explore renewable energy configurations, simulating system load capacities. Industrial and Technological Contributions 4. Schneider Electric and Eaton Corporation: o Schneider: Known for advanced power management systems that integrate energy-saving solutions and automation. o Eaton: Specializes in smart grids and electrical systems, emphasizing renewable energy storage and energy efficiency. □ Both companies support education through project-based learning, using their systems to teach power system calculations like: $$\text{Power Loss (W)} = I^2 R$$ □ II: Current; RR: Resistance. 5. DTIC (Department of Trade, Industry, and Competition): o Supports industrial collaboration by aligning energy infrastructure projects with job market demands. o Partners with councils and institutions to standardize calculations and configurations in energy sector planning. 6. Kheta and Workforce Readiness: o A digital tool that bridges students and labor market needs by providing insights into career opportunities in fields like electrical engineering and energy system management. 7. Microsoft and Digital Innovation: o Provides IoT platforms, machine learning tools, and cloud-based simulations for power grid optimization. o Supports the use of advanced analytics to monitor and predict system performance, optimizing configurations in real time. Experimental Topics Related to Power Calculations 1. Fault Current Management: o Experiment with calculations for fault current: $$I_{\text{Fault}} = \frac{V_{\text{Source}}}{Z_{\text{System}}}$$ □ Evaluate real-time fault detection systems in collaboration with Schneider and Microsoft tools. 2. Renewable Energy Systems: o Study the integration of solar panels into Eskom grids using energy flow equations to calculate load-sharing capacity. 3. Education-Industry Collaboration: o Assess how NATED program graduates utilize Schneider and Eaton technologies to improve grid resilience. 4. AI for Load Balancing: o Implement Microsoft AI solutions for Eskom’s load management strategies to optimize energy distribution during peak demand. Partial Scholarship Application at AIU Inbox Roberto Aldrett - AIU 11:07 AM (2 hours ago) to me Unique and Unrepeatable! Dear tshingombe tshitadi, We received your request to apply for a partial scholarship at Atlantic International University. 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You may opt-out at any time by emailing us at inclusion@isc2.org. Age: 45-54 Nationality: Congolese (DRC) To which gender do you most identify? Man If you selected "Not Listed", please list your gender below: male Pronouns: He/his If you selected "Not Listed", please list your pronouns below: engineering What ethnicity/race best describes you? (US) America Indian or Alaska Native US: If you selected "Other ethnic group", please list it below: black What ethnicity/race best describes you? (APAC) Prefer not to answer APAC: If you selected "Other ethnic group", please list it below: What ethnicity/race best describes you? (UK) Presentation Proposal Title: thesis master engineering Thesis master doctoral engineering electrical subject ciriculum framework qualicafition Education technology Preview - Call for Presentations - ISC2 Security Congress 2025 https://www.abstractscorecard.com/cfp/submit/submissions/summary... 5 of 6 2/27/2025, 12:38 PM What ethnicity/race best describes you? (UK) Mixed or Multiple Ethnic Groups: White and Black Caribbean, White and Black African, White and Asian, Any other Mixed or Multiple ethnic background UK: If you selected "Other ethnic group", please list it below: uk Highest level of education (US): High school graduate, diploma or the equivalent (for example: GED) Highest level of education (UK): College or university What is your preferred spoken/written language? english Do you identify as a member of any of the following groups? Veteran or Prior Armed Forces Service If you selected "Persons with a Disability", please list disability below: Attachment(s) workplace experimental ip request research met thesis aiu,,eaton microsofr eskom city power.pdf Preview - Call for Presentations - ISC2 Security Congress 2025 tshingombe.pdf This email is a service from ORCID Support. Delivered by Zendesk [Z1E5J3-GJ99K] tshingombe fiston 2:09 PM (3 minutes ago) to Support Be careful with this message. This message may contain a password field. 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Degree honorable ; college low labor ju tshingombe tshitadi, tshingombe tshitadi Submitted: 03 Mar 2025 Document 1 .1.1 *Thesis: * Research policy trade theory mini afts Submitted Published Closed Submissions Slides thesis education technology ,alumni energy rural TEVET lecture under planing..Framework qualicafication nated ncv combination irregularity back log insurance assessment policy engineering studies Work experimental based regulation discovery Portfolio skill development rural energy low rules tshingombe tshitadi, tshingombe tshingombe REJECTED Date: 03 Mar 2025 Slides Thesis. Degree honor, council quality rules low become justice development court and labor relations conciliation mediation, Engineering electrical trade research policy skill ,safety security order develop ,defense order tshingombe tshitadi REJECTED Date: 03 Mar 2025 Poster ____________ 4.1 .12.1.Name of thesis : implementation and framework national qualification and national trade examination circulum experimental job theoretical pratical college and government policy LMS in engineering studies science electrical businesses module: case studies rsa in dhet,saqa , St peace college tshingombe tshitadi, tshingombe REJECTED Date: 03 Mar 2025 Article Thesis master doctoral engineering electrical subject ciriculum framework qualicafition Education technology tshingombe tshitadi, tshingombe kb REJECTED Date: 09 Feb 2025 Article Research education technology and research engineer electrical master degree and honour framework qualification and trade master skill low test tshingombe tshitadi REJECTED Date: 24 Jan 2025 Article 1 .1.1 *Thesis: * Research policy trade theory minimum : legislation skill development : honorable member certificate transcript outcome award tshingombe tshitadi, tshingombekb@gmail.com tshingombekb@gmail.com, info@email.careersportal.co.za et al REJECTED Date: 03 Feb 2025 My Research • Submissions • Content and Tracking Alerts • My Details My Details ____ PROFILE DETAILS First Name * Last Name * Institution * Note: To add your institution or organisation, start typing the name and then select the correct name from the list. Where applicable, the name will appear in both the original language and in English. Do not paste in the name. If the name does not appear in the drop-down list, we will display the information you have entered. Department Town/City State Country/Region * ____ CHANGE EMAIL ADDRESS tshingombefiston@gmail.com Enter new email address Enter new email address again ____ CHANGE PASSWORD Existing password New password Show Typing ____ MY ORCID ID 0009-0005-2690-9559 file_uploadSubmit your research • Browse • Gateways & Collections • How to Publish o o o o o o o o o o o o o o o mum : legislation skill development : honorable member certificate transcript outcome award tshingombe tshitadi, tshingombe tshitadi Draft Last Accessed: 21 Feb 2025 tshingombe tshitadi Prospect ID : 040320242059666073800f0884bebd2415f9d5d6b20c80a2237 Postdoctoral in 0 First Name : tshingombe Last Name : tshitadi Email : tshingombefiston@gmail.com Alternative Email : Address 1 : Address 2 : City : Johannesburg State : Country : South Africa Home Phone : Work Phone : Cell Phone : 0725298946 Fax : Age : 42 Gender : Website Address : Language : English Internal Comments : The AIU AI Program Generator creates custom program courses based on your desired work field and educational background. This intelligent tool tailors a curriculum to align with industry demands and your academic strengths, ensuring efficient learning and maximizing your potential for career success. The program generator offers a preview of potential courses at AIU, each with several lessons. Once enrolled, students can customize courses during Phase 2 by collaborating with their tutor and advisor. This ensures a personalized educational experience tailored to their unique needs and goals at http://aiu.edu. 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In order to reserve your scholarship, submit your enrollment fee payment with a credit or debit card or follow the payment instructions at the end of your online application within the following 4 days. If you have any questions, feel free to contact me via email at roberto@aiu.edu or indicate the best date and time to call you. Best Regards, Roberto Aldrett - roberto@aiu.edu - Communications Coordinator - Atlantic International University - http://www.aiu.edu Pioneer Plaza 900 Fort Street - 905 Honolulu Hawaii 96813. USA Telephone: +1 (808) 215-0413 WhatsApp only: +1 (808) 215-0413 skype: aiu.roberto 900 Fort Street Mall 905, Honolulu, Hawaii 96813, roberto@aiu.edu 1. Users Table: - user_id : 040320242059666073800f0884bebd2415f9d5d6b20c80a2237 - username:tshingombe - email:tshitadi - password: kananga5 - address 2. Products Table: - product_id : 040320242059666073800f0884bebd2415f9d5d6b20c80a2237 - name: engineering - description: circulum assessment - price: 1000$ - category_id:45677 3. Categories Table: - category_id : 040320242059666073800f0884bebd2415f9d5d6b20c80a2237 - name 4. Orders Table: - order_id : 040320242059666073800f0884bebd2415f9d5d6b20c80a2237 - user_id :9879 - order_date:25/02/2025 - total_amount 5. Order_Items Table: - order_item_id : 040320242059666073800f0884bebd2415f9d5d6b20c80a2237 - order_id : 123456 - product_id:tshi - quantity:100 - item_price :10000$ -- 1.Topic one experimental: theoretical pratical company Overview : tshingombe fiston Sat, Nov 30, 2024, 5:38 PM to regionArevenue, regionBrevenue, tenderadvicecentre, estimations, wmcqueries, Mediadesk, SARS, me City Power is responsible for providing electrical services to property owners in the City of Johannesburg that are not serviced by Eskom. To determine if you are a City Power customer you can check your existing City of Johannesburg invoice and see if you are being billed for electricity. If you don't have an invoice or if you don't have a service connection you can check the township list, it will indicate in whose supply area the property is. The service connections we provide are divided into two categories namely Small Power Users (SPU) and Larger Power Users (LPU). A Small Power User is defined as a user who has an electrical service connection no greater than 56 kVA (3 phase, 80 ampere). In general most households would have this type of service connection. A Large Power User is defined as a user who has an electrical service connection larger than 56 kVA. In general these type of connections are used for medium and large commercial or industrial consumers as well as high density residential developments. We want to provide property owners with the services they require in as short time as possible. To assist with this, the information and documents required to make an application for electrical services are detailed in the documents on this webpage. 1. Apply to convert a SPU from postpaid to pre-paid billing 2. Apply for a new prepaid or postpaid SPU connection (this guide also covers application for alterations to a small power user connection) 3. Apply for a new LPU connection (the guide also covers applications for alterations to a large power user connection) The application form that needs to be submitted when making an new feed updates notifications Sales Nav City Power Johannesburg Visit website Home About Posts Jobs People Insights City Power Johannesburg Customer-focused energy services company, operating and maintaining the Johannesburg's electricity distribution network. 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See technical details below for more information. LEARN MORE This link will Dec 1, 2024, 12:53 PM Mail Delivery Subsystem Message blocked Your message to admni@resbank.co.za has been blocked. See technical details below for more information. LEARN MORE This link will take you to a Dec 1, 2024, 12:53 PM Mail Delivery Subsystem Address not found Your message wasn't delivered to customerservice@eskom.co.za because the address couldn't be found, or is unable to receive mail. LEARN MORE T Dec 1, 2024, 12:53 PM Mail Delivery Subsystem Address not found Your message wasn't delivered to GITServiceDesk@eskom.co.za because the address couldn't be found, or is unable to receive mail. LEARN MORE Th Dec 1, 2024, 12:53 PM postmaster@dmre.gov.za Your message to examweb@dmr.gov.za couldn't be delivered. 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If you don't have an invoice or if you don't have a service connection you can check the township list, it will indicate in whose supply area the property is. The service connections we provide are divided into two categories namely Small Power Users (SPU) and Larger Power Users (LPU). A Small Power User is defined as a user who has an electrical service connection no greater than 56 kVA (3 phase, 80 ampere). In general most households would have this type of service connection. A Large Power User is defined as a user who has an electrical service connection larger than 56 kVA. In general these type of connections are used for medium and large commercial or industrial consumers as well as high density residential developments. We want to provide property owners with the services they require in as short time as possible. To assist with this, the information and documents required to make an application for electrical services are detailed in the documents on this webpage. 1. Apply to convert a SPU from postpaid to pre-paid billing 2. Apply for a new prepaid or postpaid SPU connection (this guide also covers application for alterations to a small power user connection) 3. Apply for a new LPU connection (the guide also covers applications for alterations to a large power user connection) The application form that needs to be submitted when making an new feed updates notifications Sales Nav City Power Johannesburg Visit website Home About Posts Jobs People Insights City Power Johannesburg Customer-focused energy services company, operating and maintaining the Johannesburg's electricity distribution network. Electric Power Transmission, Control, and Distribution Johannesburg, Gauteng 1K followers 1K-5K employees Visit website Home About Posts Jobs People Insights City Power Johannesburg 1,034 followers See a collection of active or past ads by City Power Johannesburg. View ad library Feed post number 1 City Power JohannesburgCity Power Johannesburg 1,034 followers1,034 followers 2w • 2 weeks ago City Power's Green Energy Future: Solar Microgrids Empower Communities hashtag#CityPowerServices hashtag#CityPowerEnergyPlan City Power's Green Energy Future: Solar Microgrids Empower Communities City Power Johannesburg By Kgagodi MadibaCity Power is taking significant strides to reduce greenhouse gas emissions and bring sustainable energy solutions to Johannesburg co Home My Network Jobs 1 1 new message notification Messaging 25 25 new notifications Notifications application can also be found with the downloadable documents on the below table. 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Dec 1, 2024, 12:55 PM tshingombe fiston Dec 1, 2024, 12:55 PM to SARS, regionArevenue, regionBrevenue, tenderadvicecentre, estimations, wmcqueries, Mediadesk, customerservice, Mobility, DET, keith.bowen, SARB, admni, DSI-Notification, DMR, Advisoryservice, sarb-graduaterecruit, GITServiceDesk, csd, me Turn on more accessible mode Skip Ribbon Commands Skip to main content A A A Contact Us Webmail Job Opportunities My Details Sign Out Top Link Bar Our Company About Electricity What we're doing IDM Customer Care Careers Tenders My Applications My Applications Position Created Engineering Prof Civil Auxiliary Plant (Generation) Lethabo Power Station 2024/04/24 12:59 PM Engineers in Training X09_ Electrical HC x2_ C and I x3_Mechanical or Chemical x3_Industrial Engineering x1 (Gx Kusile Powe 2024/05/19 09:36 AM Senior-Clerk-General-Administration-(Dx)-CPM-Aliwal-North 2024/05/19 09:38 AM Engineer Prof Engineering (NP)Distribution Bloemfontein 2024/05/19 09:38 AM Middle Manager Nuclear Safety and Assurance (ISED) X1 (Generation) Koeberg NPS 2024/05/19 09:39 AM Senior Advisor Education and Training (ETD) x1 (Engineering and Maintenance) Peaking 2024/05/29 02:40 PM Technical Official PPM Mechanical X2 (Distribution) EAL Midrand 2024/09/01 01:27 PM 1 Learning-Programme-Engineer-in-Training-x-2,-Generation,-Megawatt-Park 2024/09/01 01:29 PM Learning Programme Engineer in Trainng x17 GX Matla Power Station 2024/09/01 01:29 PM Manager Site Outage Execution, Generation, Tutuka Power Station 2024/09/01 01:30 PM Re Advert Snr Technologist Electrical Engineering Substation x2 (National Transmission Company South Africa) MWP Sunninghill 2024/09/01 01:31 PM Re Advert Snr Technologist Electrical Engineering Substation x2 (National Transmission Company South Africa) MWP Sunninghill 2024/09/01 01:31 PM Senior Technician Chemistry x2 (Technical Support and Oils Micro) (Generation) Koeberg NPS 2024/09/01 01:32 PM Officer Safety Health Environment X1 Generation Medupi Power Station 2024/09/01 01:33 PM Learning Programme Outages x1 - Graduate in Training , Generation, Megawatt Park and Witbank 2024/09/01 01:34 PM Learning Programme - Graduate in Training-Quantity Surveyor, Generation, Megawatt Park 2024/09/01 01:35 PM Senior Advisor Supplier Development, Localisation and Industrialisation x2, Generation, Megawatt Park and Tutuka Power Stat 2024/09/01 01:35 PM Graduate-in-Training (Finance) 2024/09/01 01:37 PM Re Advert Snr Draughtsperson Draughting Electrical Substation Engineering x3 NTCSA MWP 2024/09/01 01:38 PM Technician-in-Training x2 (1xC+I and 1+Mech) 2024/09/01 01:39 PM Snr. Supervisor Tech Instrument x 2 (Generation) Tutuka Power Station 2024/09/01 01:39 PM Engineer-in-Training-Control and Instrumentation AND-Auxiliary and Ancillary-(Peaking Durbanville)-X2 2024/09/01 01:40 PM Re Advert Senior Technician Configuration X1 (Generation) Medupi Power Station 2024/09/01 01:42 PM Engineer Prof Eng Quality of Supply (National Transmission Company South Africa) Newscastle 2024/09/01 01:43 PM Learning Programme - Graduate in Training x1, Generation, Megawatt Park 2024/09/01 01:44 PM Learning-Programme -Graduate-in-Training-x3,-Generation,-1Megawatt-Park 2024/09/01 01:45 PM Learning Programme-Graduate in Training x 3, Generation, Megawatt Park 2024/09/01 01:46 PM Learning Programme-Graduate in Training x 2, Generation, Megawatt Park 2024/09/01 01:47 PM Senior Supervisor Technical Projects (National Transmission Company South Africa)Northwest and Limpopo 2024/09/01 01:49 PM Snr-Advisor-Applications-Support-(Group-IT-DIVISION)-Megawatt-Park 2024/09/01 01:50 PM 1 - 30 Follows us on Our Company Company Information Leadership Investors Sustainable Development CSI Media Room PAIA Eskom Heritage Photo Gallery Video Clips About Electricity Electricity Tips Electricity Technologies Eskom Power Series Renewable Energy Facts & Figures Visitor Centers MODIS Fire Alerts What we're doing Electricity Generation New Build Transmission Development Plan Ancillary Services GCCA Report Supply Status Info Site For IPPs School Of Welding Eskom initiatives IDM Integrated Demand Management Energy Advice Eskom Solar Water Heating Programme Measurement Verification Customer Care CS Online Tarrifs And Charges MYPD3 Customer Service Information Subscribe CS Mobile Customer Feedback Customer Care Video Clips IDM Careers Vacancies Tenders Eskom Purchasing Policies Tender Process Whats Out To Tender Supplier Registration Insurance Policies Procedures BBBEE Certificate Copyright © 2024 Eskom Holdings SOC Ltd Reg No 2002/15527/30. 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To determine if you are a City Power customer you can check your existing City of Johannesburg invoice and see if you are being billed for electricity. If you don't have an invoice or if you don't have a service connection you can check the township list, it will indicate in whose supply area the property is. The service connections we provide are divided into two categories namely Small Power Users (SPU) and Larger Power Users (LPU). A Small Power User is defined as a user who has an electrical service connection no greater than 56 kVA (3 phase, 80 ampere). In general most households would have this type of service connection. A Large Power User is defined as a user who has an electrical service connection larger than 56 kVA. In general these type of connections are used for medium and large commercial or industrial consumers as well as high density residential developments. We want to provide property owners with the services they require in as short time as possible. To assist with this, the information and documents required to make an application for electrical services are detailed in the documents on this webpage. 1. Apply to convert a SPU from postpaid to pre-paid billing 2. Apply for a new prepaid or postpaid SPU connection (this guide also covers application for alterations to a small power user connection) 3. Apply for a new LPU connection (the guide also covers applications for alterations to a large power user connection) The application form that needs to be submitted when making an [ ] new feed updates notifications Sales Nav City Power Johannesburg Visit website Home About Posts Jobs People Insights City Power Johannesburg Customer-focused energy services company, operating and maintaining the Johannesburg's electricity distribution network. 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On Sat, Nov 30, 2024 at 5:11 PM tshingombe fiston wrote: https://www.sars.gov.za/businesses-and-employers/trusts/registering-as-a-trust/register-a-trust-supporting-documents/ Disclaimer The information contained in this communication from the sender is confidential. It is intended solely for use by the recipient and others authorized to receive it. If you are not the recipient, you are hereby notified that any disclosure, copying, distribution or taking action in relation of the contents of this information is strictly prohibited and may be unlawful. This email has been scanned for viruses and malware, and may have been automatically archived by Mimecast Ltd, an innovator in Software as a Service (SaaS) for business. Providing a safer and more useful place for your human generated data. Specializing in; Security, archiving and compliance. To find out more Click Here. tshingombe fiston On Mon, 02 Dec 2024, 10:26 RegionB Revenue, wrote: On Sat, Nov 30, 2024 at 5:38 PM tshingombe fiston Feb 2, 2025, 2:29 PM tshingombe fiston Feb 3, 2025, 11:36 AM to regionArevenue, wmcqueries, Mediadesk, estimations, tenderadvicecentre, RegionB 6 Attachments • Scanned by Gmail RegionB Revenue Dear valued customer, Please provide us with your municipal account number and describe the nature of your query in detail. Thank you for utilizing the regional Feb 5, 2025, 12:50 PM tshingombe fiston Thanks - municipality city Johannesburg - CDs R169241870 -; Feb 5, 2025, 1:19 PM RegionB Revenue Dear valued customer, Kindly provide a transfer letter The Region B Customer Service Team On Mon, Dec 2, 2024 at 10:26 AM RegionB Revenue <regionBrevenue@joburg Feb 5, 2025, 1:35 PM tshingombe fiston Thank you, will do. Feb 6, 2025, 9:33 AM RegionB Revenue Thanks City Power Johannesburg Visit website Feed post number 1 Feb 7, 2025, 8:58 AM RegionB Revenue Feb 10, 2025, 8:06 AM to me Dear valued customer, Thank you for utilizing the regional email service. Kind Regards, tshingombe fiston You are welcome. Feb 10, 2025, 6:03 PM RegionB Revenue Feb 12, 2025, 10:43 AM (12 days ago) to me Most Welcome tshingombe fiston Feb 23, 2025, 10:28 AM (1 day ago) to RegionB 2 Attachments • Scanned by Gmail tshingombe fiston Feb 23, 2025, 1:18 PM (21 hours ago) to RegionB 6 Attachments • Scanned by Gmail City Power Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia City Power Company type Electric utility Industry Electric power industry Founded January 1, 2001; 24 years ago Headquarters 40 Heronmere Road, Reuven, Johannesburg , South Africa Area served Johannesburg Key people Tshifularo Mashava (CEO) Revenue R 17 billion (2020/21) Total assets R 19.7 billion (2019/20) Number of employees 1750 (2020/21) Website citypower.co.za City Power Johannesburg (or Joburg City Power) is a state owned power utility, wholly owned by the City of Johannesburg. Its responsibilities include buying electricity from power producers and supplying it to the public, and installing and maintaining the electrical infrastructure in the city of Johannesburg. It supplies electricity to 3.2 million people in the Greater Johannesburg Metropolitan Area.[1] History Joburg City Power was established as a separate company from the City of Johannesburg on 1 January 2000. On the 19th December 2001, the National Energy Regulator of South Africa (NERSA), granted City Power a licence to trade. In 2022, it took over the electricity distribution functions from Eskom to Soweto and parts of Johannesburg, including Sandton, Orange Farm, Finetown, Ivory Park and Diepsloot; Eskom was previously responsible for supplying electricity to most parts of Johannesburg.[2][3] Corruption In 2013, a controversial R1.2 billion contract was awarded by the City of Johannesburg to Edison Power, a company owned by Vivian Reddy, a close ally of Jacob Zuma, for smart meters used by City Power customers.[4] Edison Power was initially allocated a R600-million share of an R800-million contract. Subsequently, the contract value was revised to R1.25 billion and Edison Power received the exclusive contract.[4] Load shedding Kelvin Power Station, a coal-fired power station, provides the City Johannesburg 10% of its power. City Power currently obtains 90% of its power from Eskom and 10% from the Kelvin Power Station from which it seeks to move away from.[5] In 2014, it announced that it will remotely switch off geysers "to reduce the impact of load shedding. [6] In 2021, it resolved to be an electricity generator to "reduce over-reliance on Eskom".[7] In 2023, the City of Johannesburg along with City Power aimed to cut load shedding in Johannesburg by 3 stages through the use of smart meters and the recommissioning of two existing open cycle gas turbines. It also sought to secure power on a long-term basis from independent power producers (IPPs).[8] In 2023, City Power said it had to replace more than 390 mini-substations (pole-mounted transformers), at a cost of R200 million which constituted 80% of its budget for the year. The cause of this was load shedding, theft and vandalism.[9][10][11] In September 2023, City Power announced a drive that would replace all meters with smart meters before 24 November 2024. This was due to a limitation in all meters that generate a token ID using the Standard Transfer Specification. This change would also enable City Power to remotely limit electricity usage in households whose usage is higher than normal.[12] From 6 November 2023, City Power took over management of the load shedding schedule from Eskom.[13] From 10 June 2024, City Power implemented its own form of load shedding called load reduction.[14] Electricity procurement In 2023, through grid access it aims to obtain 53MW from customer-embedded rooftop solar generation and 3.7MW from municipal building PV generation, for a total of 60MW.[2] By 2026/27, it hopes to target 480MW (with 200MW coming from households and businesses, 150MW from independent power producers on private and mining land, 50MW from financed rooftop IPP PV programmes, 27MW through municipal building PV generation, 33.5MW from landfill gas generation and solid waste-to-energy, and 20MW from natural gas generation.)[2] In July 2023, the City of Johannesburg introduced wheeling tariffs which charge both independent power producers and City Power customers to allow use of the existing grid infrastructure to supply customers with electricity.[15] In August 2023, City Power secured 92MW from four IPPs: waste-to-energy (20MW), gas-to-power (31MW) and PV solar generation (40.8MW).[16] In April 2024, the 50 MW John Ware Gas Turbine Power Station was recommissioned.[17] Revenue recuperation City Power has endeavoured to collect R8.9 billion owed by businesses and households. It did this by first giving notices of disconnecting the power of delinquent parties, and compelling them to pay. It said it will impose penalties on businesses and residential complexes that have defaulted on their accounts and connected electricity illegally.[18] Businesses The Apartheid Museum was one of the disconnected clients, with it owing R1.8 million.[19] The Gauteng Treasury was another, with it owing over R34 million.[20] In February 2023, some of the disconnected clients were a shopping centre running an illegal connection on its meters and was penalised with a R100 000 fine, the Church of Scientology with R877 000 in arrears, a sports club in Bryanston which owed R2.3 million and the Nigerian consulate which owed R406 000.[18] In October 2023, it announced that it would give government entities Rahima Moosa Mother and Child Hospital and the Helen Joseph Hospital 14 days to settle a combined debt of R32 million.[21] In June 2024, Eskom issued an ultimatum to the City of Johannesburg (COJ) and City Power for electricity non payment. Joburg owes Eskom R3.4 billion.[22] According to the record, last payments were made in October 2023.[23] The Johannesburg High Court instructed the City of Johannesburg and City Power to immediately pay the first billion of their defaulting amount.[24] Residential customers In September 2023, City Power conducted a disconnection drive of non-paying customers in Naturena and the Lenasia Service Delivery Centre (SDC) in an attempt to collect revenue; the Lenasia SDC which includes surrounding areas like Eldorado Park, Ennerdale, Zakariyya Park and Lehae, owed R 1.3 billion.[25] The City of Johannesburg, through City Power meters, began subtracting municipal debt owed by businesses and residential customers from prepaid electricity purchases.[26] From July 2024, City Power began deducting a R230 service charge from its prepaid customers; along with an increase in the electricity price per KWh, this saw a 23.15% increase from the previous year for all customers including indigent customers (6 to 12 times the inflation rate).[27][28] Photograph your local culture, help Wikipedia and win! Contents · (Top) · Organization Power transactions Executive compensation Oversight Alternative energy promotion Nuclear energy Customer expectations See also References Electric utility Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia An electric utility, or a power company, is a company in the electric power industry (often a public utility) that engages in electricity generation and distribution of electricity for sale generally in a regulated market.[1] The electrical utility industry is a major provider of energy in most countries. Electric utilities include investor owned, publicly owned, cooperatives, and nationalized entities. They may be engaged in all or only some aspects of the industry. Electricity markets are also considered electric utilities—these entities buy and sell electricity, acting as brokers, but usually do not own or operate generation, transmission, or distribution facilities. Utilities are regulated by local and national authorities. Electric utilities are facing increasing demands[2] including aging infrastructure, reliability, and regulation. In 2009, the French company EDF was the world's largest producer of electricity.[3] Organization Power transactions An electric power system is a group of generation, transmission, distribution, communication, and other facilities that are physically connected.[4] The flow of electricity within the system is maintained and controlled by dispatch centers which can buy and sell electricity based on system requirements. Executive compensation The examples and perspective in this article may not represent a worldwide view of the subject. You may improve this article, discuss the issue on the talk page, or create a new article, as appropriate. (February 2016) (Learn how and when to remove this message) The executive compensation received by the executives in utility companies often receives the most scrutiny in the review of operating expenses. Just as regulated utilities and their governing bodies struggle to maintain a balance between keeping consumer costs reasonable and being profitable enough to attract investors, they must also compete with private companies for talented executives and then be able to retain those executives.[5] Regulated companies are less likely to use incentive-based remuneration in addition to base salaries. Executives in regulated electric utilities are less likely to be paid for their performance in bonuses or stock options.[5] They are less likely to approve compensation policies that include incentive-based pay.[5] The compensation for electric utility executives will be the lowest in regulated utilities that have an unfavorable regulatory environment. These companies have more political constraints than those in a favorable regulatory environment and are less likely to have a positive response to requests for rate increases.[6] Just as increased constraints from regulation drive compensation down for executives in electric utilities, deregulation has been shown to increase remuneration. The need to encourage risk-taking behavior in seeking new investment opportunities while keeping costs under control requires deregulated companies to offer performance-based incentives to their executives. It has been found that increased compensation is also more likely to attract executives experienced in working in competitive environments.[7] In the United States, the Energy Policy Act of 1992 removed previous barriers to wholesale competition in the electric utility industry. Currently 24 states allow for deregulated electric utilities: Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Texas, Virginia, Arizona, Arkansas, California, Connecticut, Delaware, Illinois, Maine, Maryland, Massachusetts, Michigan, Montana, New Hampshire, New Jersey, New Mexico, New York, and Washington D.C.[8] As electric utility monopolies have been increasingly broken up into deregulated businesses, executive compensation has risen; particularly incentive compensation.[9] Oversight Oversight is typically carried out at the national level, however it varies depending on financial support and external influences.[10] There is no existence of any influential international energy oversight organization. There does exist a World Energy Council, but its mission is mostly to advise and share new information.[11] It does not hold any kind of legislative or executive power. Alternative energy promotion Alternative energy has become more and more prevalent in recent times and as it is inherently independent of more traditional sources of energy, the market seems to have a very different structure. In the United States, to promote the production and development of alternative energies, there are many subsidies, rewards, and incentives that encourage companies to take up the challenge themselves. There is precedent for such a system working in countries like Nicaragua. In 2005, Nicaragua gave renewable energy companies tax and duty exemptions, which spurred a great deal of private investment.[12] The success in Nicaragua may not be an easily replicated situation however. The movement was known as Energiewende and it is generally considered a failure for many reasons.[13] A primary reason was that it was improperly timed and was proposed during a period in which their energy economy was under more competition. Globally, the transition of electric utilities to renewables remains slow, hindered by concurrent continued investment in the expansion of fossil fuel capacity.[14] Nuclear energy Nuclear energy may be classified as a green source depending on the country. Although there used to be much more privatization in this energy sector, after the 2011 Fukushima district nuclear power plant disaster in Japan, there has been a move away from nuclear energy itself, especially for privately owned nuclear power plants.[citation needed] The criticism being that privatization of companies tend to have the companies themselves cutting corners and costs for profits which has proven to be disastrous in the worst-case scenarios. This placed a strain on many other countries as many foreign governments felt pressured to close nuclear power plants in response to public concerns.[13] Nuclear energy however still holds a major part in many communities around the world. Customer expectations Utilities have found that it isn't simple to meet the unique needs of individual customers, whether residential, corporate, industrial, government, military, or otherwise. Customers in the twenty-first century have new and urgent expectations that demand a transformation of the electric grid. They want a system that gives them new tools, better data to help manage energy usage, advanced protections against cyberattacks, and a system that minimizes outage times and quickens power restoration.[15] See also Electrical grid Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia (Redirected from Grid access) For other uses, see Grid (disambiguation). "Power grid" redirects here. For the board game, see Power Grid. Diagram of an electrical grid (generation system in red, transmission system in blue, distribution system in green) An electrical grid (or electricity network) is an interconnected network for electricity delivery from producers to consumers. Electrical grids consist of power stations, electrical substations to step voltage up or down, electric power transmission to carry power over long distances, and finally electric power distribution to customers. In that last step, voltage is stepped down again to the required service voltage. Power stations are typically built close to energy sources and far from densely populated areas. Electrical grids vary in size and can cover whole countries or continents. From small to large there are microgrids, wide area synchronous grids, and super grids. The combined transmission and distribution network is part of electricity delivery, known as the power grid. Grids are nearly always synchronous, meaning all distribution areas operate with three phase alternating current (AC) frequencies synchronized (so that voltage swings occur at almost the same time). This allows transmission of AC power throughout the area, connecting the electricity generators with consumers. Grids can enable more efficient electricity markets. Although electrical grids are widespread, as of 2016, 1.4 billion people worldwide were not connected to an electricity grid.[1] As electrification increases, the number of people with access to grid electricity is growing. About 840 million people (mostly in Africa), which is ca. 11% of the World's population, had no access to grid electricity in 2017, down from 1.2 billion in 2010.[2] Electrical grids can be prone to malicious intrusion or attack; thus, there is a need for electric grid security. Also as electric grids modernize and introduce computer technology, cyber threats start to become a security risk.[3] Particular concerns relate to the more complex computer systems needed to manage grids.[4] Types (grouped by size) Part of a series on Power engineering Electric power conversion Voltage converter Electric power conversion HVDC converter station AC-to-AC converter DC-to-DC converter Rectifier Inverter Electric power infrastructure Electric power system Power station Electrical grid Interconnector Demand response Electric power systems components Ring main unit Grid-tie inverter Energy storage Busbar Bus duct Recloser Protective relay v t e Microgrid Main article: Microgrid A microgrid is a local grid that is usually part of the regional wide-area synchronous grid, but which can disconnect and operate autonomously.[5] It might do this in times when the main grid is affected by outages. This is known as islanding, and it might run indefinitely on its own resources. Compared to larger grids, microgrids typically use a lower voltage distribution network and distributed generators.[6] Microgrids may not only be more resilient, but may be cheaper to implement in isolated areas. A design goal is that a local area produces all of the energy it uses.[5] Example implementations include: Hajjah and Lahj, Yemen: community-owned solar microgrids.[7] Île d'Yeu pilot program: sixty-four solar panels with a peak capacity of 23.7 kW on five houses and a battery with a storage capacity of 15 kWh.[8][9] Les Anglais, Haiti:[10] includes energy theft detection.[11] Mpeketoni, Kenya: a community-based diesel-powered micro-grid system.[12] Stone Edge Farm Winery: micro-turbine, fuel-cell, multiple battery, hydrogen electrolyzer, and PV enabled winery in Sonoma, California.[13][14] Wide area synchronous grid Main article: Wide area synchronous grid A wide area synchronous grid (also called an "interconnection" in North America) is an electrical grid at a regional scale or greater that operates at a synchronized frequency and is electrically tied together during normal system conditions. For example, there are four major interconnections in North America (the Western Interconnection, the Eastern Interconnection, the Quebec Interconnection and the Texas Interconnection). In Europe, one large grid connects most of Western Europe. These are also known as synchronous zones, the largest of which is the synchronous grid of Continental Europe (ENTSO-E) with 667 gigawatts (GW) of generation, and the widest region served being that of the IPS/UPS system serving countries of the former Soviet Union. Synchronous grids with ample capacity facilitate electricity market trading across wide areas. In the ENTSO-E in 2008, over 350,000 megawatt hours were sold per day on the European Energy Exchange (EEX).[15] Each of the interconnects in North America are run at a nominal 60 Hz, while those of Europe run at 50 Hz. Neighbouring interconnections with the same frequency and standards can be synchronized and directly connected to form a larger interconnection, or they may share power without synchronization via high-voltage direct current power transmission lines (DC ties), or with variable-frequency transformers (VFTs), which permit a controlled flow of energy while also functionally isolating the independent AC frequencies of each side. The benefits of synchronous zones include pooling of generation, resulting in lower generation costs; pooling of load, resulting in significant equalizing effects; common provisioning of reserves, resulting in cheaper primary and secondary reserve power costs; opening of the market, resulting in possibility of long-term contracts and short term power exchanges; and mutual assistance in the event of disturbances.[16] One disadvantage of a wide-area synchronous grid is that problems in one part can have repercussions across the whole grid. For example, in 2018, Kosovo used more power than it generated due to a dispute with Serbia, leading to the phase across the whole synchronous grid of Continental Europe lagging behind what it should have been. The frequency dropped to 49.996 Hz. This caused certain kinds of clocks to become six minutes slow.[17] The synchronous grids of Europe The two major and three minor interconnections of North America Major WASGs around the world Super grid Main article: Super grid One conceptual plan of a super grid linking renewable sources across North Africa, the Middle East and Europe. (DESERTEC)[18] A super grid or supergrid is a wide-area transmission network that is intended to make possible the trade of high volumes of electricity across great distances. It is sometimes also referred to as a mega grid. Super grids can support a global energy transition by smoothing local fluctuations of wind energy and solar energy. In this context, they are considered as a key technology to mitigate global warming. Super grids typically use high-voltage direct current (HVDC) to transmit electricity long distances. The latest generation of HVDC power lines can transmit energy with losses of only 1.6% per 1000 km.[19] Electric utilities between regions are many times interconnected for improved economy and reliability. Electrical interconnectors allow for economies of scale, allowing energy to be purchased from large, efficient sources. Utilities can draw power from generator reserves from a different region to ensure continuing, reliable power and diversify their loads. Interconnection also allows regions to have access to cheap bulk energy by receiving power from different sources. For example, one region may be producing cheap hydro power during high water seasons, but in low water seasons, another area may be producing cheaper power through wind, allowing both regions to access cheaper energy sources from one another during different times of the year. Neighboring utilities also help others to maintain the overall system frequency and also help manage tie transfers between utility regions.[20] Electricity Interconnection Level (EIL) of a grid is the ratio of the total interconnector power to the grid divided by the installed production capacity of the grid. Within the EU, it has set a target of national grids reaching 10% by 2020, and 15% by 2030.[21] Components Generation Main article: Electricity generation Turbo generator Electricity generation is the process of generating electric power at power stations. This is done ultimately from sources of primary energy typically with electromechanical generators driven by heat engines from fossil, nuclear, and geothermal sources, or driven by the kinetic energy of water or wind. Other power sources are photovoltaics driven by solar insolation, and grid batteries.[nb 1] The sum of the power outputs of generators on the grid is the production of the grid, typically measured in gigawatts (GW). Transmission Main article: Electric power transmission 500 kV Three-phase electric power Transmission Lines at Grand Coulee Dam; four circuits are shown; two additional circuits are obscured by trees on the right; the entire 7079 MW generation capacity of the dam is accommodated by these six circuits. Network diagram of a high voltage transmission system, showing the interconnection between the different voltage levels. This diagram depicts the electrical structure[22] of the network, rather than its physical geography. Electric power transmission is the bulk movement of electrical energy from a generating site, via a web of interconnected lines, to an electrical substation, from which is connected to the distribution system. This networked system of connections is distinct from the local wiring between high-voltage substations and customers. Transmission networks are complex with redundant pathways. Redundancy allows line failures to occur and power is simply rerouted while repairs are done. Because the power is often generated far from where it is consumed, the transmission system can cover great distances. For a given amount of power, transmission efficiency is greater at higher voltages and lower currents. Therefore, voltages are stepped up at the generating station, and stepped down at local substations for distribution to customers. Most transmission is three-phase. Three-phase, compared to single-phase, can deliver much more power for a given amount of wire, since the neutral and ground wires are shared.[23] Further, three-phase generators and motors are more efficient than their single-phase counterparts. However, for conventional conductors one of the main losses are resistive losses which are a square law on current, and depend on distance. High voltage AC transmission lines can lose 1-4% per hundred miles.[24] However, high-voltage direct current can have half the losses of AC. Over very long distances, these efficiencies can offset the additional cost of the required AC/DC converter stations at each end. Substations Main article: Electrical substation Substations may perform many different functions but usually transform voltage from low to high (step up) and from high to low (step down). Between the generator and the final consumer, the voltage may be transformed several times.[25] The three main types of substations, by function, are:[26] Step-up substation: these use transformers to raise the voltage coming from the generators and power plants so that power can be transmitted long distances more efficiently, with smaller currents. Step-down substation: these transformers lower the

voltage coming from the transmission lines which can be used in industry or sent to a distribution substation. Distribution substation: these transform the voltage lower again for the distribution to end users. Aside from transformers, other major components or functions of substations include: Circuit breakers: used to automatically break a circuit and isolate a fault in the system.[27] Switches: to control the flow of electricity, and isolate equipment.[28] The substation busbar: typically a set of three conductors, one for each phase of current. The substation is organized around the buses, and they are connected to incoming lines, transformers, protection equipment, switches, and the outgoing lines.[27] Lightning arresters Capacitors for power factor correction Synchronous condensers for power factor correction and grid stability Electric power distribution Main article: Electric power distribution General layout of electricity grids. Voltages and depictions of electrical lines are typical for Germany and other European systems. Distribution is the final stage in the delivery of power; it carries electricity from the transmission system to individual consumers. Substations connect to the transmission system and lower the transmission voltage to medium voltage ranging between 2 kV and 35 kV. But the voltage levels varies very much between different countries, in Sweden medium voltage are normally 10 kV between 20 kV.[29] Primary distribution lines carry this medium voltage power to distribution transformers located near the customer's premises. Distribution transformers again lower the voltage to the utilization voltage. Customers demanding a much larger amount of power may be connected directly to the primary distribution level or the subtransmission level.[30] Distribution networks are divided into two types, radial or network.[31] In cities and towns of North America, the grid tends to follow the classic radially fed design. A substation receives its power from the transmission network, the power is stepped down with a transformer and sent to a bus from which feeders fan out in all directions across the countryside. These feeders carry three-phase power, and tend to follow the major streets near the substation. As the distance from the substation grows, the fanout continues as smaller laterals spread out to cover areas missed by the feeders. This tree-like structure grows outward from the substation, but for reliability reasons, usually contains at least one unused backup connection to a nearby substation. This connection can be enabled in case of an emergency, so that a portion of a substation's service territory can be alternatively fed by another substation. Storage Main article: Grid energy storage Energy from fossil or nuclear power plants and renewable sources is stored for use by customers. Simplified grid energy flow over the course of a day Grid energy storage (also called large-scale energy storage) is a collection of methods used for energy storage on a large scale within an electrical power grid. Electrical energy is stored during times when electricity is plentiful and inexpensive (especially from intermittent power sources such as renewable electricity from wind power, tidal power and solar power) or when demand is low, and later power is generated when demand is high, and electricity prices tend to be higher. As of 2020, the largest form of grid energy storage is dammed hydroelectricity, with both conventional hydroelectric generation as well as pumped storage hydroelectricity. Developments in battery storage have enabled commercially viable projects to store energy during peak production and release during peak demand, and for use when production unexpectedly falls giving time for slower responding resources to be brought online. Two alternatives to grid storage are the use of peaking power plants to fill in supply gaps and demand response to shift load to other times. Functionalities Demand The demand, or load on an electrical grid is the total electrical power being removed by the users of the grid. The graph of the demand over time is called the demand curve. Baseload is the minimum load on the grid over any given period, peak demand is the maximum load. Historically, baseload was commonly met by equipment that was relatively cheap to run, that ran continuously for weeks or months at a time, but globally this is becoming less common. The extra peak demand requirements are sometimes produced by expensive peaking plants that are generators optimised to come on-line quickly but these too are becoming less common. However, if the demand of electricity exceed the capacity of a local power grid, it will cause safety issue like burning out.[32] Voltage Grids are designed to supply electricity to their customers at largely constant voltages. This has to be achieved with varying demand, variable reactive loads, and even nonlinear loads, with electricity provided by generators and distribution and transmission equipment that are not perfectly reliable.[33] Often grids use tap changers on transformers near to the consumers to adjust the voltage and keep it within specification. Frequency Main article: Utility frequency In a synchronous grid all the generators must run at the same frequency, and must stay very nearly in phase with each other and the grid. Generation and consumption must be balanced across the entire grid, because energy is consumed as it is produced. For rotating generators, a local governor regulates the driving torque, maintaining almost constant rotation speed as loading changes. Energy is stored in the immediate short term by the rotational kinetic energy of the generators. Although the speed is kept largely constant, small deviations from the nominal system frequency are very important in regulating individual generators and are used as a way of assessing the equilibrium of the grid as a whole. When the grid is lightly loaded the grid frequency runs above the nominal frequency, and this is taken as an indication by Automatic Generation Control systems across the network that generators should reduce their output. Conversely, when the grid is heavily loaded, the frequency naturally slows, and governors adjust their generators so that more power is output (droop speed control). When generators have identical droop speed control settings it ensures that multiple parallel generators with the same settings share load in proportion to their rating. In addition, there's often central control, which can change the parameters of the AGC systems over timescales of a minute or longer to further adjust the regional network flows and the operating frequency of the grid. For timekeeping purposes, the nominal frequency will be allowed to vary in the short term, but is adjusted to prevent line-operated clocks from gaining or losing significant time over the course of a whole 24 hour period. An entire synchronous grid runs at the same frequency, neighbouring grids would not be synchronised even if they run at the same nominal frequency. High-voltage direct current lines or variable-frequency transformers can be used to connect two alternating current interconnection networks which are not synchronized with each other. This provides the benefit of interconnection without the need to synchronize an even wider area. For example, compare the wide area synchronous grid map of Europe with the map of HVDC lines. Capacity and firm capacity The sum of the maximum power outputs (nameplate capacity) of the generators attached to an electrical grid might be considered to be the capacity of the grid. However, in practice, they are never run flat out simultaneously. Typically, some generators are kept running at lower output powers (spinning reserve) to deal with failures as well as variation in demand. In addition generators can be off-line for maintenance or other reasons, such as availability of energy inputs (fuel, water, wind, sun etc.) or pollution constraints. Firm capacity is the maximum power output on a grid that is immediately available over a given time period, and is a far more useful figure. Production Most grid codes specify that the load is shared between the generators in merit order according to their marginal cost (i.e. cheapest first) and sometimes their environmental impact. Thus cheap electricity providers tend to be run flat out almost all the time, and the more expensive producers are only run when necessary. Failures and issues Failures are usually associated with generators or power transmission lines tripping circuit breakers due to faults leading to a loss of generation capacity for customers, or excess demand. This will often cause the frequency to reduce, and the remaining generators will react and together attempt to stabilize above the minimum. If that is not possible then a number of scenarios can occur. A large failure in one part of the grid — unless quickly compensated for — can cause current to re-route itself to flow from the remaining generators to consumers over transmission lines of insufficient capacity, causing further failures. One downside to a widely connected grid is thus the possibility of cascading failure and widespread power outage. A central authority is usually designated to facilitate communication and develop protocols to maintain a stable grid. For example, the North American Electric Reliability Corporation gained binding powers in the United States in 2006, and has advisory powers in the applicable parts of Canada and Mexico. The U.S. government has also designated National Interest Electric Transmission Corridors, where it believes transmission bottlenecks have developed. Brownout Main article: Brownout (electricity) A brownout near Tokyo Tower in Tokyo, Japan A brownout is an intentional or unintentional drop in voltage in an electrical power supply system. Intentional brownouts are used for load reduction in an emergency.[34] The reduction lasts for minutes or hours, as opposed to short-term voltage sag (or dip). The term brownout comes from the dimming experienced by incandescent lighting when the voltage sags. A voltage reduction may be an effect of disruption of an electrical grid, or may occasionally be imposed in an effort to reduce load and prevent a power outage, known as a blackout.[35] Blackout Main article: Power outage A power outage (also called a power cut, a power out, a power blackout, power failure or a blackout) is a loss of the electric power to a particular area. Power failures can be caused by faults at power stations, damage to electric transmission lines, substations or other parts of the distribution system, a short circuit, cascading failure, fuse or circuit breaker operation, and human error. Power failures are particularly critical at sites where the environment and public safety are at risk. Institutions such as hospitals, sewage treatment plants, mines, shelters and the like will usually have backup power sources such as standby generators, which will automatically start up when electrical power is lost. Other critical systems, such as telecommunication, are also required to have emergency power. The battery room of a telephone exchange usually has arrays of lead–acid batteries for backup and also a socket for connecting a generator during extended periods of outage. Load shedding Main article: Demand response Electrical generation and transmission systems may not always meet peak demand requirements— the greatest amount of electricity required by all utility customers within a given region. In these situations, overall demand must be lowered, either by turning off service to some devices or cutting back the supply voltage (brownouts), in order to prevent uncontrolled service disruptions such as power outages (widespread blackouts) or equipment damage. Utilities may impose load shedding on service areas via targeted blackouts, rolling blackouts or by agreements with specific high-use industrial consumers to turn off equipment at times of system-wide peak demand. Black start Main article: Black start Toronto during the Northeast blackout of 2003, which required black-starting of generating stations. A black start is the process of restoring an electric power station or a part of an electric grid to operation without relying on the external electric power transmission network to recover from a total or partial shutdown.[36] Normally, the electric power used within the plant is provided from the station's own generators. If all of the plant's main generators are shut down, station service power is provided by drawing power from the grid through the plant's transmission line. However, during a wide-area outage, off-site power from the grid is not available. In the absence of grid power, a so-called black start needs to be performed to bootstrap the power grid into operation. To provide a black start, some power stations have small diesel generators, normally called the black start diesel generator (BSDG), which can be used to start larger generators (of several megawatts capacity), which in turn can be used to start the main power station generators. Generating plants using steam turbines require station service power of up to 10% of their capacity for boiler feedwater pumps, boiler forced-draft combustion air blowers, and for fuel preparation. It is uneconomical to provide such a large standby capacity at each station, so black-start power must be provided over designated tie lines from another station. Often hydroelectric power plants are designated as the black-start sources to restore network interconnections. A hydroelectric station needs very little initial power to start (just enough to open the intake gates and provide excitation current to the generator field coils), and can put a large block of power on line very quickly to allow start-up of fossil-fuel or nuclear stations. Certain types of combustion turbine can be configured for black start, providing another option in places without suitable hydroelectric plants.[37] In 2017 a utility in Southern California has successfully demonstrated the use of a battery energy storage system to provide a black start, firing up a combined cycle gas turbine from an idle state.[38] Obsolescence Despite novel institutional arrangements and network designs, power delivery infrastructures is experiencing aging across the developed world. Contributing factors include: Aging equipment – older equipment has higher failure rates, leading to customer interruption rates affecting the economy and society; also, older assets and facilities lead to higher inspection maintenance costs and further repair and restoration costs. Obsolete system layout – older areas require serious additional substation sites and rights-of-way that cannot be obtained in the current area and are forced to use existing, insufficient facilities. Outdated engineering – traditional tools for power delivery planning and engineering are ineffective in addressing current problems of aged equipment, obsolete system layouts, and modern deregulated loading levels. Old cultural value – planning, engineering, operating of system using concepts and procedures that worked in vertically integrated industry exacerbate the problem under a deregulated industry.[39] Trends Demand response Demand response is a grid management technique where retail or wholesale customers are requested or incentivised either electronically or manually to reduce their load. Currently, transmission grid operators use demand response to request load reduction from major energy users such as industrial plants.[40] Technologies such as smart metering can encourage customers to use power when electricity is plentiful by allowing for variable pricing. Smart grid This section is an excerpt from Smart grid.[edit] Characteristics of a traditional centralized electrical system (left) vis-à-vis those of a smart grid (right) The smart grid is an enhancement of the 20th century electrical grid, using two-way communications and distributed so-called intelligent devices.[41] Two-way flows of electricity and information could improve the delivery network. Research is mainly focused on three systems of a smart grid – the infrastructure system, the management system, and the protection system.[42] Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid.[43] The smart grid represents the full suite of current and proposed responses to the challenges of electricity supply. Numerous contributions to the overall improvement of energy infrastructure efficiency are anticipated from the deployment of smart grid technology, in particular including demand-side management. The improved flexibility of the smart grid permits greater penetration of highly variable renewable energy sources such as solar power and wind power, even without the addition of energy storage. Smart grids could also monitor/control residential devices that are noncritical during periods of peak power consumption, and return their function during nonpeak hours.[44] A smart grid includes a variety of operation and energy measures: Advanced metering infrastructure (of which smart meters are a generic name for any utility side device even if it is more capable e.g. a fiber optic router) Smart distribution boards and circuit breakers integrated with home control and demand response (behind the meter from a utility perspective) Load control switches and smart appliances, often financed by efficiency gains on municipal programs (e.g. PACE financing) Renewable energy resources, including the capacity to charge parked (electric vehicle) batteries or larger arrays of batteries recycled from these, or other energy storage. Energy efficient resources Electric surplus distribution by power lines and auto-smart switch Sufficient utility grade fiber broadband to connect and monitor the above, with wireless as a backup. Sufficient spare if "dark" capacity to ensure failover, often leased for revenue.[45][46] Concerns with smart grid technology mostly focus on smart meters, items enabled by them, and general security issues. Roll-out of smart grid technology also implies a fundamental re-engineering of the electricity services industry, although typical usage of the term is focused on the technical infrastructure.[47] Smart grid policy is organized in Europe as Smart Grid European Technology Platform.[48] Policy in the United States is described in Title 42 of the United States Code.[49] Grid defection Resistance to distributed generation among grid operators may encourage providers to leave the grid and instead distribute power to smaller geographies.[50][51][52] The Rocky Mountain Institute[53] and other studies[54] foresee widescale grid defection. However, grid defection may be less likely in places such as Germany that have greater power demands in the winter.[55] History Early electric energy was produced near the device or service requiring that energy. In the 1880s, electricity competed with steam, hydraulics, and especially coal gas. Coal gas was first produced on customer's premises but later evolved into gasification plants that enjoyed economies of scale. In the industrialized world, cities had networks of piped gas, used for lighting. But gas lamps produced poor light, wasted heat, made rooms hot and smoky, and gave off hydrogen and carbon monoxide. They also posed a fire hazard. In the 1880s electric lighting soon became advantageous compared to gas lighting. Electric utility companies established central stations to take advantage of economies of scale and moved to centralized power generation, distribution, and system management.[56] After the war of the currents was settled in favor of AC power, with long-distance power transmission it became possible to interconnect stations to balance the loads and improve load factors. Historically, transmission and distribution lines were owned by the same company, but starting in the 1990s, many countries have liberalized the regulation of the electricity market in ways that have led to the separation of the electricity transmission business from the distribution business.[57] In the United Kingdom, Charles Merz, of the Merz & McLellan consulting partnership, built the Neptune Bank Power Station near Newcastle upon Tyne in 1901,[58] and by 1912 had developed into the largest integrated power system in Europe.[59] Merz was appointed head of a parliamentary committee and his findings led to the Williamson Report of 1918, which in turn created the Electricity (Supply) Act 1919. The bill was the first step towards an integrated electricity system. In 1925 the Weir Committee recommended the creation of a "national gridiron" and so the Electricity (Supply) Act 1926 created the Central Electricity Board (CEB).[60] The CEB standardized the nation's electricity supply and established the first synchronized AC grid, running at 132 kilovolts and 50 hertz but initially operated as regional grids. After brief overnight interconnection in 1937 they permanently and officially joined in 1938 becoming the UK National Grid. In France, electrification began in the 1900s, with 700 communes in 1919, and 36,528 in 1938. At the same time, these close networks began to interconnect: Paris in 1907 at 12 kV, the Pyrénées in 1923 at 150 kV, and finally almost all of the country interconnected by 1938 at 220 kV. In 1946, the grid was the world's most dense. That year the state nationalised the industry, by uniting the private companies as Électricité de France. The frequency was standardised at 50 Hz, and the 225 kV network replaced 110 kV and 120 kV. Since 1956, service voltage has been standardised at 220/380 V, replacing the previous 127/220 V. During the 1970s, the 400 kV network, the new European standard, was implemented. Starting on May 29, 1986, the end user service voltage will progressively change to 230/400 V +/-10%.[61][62] In the United States in the 1920s, utilities formed joint-operations to share peak load coverage and backup power. In 1934, with the passage of the Public Utility Holding Company Act (USA), electric utilities were recognized as public goods of importance and were given outlined restrictions and regulatory oversight of their operations. The Energy Policy Act of 1992 required transmission line owners to allow electric generation companies open access to their network[56][63] and led to a restructuring of how the electric industry operated in an effort to create competition in power generation. No longer were electric utilities built as vertical monopolies, where generation, transmission and distribution were handled by a single company. Now, the three stages could be split among various companies, in an effort to provide fair access to high voltage transmission.[20][21] The Energy Policy Act of 2005 allowed incentives and loan guarantees for alternative energy production and advance innovative technologies that avoided greenhouse emissions. In China, electrification began in the 1950s.[64] In August 1961, the electrification of the Baoji-Fengzhou section of the Baocheng Railway was completed and delivered for operation, becoming China's first electrified railway.[65] From 1958 to 1998, China's electrified railway reached 6,200 miles (10,000 kilometres).[66] As of the end of 2017, this number has reached 54,000 miles (87,000 kilometres).[67] In the current railway electrification system of China, State Grid Corporation of China—Archived 2021-12-21 at the Wayback Machine—is an important power supplier. In 2019, it completed the power supply project of China's important electrified railways in its operating areas, such as Jingtong Railway, Haoji Railway, Zhengzhou–Wanzhou high-speed railway, et cetera, providing power supply guarantee for 110 traction stations, and its cumulative power line construction length reached 6,586 kilometres.[68] Contents (Top) Background References National Energy Regulator of South Africa Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia National Energy Regulator of South Africa Agency overview Formed 2005; 20 years ago Jurisdiction South Africa Headquarters Kulawula House, 526 Madiba Street, Arcadia, Pretoria Agency executives Thembani Bukula, Chairperson Nomalanga Sithole, CEO Website https://www.nersa.org.za/ National Energy Regulator of South Africa (NERSA), is the regulatory authority for the electricity supply industry in South Africa.[1] Background National Energy Regulator of South Africa was established to regulate the energy industry in South Africa and to follow government standards, laws, policies and international best practices in support of sustainable development.[2][3][4] It was established by the section 3 of the National Energy Regulator Act, 2004 (Act No. 40 of 2004). NERSA's mandate is to regulate the electricity, piped-gas and petroleum pipelines industries in terms of the 2001 Gas Act, Petroleum Pipelines act of 2003 and the Electricity Regulation Act..[5][6] In November 2020, NERSA announced it was approving the procurement of 2,500 megawatts of nuclear power by the Department of Mineral Resources and Energy skom Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia Not to be confused with other similarly-named but unrelated businesses known as Escom. Eskom Company type Public utility Traded as JSE: BIESKM Industry Energy Founded 1 March 1923; 101 years ago Headquarters Sunninghill, Sandton, South Africa Key people Mteto Nyati (Chairman) Dan Marokane (Group Chief Executive) Calib Cassim (Chief Financial Officer) Services Electricity generation, transmission and distribution Revenue R 204.3 billion (FY2021)[1] US$ 13.82 billion Net income R-18.9 billion (FY2021)[1] US$ -1.28 billion Total assets R 781 billion (FY2021)[1] US$52.84 billion Number of employees 42,749 (FY2021)[1] Subsidiaries List ASN 37121 Website www.eskom.co.za Eskom Hld SOC Ltd or Eskom is a South African electricity public utility. Eskom was established in 1923 as the Electricity Supply Commission (ESCOM) (Afrikaans: Elektrisiteitsvoorsieningskommissie (EVKOM)). Eskom represents South Africa in the Southern African Power Pool. The utility is the largest producer of electricity in Africa,[2][3] and was among the top utilities in the world in terms of generation capacity and sales. It is the largest of South Africa's state owned enterprises. Eskom operates a number of notable power stations, including Matimba Power Station and Medupi Power Station in Lephalale, Kusile Power Station in Witbank, Kendal Power Station, and Koeberg Nuclear Power Station in the Western Cape Province, the only nuclear power plant in Africa. The company is divided into Generation, Transmission and Distribution divisions, and together Eskom generates approximately 95% of electricity used in South Africa, amounting to ~45% used in Africa,[4] and emits 42% of South Africa's total greenhouse gas emissions.[5][6][7][8] By releasing 1.6 million tons of sulphur dioxide into the air in 2019, Eskom is also the largest emitter of sulphur dioxide in the power industry in the world.[9] Eskom has periodically implemented rolling blackouts since January 2008, a practice ascribed to basic dereliction of duty by former president Thabo Mbeki.[10] Implementation of new generating capacity during this period was fraught with delays and cost overruns which brought the utility to the brink of bankruptcy.[11] In 2019, it was announced that Eskom was to be split up into three distinct nationally owned entities due to huge debts and poor reliability of supply.[12] At the 2021 United Nations Climate Change Conference, a deal was announced for developed countries to fund South Africa's transition from coal power to renewable energy. However, employment in the mining sector threatens this transition.[13] History The Congella Power Station completed in 1928 was one of the first power plants built and owned by Eskom. Prior to the establishment of Eskom, the provision of electricity was dominated by municipalities and private companies. The city of Kimberley was one of the first users of public electricity when it installed electric streetlights in 1882 to reduce crime at night.[14]: 5 [15] This was followed by Cape Town in 1895 with the construction of the Graaff Electric Lighting Works to power 775 street lights. Eskom was founded by the Electricity Act of 1922 which allowed the South African Electricity Control Board to appoint Hendrik Johannes van der Bijl as chairman.[16] The company changed its name by combining the two acronyms in its previous name (ESCOM and ESKOM) in 1987 to become known as Eskom. The Electricity Act stated that Eskom could only sell electricity at cost and was exempted from tax with the firm initially raising capital through the issuing of debentures, later issuing state-guaranteed loans instead. The coal-fired Congella Power Station in Durban and Salt River Power Station in Cape Town were the first power stations built by Eskom, both completed in mid-1928.[17] One of Eskom's first power plants was a coal-fired 128 MW station in Witbank, completed in 1935 to provide power to the mining industry. The plant was built and run in partnership with the privately owned Victoria Falls and Transvaal Power Company, which owned a number of other power plants across the country. Thanks to state support, Eskom was able to buy out the Victoria Falls and Transvaal Power Company in 1948 for £14.5 million (roughly equivalent to £2.55 billion in 2017). Following World War 2, South Africa experienced power shortages that led to Eskom negotiating power saving agreements with the mining industry in June 1948.[14]: 6 First expansion period: 1960-1994 Arnot Power Station completed in 1975 was one of the first of the "six-pack" coal-fired power plants built during this period that Eskom was well known for. From 1960 to 1990 Eskom increased its installed power production capacity from 4,000 MW to 40,000 MW so as to keep up with rapid economic growth in the 1960s and 70s.[14]: 4 During the same period, Eskom established a nationwide 400 kV power network. During this period the company built a number of large standardised coal-fired power plants that could produce power at very low cost due to the large economies of scale. These plants were known colloquially as "six-packs" for the 6 large generator units they were designed to accommodate.[14]: 7 In 1974 the company was instructed to start work on Koeberg nuclear power station to both provide power to Cape Town and help facilitate the South African government's nuclear program.[14]: 7 In 1981 Eskom was involved in one of its first large financial scandals when its Assistant Chief Accountant was caught embezzling R8 million from the company[14]: 7 (equivalent to roughly R164.37 million in 2018).[18] During the 1970s the company controversially sought to increase electrical tariffs to help pay for its large expansion plans. Due to its financial situation, the government appointed Dr. W.J. de Villiers to chair a commission that recommended a number of financial and organisational changes for the company to adopt. This led to the company abandoning its no-profit objective and to raise funds by taking out international loans. The number of Eskom employees was also reduced from 66,000 to 60,000 in the late-1980s.[14]: 8 Post-1994 election period: 1994-2007 Following democratic elections in 1994 and the start of the Mandela government the company changed focus to electrification of previously neglected residential homes and to provide low cost electricity for economic growth. Following the passing of the 1998 Eskom Amendment Act government's powers to influence company policy and investment decisions were greatly expanded.[14]: 8–9 Due to the South African government's attempted privatisation of Eskom in the late 1990s during the administration of President Thabo Mbeki, Eskom requests for budget to build new stations were denied. After leaving the presidency, Mbeki would later state in December 2007 that this was an error, resulting in adverse affects for the South African economy.[19] Construction work on the Medupi (pictured) and Kusile coal-fired power stations was started in the 2007-2019 period as part of Eskom's capacity expansion program following the energy crisis. Load shedding and second expansion: 2007-present See also: South African energy crisis In February 2006, Eskom announced "load shedding" in the Western Cape province, due to issues experienced by Koeberg Nuclear Power Plant[20] this continued until June 2006. In January 2008, Eskom controversially introduced load shedding nationally (rolling blackouts) based on a rotating schedule, in periods where short supply threatened the integrity of the grid. Demand-side management has focused on encouraging consumers to conserve power during peak periods in order to reduce the incidence of load shedding. Following the national power shortage in 2007, Eskom embarked on an aggressive electricity production expansion programme during the administration of President Jacob Zuma. The Zuma administration decided to focus expansion efforts on building additional large scale six-pack coal-fired power plants.[21] In 2016, Eskom stated it intended to pursue a nuclear solution to the country's energy shortage. According to projections from late 2016, the use of nuclear power would provide over 1000GW of power by 2050. In preparation, the company launched a training program for 100 technicians, engineers and artisans that would certify them as nuclear operators.[22] In January 2018, Eskom's acting chief financial officer stated that the company could not afford a new build, following a 34% drop in interim profits due to declining sales and increasing financing costs. The government stated it would proceed with the plan but more slowly.[23] In 2017, Eskom was the focus of a major corruption scandal involving the Gupta family and the administration of then President Jacob Zuma. The National Energy Regulator of South Africa denied an application by Eskom to increase electricity tariffs by a future 19.9% for the financial year 2018/19. The regulator instead granted a 5.2% increase and gave a list of reasons for the refusal to grant higher tariffs that the South African newspaper Business Day stated painted "a picture of inefficiency, inaccurate forecasting and cost overruns" at the power utility. Part of the refusal was the finding that Eskom had 6,000 more employees than needed, costing the company R3.8 billion annually.[24] In February 2019, shortly after the announcement by government that the company would be broken up, Eskom initiated another round of emergency load shedding. Eskom stated that the 2019 load shedding was initiated due to breakdowns at power stations as well as the depletion of water and diesel resources. Other reasons cited included legacy issues from state capture corruption, coal availability, and that new power plants such as Medupi and Kusile were not yet operational.[25][26] Corruption during the Zuma administration had been noted as a major factor in the cost overruns and long delays in completing Medupi and Kusile power plants that had a knock-on effect leading to the 2019 power shortages.[26] The power shortage and related troubles at Eskom was blamed as a significant contributing factor to a 3.2% decline in GDP growth in the first quarter of 2019,[27] prompting fears of a recession in 2019.[28] In December 2019, President Ramaphosa, deputy president David Mabuza and Ministers Gwede Mantashe and Pravin Gordhan met with Eskom's board and management to discuss about the energy crises.[29] The president attributed the recent blackouts partly to sabotage at the Tutuka Power Station in Mpumalanga which had caused a loss of 2000 megawatts of electricity,[30] and announced measures to bring an end to load-shedding. Mantashe and Gordhan were tasked with presenting ways to increase electricity capacity to the cabinet, which would include self-generation.[31] Amid the crisis, Jabu Mabuza resigned from his post as chairperson of Eskom's board in January 2020.[32] Between March and July 2020 the power supply was stable due to reduced demand during the COVID-19 lockdown,[33] but on 12 July a new round of level 2 load shedding began due to the breakdown of generating units.[34] During the winter of 2023, the country experienced Stage 6 blackouts, shaving a projected 2% off the country's GDP.[35] During the worst period, power cuts lasted 12 hours a day.[36] The company faces theft of materials for resale, sabotage to force repairs to be made at corruptly inflated prices, and assassination attempts which may be motivated by the attempt to replace coal with renewable sources.[37] Logos Eskom's logo has been an integral symbol of the company since its founding. For a brief period in 1986 Eskom had no logo when it was moving away from the company's original logo of stylised letters spelling "ESC" within a circle to the more contemporary version with a blue shield with a stylised lightning bolt in its centre. The 1987 logo was replaced in 2002 with its current logo that replaced the shield with a circle but otherwise kept the logo as it was. 1923 1987 2002 Restructuring efforts Eskom's sales have been declining by about 1% per annum. The less it sells, the higher the tariff it wants, and the less it sells – the utility death spiral. Rod Crompton, Adjunct professor African Energy Leadership Centre Wits Business School, University of the Witwatersrand[38] In December 1998, a white paper prepared by the Department of Minerals and Energy recommended that the government restructure Eskom into separate generation and transmission businesses. Although the report predicted that this action would improve power supply and reliability, it was never enacted.[39] In February 2019, these plans were resurrected during the State of the Nation address. President Ramaphosa announced that the government would be splitting Eskom up into three new state-owned entities focusing on generation, transmission and distribution.[12] This was done so as to better manage the serious operational and financial problems facing the company. By the time of the speech Eskom had a total debt burden of R419 billion[12] (US$30.8 billion) and was entering a death spiral whereby there was not enough revenue to make debt repayments.[38] In a February 2019 briefing, the Department of Public Enterprises stated that Eskom was "technically insolvent" and would not be able to operate past the next three months if it did not receive additional loans.[40] Finance Minister Tito Mboweni then announced in his 2019 budget speech that government would be providing a R69 billion rand (US$5 billion) bail-out to Eskom over a three-year period so as to stabilise the company's serious financial situation.[41] Transmission Main article: National Transmission Company of South Africa As result of the restructuring, a transmission entity called the National Transmission Company of South Africa (NTCSA), a wholly-owned subsidiary of Eskom, would be given its own board, by 31 March 2020 in which the transmission legal entity would be responsible for hearing legislative amendments in accordance to government law. This new transmission entity would involve up to 6,000 people that are responsible of setting up thousands of kilometres of "wires" and transmission lines that would ensure electricity from the power stations to where power is needed.[42] As part of the Transmission Development Plan (TDP) for 2020–2029 Eskom has plans to increase its transmission infrastructure by approximately 4,800 km of extra high voltage transmission lines, and over 35,000 MVA of transformer capacity over the next 10 years. This new outline of reconstructing Eskom comes from new regulatory guidelines from the National Energy Regulator of South Africa (NERSA) to publish an annual TDP report.[citation needed] In July 2023, NERSA approved for the National Transmission Company of South Africa to operate a transmission system in South Africa.[43] In September 2023, NERSA approved the remaining trading and import/export licences.[44] COSATU response In response to feared job losses resulting from the breakup the trade union COSATU organised a national strike and called for a moratorium on retrenchments in the private and public sectors.[45][46][47] This caused to the apparent abandonment of the government's company breakup and restructuring plans.[46][48] In July 2019 the outgoing Eskom CEO announced that Eskom had entered a "death spiral" and highlighted the need for the company to restructure.[48][49] Following the appointment of André de Ruyter as Eskom CEO trade unions National Union of Mineworkers and Solidarity stated that they would fight any government restructuring efforts that might result in job losses.[50] In December 2019 COSATU suggested that money be used from the Public Investment Corporation (PIC) to reduce Eskom's debt from around R450 billion to more manageable levels.[51] In return COSATU proposed a number of conditions that included keeping workers employed.[52] The trade union Solidarity was strongly apposed to the COSATU proposal arguing that it put the pensions of public employees at risk.[53] The country's second biggest trade union, the Federation of Unions of South Africa, was also skeptical of COSATU's proposed plan.[54] Job losses Between 2020 and 2021, two thousand employees lost their jobs at the power utility. 6000 more jobs are reportedly at risk in order for the company to continue operating.[55] Installed capacity Main article: List of power stations in South Africa Subscribers Eskom – the only electricity utility in the country – has 16,789,974 subscribers in South Africa, comprising about one-third of the population. Fossil-fuelled power stations Power plant Province Type Date commissioned (planned) Capacity (MW) (planned) Status Notes Acacia Power Station Western Cape Gas turbine 1976 171 Operational [56] [permanent dead link] Ankerlig Power Station Western Cape Gas turbine 2007 1,338 Operational [57] Arnot Power Station Mpumalanga Coal-fired 1971-1975 2,352 Operational [58][59] Camden Power Station Mpumalanga Coal-fired 1967-1969; 2005-2008 1,561 Operational [59][60] Duvha Power Station Mpumalanga Coal-fired 1980-1984 3,600 Operational [59][61][62] Gourikwa Power Station Western Cape Gas turbine 2007 746 Operational [57] Grootvlei Power Station Mpumalanga Coal-fired 1969-1977; 2008-2011 1,180 Operational [59][63] Hendrina Power Station Mpumalanga Coal-fired 1970-1976 1,893 Operational [59][64] Kendal Power Station Mpumalanga Coal-fired 1988-1992 4,116 Operational [59][65][66] Komati Power Station Mpumalanga Coal-fired 1961-1966; 2009-2013 990 Operational [59][67] Kriel Power Station Mpumalanga Coal-fired 1976-1979 3,000 Operational [59][68][69] Kusile Power Station Mpumalanga Coal-fired (2017–2025) 3,200 (4,800) 4/6 units operational [70][71][72][73][74] Lethabo Power Station Free State Coal-fired 1985-1990 3,708 Operational [59][75] Majuba Power Station Mpumalanga Coal-fired 1996–2001 4,110 Operational [59][76][77][unreliable source?] Matimba Power Station Limpopo Coal-fired 1987-1991 3,990 Operational [59][78] Matla Power Station Mpumalanga Coal-fired 1979-1983 3,600 Operational [59][79] Medupi Power Station Limpopo Coal-fired 2015–2019 4,764 Operational [72][80][81][73][74] Port Rex Power Station Eastern Cape Gas turbine 1976 171 Operational [56] Tutuka Power Station Mpumalanga Coal-fired 1985-1990 3,654 Operational [59][82] Renewable and nuclear power stations Eskom Generation's pilot wind farm facility at Klipheuwel in the Western Cape, South Africa. Power plant Province Type Date commissioned Installed capacity (MW) Status Notes Colley Wobbles Power Station Eastern Cape Hydroelectric 1984 42 Operational Drakensberg Pumped Storage Scheme Free State Hydroelectric 1981 1,000 Operational [83] Gariep Dam Free State-Eastern Cape border Hydroelectric 1971 360 Operational [84] Ingula Pumped Storage Scheme KwaZulu-Natal Hydroelectric 2017 1,332 Operational [73][85] Koeberg Power Station Western Cape Nuclear 1984 1,860 Operational [86][87] Ncora Dam Eastern Cape Hydroelectric 1972 2.1 Operational [88] Palmiet Pumped Storage Scheme Western Cape Hydroelectric 1988 400 Operational [89][90] Sere Wind Farm Western Cape Wind Jan 2015 100 Operational [91][92][93][94] Vanderkloof Dam Northern Cape Hydroelectric 1977 240 Operational Future projects Eskom has a number of planned infrastructure projects to further expand electrical production. Tubatse Pumped Storage Scheme – 1500MWe Wind 500 – 550MWe Tasakoolo Wind farm 200 – 200Mwe Investment in renewables As of October 2019 Eskom Holdings SOC Ltd issued a tender to introduce 20 three-phase KW inverters and mountains structures. These structures are planned to distribute power to four power plants, and would introduce Eskom into the solar energy market. The African Investment Forum has announced that it has raised over $40.1 billion in investment into developing new infrastructure, related to renewable energies.[95] This is aimed to help distance itself from Eskom coal power plants, and to focus more on wind and solar developments. The African investment forum is backed up by corporate organizations and lenders, private donors, and the African Development Bank.[96] These new inverters would be align with South Africa's Integrated Resource Plan (IRP).[citation needed] South Africa's integrated resource plan The IRP supports a diverse energy mix with policy aimed to help aim to meet the need of South Africa's energy goals. The Integrated Resource Plan supports electrical infrastructure developments with an aim focused on renewable energy sources.[97] These new investments are directed towards more high efficiency, low emission standards with an emphasis on solar technologies in which 6,000 MW of new Solar PV capabilities and 14,400 MW of new wind power technologies.[98] With renewable energies, the IRP plans to increase its investment in hydro-electric power.[99] Investment in renewables, hydro, wind, solar With failing power plants and coal not working as a viable solution, progress towards a greener future is in sight for South Africa. In agreement to the Paris Agreement, South Africa needs to reduce its carbon emission and cut-back from being dependent on Coal. There is new US$11 Billion Green-Energy Initiative aimed at the development of solar and wind. This new initiative would allow loans to Eskom and below commercial rates on conditions that it would accelerate its closure of power plants and to start building renewable energy structures.[100] This plan takes the steps in moving away from coal, and investing in alternative methods that better suit their needs for the future.[citation needed] Other infrastructure In 2002, Eskom was issued a network operator licence. It embarked on a $100 million project installing fibre optic cables on 10 000 kilometres of its existing power lines for the purpose of real-time monitoring of the electrical network; 80% consists of all-dielectric lashed cabling and 10% All-dielectric self-supporting cabling. It currently has the sixth most ASN prefixes of all registered network operator licensees.[101] Corporate affairs Eskom executives including Phakamani Hadebe (CEO), front row second from the left, and Jan Oberholzer (CTO), front row far left, at a 2019 public forum in Cape Town on Eskom's financial situation. In 2011 eight out of ten Eskom board members were controversially sacked by the Zuma administration.[21] From 2015 to 2017 the Zuma administration appointed Ben Ngubane as chairperson of the board. Brian Molefe was appointed by Zuma as Eskom CEO from April 2015 to November 2016. Molefe[102] and Ngubane's[103] tenure was controversial for their involvement with the Gupta family and for allegedly allowing the company to become a vehicle for state capture.[104][105][106][107] Ngubane also controversially attempted to blacklist newspapers perceived as unfriendly to Eskom.[103] During parliament's state capture inquiry in 2017 former Eskom chairperson Zola Tsotsi (2012–2015) testified that Gupta family member Tony Gupta made threats against Tsotsi allegedly stating that Tsotsi will lose his job as he was not 'helping' the Guptas.[108] In December 2016, Matshela Koko, former head of generation for Eskom, was named as acting CEO.[109] He resigned in 2018 after being implicated in awarding contracts to a company linked to his stepdaughter.[110] Koko, along with his wife and stepdaughter, were arrested in October 2022.[111] In early 2018, following the establishment of the Ramaphosa government, multiple members of the Eskom board and executive team were replaced by government due to allegations of corruption and mismanagement.[112] Phakamani Hadebe was made acting CEO and director of Eskom in May 2018 as part of President Ramaphosa's replacement of the company's executive team.[113] A year into his term as CEO Hadebe resigned citing poor health and the difficult circumstances of the job.[114] His resignation sparked a debate amongst political parties over the difficult state of managing the financially strained state owned company[115] as well as the lack of political cover he was given to deal with labour unions and tackle corruption.[116] Six months after Hadebe's departure, former Nampak Chief Executive[117] André de Ruyter was appointed CEO of Eskom.[118][119] De Ruyter's appointment was criticised by the EFF[120] and factions within the ANC who instead wanted a black CEO appointed to the position.[121] De Ruyter resigned in December 2022 after repeated attacks on him by Gwede Mantashe, Minister of Mineral Resources and Energy[122][123][124] partly due to de Ruyter's advocacy for replacing coal with renewables as an energy source.[125] News24 reported that he was not given the support needed to succeed in the position.[126] Shortly after the announcement that de Ruyter would be leaving Eskom it was reported that he survived a poisoning attempt after he unknowingly drank a cup of coffee at his office that was laced with cyanide.[127] Financials 2011[128] 2012[129] 2013[129] 2014[130] 2015[130] 2016[131] 2017[131] 2018[132] 2019[133] 2020[1] 2021[1] Revenue (R billion) 91.45 114.8 128.9 138.3 147.7 164.2 177.1 177.4 179.8 199.5 204.3 Operating profit (R billion) 14.5 22.3 3.99 13.2 11.1 15.7 15.5 20.5 −1.77 4.41 6.68 Net income (R billion) 8.36 13.2 5.18 7.09 3.62 5.15 0.88 −2.33 −20.7 −20.8 −18.9 Total debt (R billion) 160.3 182.6 202.9 254.8 297.4 322.7 355.3 388.7 440.6 483.7 401.8 Employee benefit expenses (R billion) 16.7 20.2 23.6 25.6 25.9 29.2 33.1 29.4 33.3 33.2 32.9 Number of employees 41,778 43,473 46,266 46,919 46,490 47,978 47,658 48,628 46,665 44,772 42,749 Electrical output capacity (GWh) 237,430 237,414 232,228 231,129 226,300 238,599 220,166 221,936 218,939 214,968 201,400 In 2018 and 2019 Eskom's negative financial situation became serious as costs started exceeding income and the company started experiencing trouble raising money. For 72 hours between 26 March and 29 March 2019 it was reported that Eskom had run out of funds thereby threatening to negatively impact the broader South African economy. The situation was alleviated once Eskom secured a R3 billion commercial loan which was paid back on 2 April after the Reserve Bank disbursed R5 billion to Eskom through an emergency provision.[134] In July 2019 Eskom announced a loss of R20.7 billion due to the cost of servicing high levels of debt, the increased cost of primary energy and unpaid municipal debts.[135] Debt In late 2016, Standard & Poor's Global Ratings downgraded Eskom's credit rating further into subinvestment grade cutting its long-term credit rating to BB – two levels below the investment threshold.[136] By 2017 increasing levels of debt and corruption scandals affecting the company has led investment bank Goldman Sachs to declare Eskom as being the "biggest risk to South Africa's economy." The company had R413 billion in debt and planned to raise an additional R340 billion (US$26 billion) by 2022 thereby representing eight percent of South Africa's GDP. R218.2 billion of the company's debt consist of government guarantees.[137] Exacerbating the company's financial situation was a recorded R3 billion worth of irregular expenditures in 2017.[115] On 28 March 2018 Moody's Investors Service downgraded Eskom's credit rating to B2 from B1 stating that it was concerned with "the lack of any tangible financial support for the company in the February state budget".[138] On 24 November 2020, Moody's further downgraded Eskom's long-term credit rating to Caa1.[139] This places Eskom's credit within the "speculative grade" of investment, with a "very high credit risk". Due to the company's large size and important role as the region's primary energy producer President Ramaphosa stated that Eskom was "too big to fail" as the reason why government had to continue to fund it despite its serious financial situation.[140] In February 2023, with debt sitting at R423 billion, the South African government announced that, subject to approval from existing debt holders, it would be providing support worth R254 billion, including interest payments for the following three years and three capital payments of R78-billion in 2023/24, R66 billion in 2024/25 and R40-billion in 2025/26, with the intention to reduce Eskom's overall debt to R300 billion.[141] Chinese debt In July 2018 it was announced that Eskom had taken out a R33 billion loan from the Chinese government owned China Development Bank.[142] The loan conditions were controversially[143] not made public with accusations that it was an example of debt-trap diplomacy by China.[144] During the Zondo Commission of Inquiry into state corruption a senior Eskom executive stated that an additional R25 billion loan from the China-based company Huarong Energy Africa was improperly and controversially taken out by Eskom.[145] After the loan had been issued Eskom chairperson Jabu Mabuza stated to the Zondo Commission that Eskom would not be repaying the Huarong loan due to irregularities and corruption involved in the issuing of the loan.[146] Controversies Municipal debts A number of South African municipalities are in significant arrears in paying Eskom for electricity supplied to them. The large amount owed to Eskom has caused significant controversy given the state utilities financial difficulties and repeated periods of load-shedding.[147] By January 2020 South African municipalities owed Eskom a total of roughly R43 billion[148] (equivalent to US$2.88 billion). This had increased to R49.1 billion by July 2022.[149] Soweto The single largest South African municipality to owe Eskom for unpaid electricity is the City of Johannesburg Metropolitan Municipality in which Soweto owes R13 billion[150] to R16.4 billion[148] in 2019. In response, Eskom initiated a process of cutting off electricity to debtors in the city, which resulted in violent public protests.[151][152] The city has a history of non-payment dating back to the 1980s when non-payment was used as a form of non-violent protest against apartheid era policies.[153] This is thought to have cultivated a culture of non-payment.[150] Zimbabwe Power Exports 300MW of power are exported to Zimbabwe in a deal valued at US$2 million a month. At the end of November 2019 it was revealed that Zimbabwe owed $22 million in debt to Eskom (about 11 months in areas). Despite statements that Eskom continues to supply Zimbabwe during scheduled blackouts,[154] electricity is only supplied if Eskom does not need it.[155][156] Power shortage: 2007 - ongoing See also: South African energy crisis An election poster referring to the Eskom energy crisis in the run up to the 2019 general election. In the later months of 2007, South Africa started experiencing widespread rolling blackouts as supply fell behind demand, threatening to destabilise the national grid. With a reserve margin estimated at 8% or below,[157] such "load shedding" is implemented whenever generating units are taken offline for maintenance, repairs or re-fuelling (in the case of nuclear units). From February 2008 to November 2014 blackouts were temporarily halted due to reduced demand and maintenance stabilization.[158] This drop in demand was caused by many of the country's mines shutting down or slowing to help alleviate the burden. Load shedding was reintroduced in early November 2014. The Majuba power plant lost its capacity to generate power after a collapse of one of its coal storage silos on 1 November 2014. The Majuba power plant delivered approximately 10% of the country's entire capacity and the collapse halted the delivery of coal to the plant.[159] A second silo developed a major crack on 20 November causing the shut down of the plant again, this after temporary measures were instituted to deliver coal to the plant.[160] In 2016, Eskom said that unplanned outages had been reduced. In May 2016, former president Jacob Zuma said assurances had been given to him by Eskom management.[161] In June 2018, there was Stage 1 load shedding along with a strike over wages.[161] In February 2019, a new round of load shedding began due to the failure of coal burning boilers at some power stations due to poor quality coal. This resulted in long running periods of level 4 load shedding across the country in mid-March 2019, including night-time load shedding[162] and promised to report back.[161] The situation at Eskom and resulting energy crisis became a political issue during the 2019 South African general elections.[163][164][165] Sabotage In December 2019, load shedding reached a new high as Eskom introduced stage 6 load shedding for the first time.[166] Cyril Ramaphosa faced criticism as his departure for Egypt was announced shortly after the move to stage 6.[167] He returned early to address the problem, meeting on 11 December with the Eskom board. Ramaphosa then announced that there had been an element of sabotage involved, leading to the loss of 2000MW capacity. Ramaphosa faced criticism on social media, with many blaming incompetence rather than sabotage.[168] On 19 November 2021, Eskom announced that an initial forensic investigation found evidence that recent damage to a coal conveyor at Lethabo was the result of deliberate sabotage. Steel supports had been severed, causing a power supply pylon to collapse.[169][170] In a media briefing, de Ruyter commented that the matter had been referred to the Hawks for further investigation.[171] In May 2022 the Minister for Public Enterprises, Pravin Gordhan, reported to Parliament that additional incidents of cables being cut intentionally by saboteurs, rising theft at its power plants, and corruption around the supply of fuel oil, had greatly worsened the energy crisis and Eskom's ability to resolve it.[172] Corruption 2017 corruption scandal See also: Gupta family Eskom was forced to suspend its chief financial officer Anoj Singh in July 2017 when the Development Bank of South Africa threatened to recall a R15 billion loan if no action was taken against Eskom officials (including Singh) who were involved in corruption allegations involving the Gupta family.[115] In September 2017, Minister for Public Enterprises, Lynne Brown, instructed Eskom to take legal action against firms and individuals involved; ranging from Gupta family-owned consultancy firm Trillian Capital Partners Ltd. and consultancy firm McKinsey to Anoj Singh and acting chief executive Matshela Koko. A report compiled by Eskom and G9 Forensic found that the two consulting firms including Gupta owned Trillian made R1.6 billion (US$120 million) in fees with an additional R7.8 billion made from future contracts.[173] An investigation done by the amaBhungane Centre for Investigative Journalism found that the Gupta family had received contracts worth R11.7 billion from Eskom to supply coal between 2014 and 2017. With pressure for Eskom to sign the first coal supply contracts with Gupta-owned entities being applied on the state-owned firm by then President Jacob Zuma.[174] In 2019 South African Special Investigating Unit launched an investigation into corruption related to the construction of the Medupi and Kusile power stations as a cause of repeated construction delays and project cost increases;[175] this led to the investigation of 11 contractors for allegedly stealing R139 billion (US$9.13 billion) from the projects.[175][176] In 2019, two senior Eskom managers and two business people were charged with fraud and corruption related to the construction of the Kusile power station.[177] In January 2020 South African Minister for Public Enterprises, Pravin Gordhan, stated that cost overruns and corruption during the construction of Medupi and Kusile power stations was an important reason for the dramatic increase in Eskom electricity prices.[178] 2019 Deloitte consulting lawsuit In October 2019, Eskom's chairman Jabu Mabuza filed a court affidavit at the Johannesburg High Court to recover R207 million in consulting fees from the consulting firm Deloitte. The affidavit alleged that Eskom executives had improperly awarded two consulting contracts to the consulting firm Deloitte. According to Eskom, in one contract awarded to Deloitte, Deloitte proposed a fee of R88.8-million while the competing bids from other firms were for R14.6-million and R13.3-million. In the other contract, Deloitte's bid was R79.1-million, while the other bids were for R16-million and R9.1-million.[179] In March 2020, Deloitte agreed to pay back R150 million of the R207 million sought by Eskom. However, in a joint statement, it denied being part of any corruption, and that they acknowledged that there were technical irregularities in the process of awarding the contracts.[180] In April 2020, Deloitte told AmaBhungane that the managing director for Deloitte Africa's advisory division Thiru Pillay and the lead consultant on the Eskom contract Shamal Sivasanker had resigned effective 31 March 2020 for their roles in the Eskom event.[181] In November 2021, Eskom announced that it had appointed Deloitte as its next external auditor, as its contract with Grant Thornton was expiring at the end of that month.[182] power transmission is the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation. The interconnected lines that facilitate this movement form a transmission network. This is distinct from the local wiring between high-voltage substations and customers, which is typically referred to as electric power distribution. The combined transmission and distribution network is part of electricity delivery, known as the electrical grid. Efficient long-distance transmission of electric power requires high voltages. This reduces the losses produced by strong currents. Transmission lines use either alternating current (AC) or direct current (DC). The voltage level is changed with transformers. The voltage is stepped up for transmission, then reduced for local distribution. A wide area synchronous grid, known as an interconnection in North America, directly connects generators delivering AC power with the same relative frequency to many consumers. North America has four major interconnections: Western, Eastern, Quebec and Texas. One grid connects most of continental Europe. Historically, transmission and distribution lines were often owned by the same company, but starting in the 1990s, many countries liberalized the regulation of the electricity market in ways that led to separate companies handling transmission and distribution.[2] System A diagram of an electric power system. The transmission system is in blue. Most North American transmission lines are high-voltage three-phase AC, although single phase AC is sometimes used in railway electrification systems. DC technology is used for greater efficiency over longer distances, typically hundreds of miles. High-voltage direct current (HVDC) technology is also used in submarine power cables (typically longer than 30 miles (50 km)), and in the interchange of power between grids that are not mutually synchronized. HVDC links stabilize power distribution networks where sudden new loads, or blackouts, in one part of a network might otherwise result in synchronization problems and cascading failures. Electricity is transmitted at high voltages to reduce the energy loss due to resistance that occurs over long distances. Power is usually transmitted through overhead power lines. Underground power transmission has a significantly higher installation cost and greater operational limitations, but lowers maintenance costs. Underground transmission is more common in urban areas or environmentally sensitive locations. Electrical energy must typically be generated at the same rate at which it is consumed. A sophisticated control system is required to ensure that power generation closely matches demand. If demand exceeds supply, the imbalance can cause generation plant(s) and transmission equipment to automatically disconnect or shut down to prevent damage. In the worst case, this may lead to a cascading series of shutdowns and a major regional blackout. The US Northeast faced blackouts in 1965, 1977, 2003, and major blackouts in other US regions in 1996 and 2011. Electric transmission networks are interconnected into regional, national, and even continent-wide networks to reduce the risk of such a failure by providing multiple redundant, alternative routes for power to flow should such shutdowns occur. Transmission companies determine the maximum reliable capacity of each line (ordinarily less than its physical or thermal limit) to ensure that spare capacity is available in the event of a failure in another part of the network. Overhead Main article: Overhead power line A four-circuit, two-voltage power transmission line; Bundled 2-ways A typical ACSR. The conductor consists of seven strands of steel surrounded by four layers of aluminium. This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) High-voltage overhead conductors are not covered by insulation. The conductor material is nearly always an aluminium alloy, formed of several strands and possibly reinforced with steel strands. Copper was sometimes used for overhead transmission, but aluminum is lighter, reduces yields only marginally and costs much less. Overhead conductors are supplied by several companies. Conductor material and shapes are regularly improved to increase capacity. Conductor sizes range from 12 mm2 (#6 American wire gauge) to 1,092 mm2 (2,156,000 circular mils area), with varying resistance and current-carrying capacity. For large conductors (more than a few centimetres in diameter), much of the current flow is concentrated near the surface due to the skin effect. The center of the conductor carries little current but contributes weight and cost. Thus, multiple parallel cables (called bundle conductors) are used for higher capacity. Bundle conductors are used at high voltages to reduce energy loss caused by corona discharge. Today, transmission-level voltages are usually considered to be 110 kV and above. Lower voltages, such as 66 kV and 33 kV, are usually considered subtransmission voltages, but are occasionally used on long lines with light loads. Voltages less than 33 kV are usually used for distribution. Voltages above 765 kV are considered extra high voltage and require different designs. Overhead transmission wires depend on air for insulation, requiring that lines maintain minimum clearances. Adverse weather conditions, such as high winds and low temperatures, interrupt transmission. Wind speeds as low as 23 knots (43 km/h) can permit conductors to encroach operating clearances, resulting in a flashover and loss of supply.[3] Oscillatory motion of the physical line is termed conductor gallop or flutter depending on the frequency and amplitude of oscillation. A five-hundred kilovolt (500 kV) three-phase transmission tower in Washington State, the line is bundled 3-ways Three abreast electrical pylons in Webster, Texas Underground Main article: Undergrounding Electric power can be transmitted by underground power cables. Underground cables take up no right-of-way, have lower visibility, and are less affected by weather. However, cables must be insulated. Cable and excavation costs are much higher than overhead construction. Faults in buried transmission lines take longer to locate and repair. In some metropolitan areas, cables are enclosed by metal pipe and insulated with dielectric fluid (usually an oil) that is either static or circulated via pumps. If an electric fault damages the pipe and leaks dielectric, liquid nitrogen is used to freeze portions of the pipe to enable draining and repair. This extends the repair period and increases costs. The temperature of the pipe and surroundings are monitored throughout the repair period.[4][5][6] Underground lines are limited by their thermal capacity, which permits less overload or re-rating lines. Long underground AC cables have significant capacitance, which reduces their ability to provide useful power beyond 50 miles (80 kilometres). DC cables are not limited in length by their capacitance. History Main article: History of electric power transmission New York City streets in 1890. Besides telegraph lines, multiple electric lines were required for each class of device requiring different voltages. Commercial electric power was initially transmitted at the same voltage used by lighting and mechanical loads. This restricted the distance between generating plant and loads. In 1882, DC voltage could not easily be increased for long-distance transmission. Different classes of loads (for example, lighting, fixed motors, and traction/railway systems) required different voltages, and so used different generators and circuits.[7][8] Thus, generators were sited near their loads, a practice that later became known as distributed generation using large numbers of small generators.[9] Transmission of alternating current (AC) became possible after Lucien Gaulard and John Dixon Gibbs built what they called the secondary generator, an early transformer provided with 1:1 turn ratio and open magnetic circuit, in 1881. The first long distance AC line was 34 kilometres (21 miles) long, built for the 1884 International Exhibition of Electricity in Turin, Italy. It was powered by a 2 kV, 130 Hz Siemens & Halske alternator and featured several Gaulard transformers with primary windings connected in series, which fed incandescent lamps. The system proved the feasibility of AC electric power transmission over long distances.[8] The first commercial AC distribution system entered service in 1885 in via dei Cerchi, Rome, Italy, for public lighting. It was powered by two Siemens & Halske alternators rated 30 hp (22 kW), 2 kV at 120 Hz and used 19 km of cables and 200 parallel-connected 2 kV to 20 V step-down transformers provided with a closed magnetic circuit, one for each lamp. A few months later it was followed by the first British AC system, serving Grosvenor Gallery. It also featured Siemens alternators and 2.4 kV to 100 V step-down transformers – one per user – with shunt-connected primaries.[10] Working to improve what he considered an impractical Gaulard-Gibbs design, electrical engineer William Stanley, Jr. developed the first practical series AC transformer in 1885.[11] Working with the support of George Westinghouse, in 1886 he demonstrated a transformer-based AC lighting system in Great Barrington, Massachusetts. It was powered by a steam engine-driven 500 V Siemens generator. Voltage was stepped down to 100 volts using the Stanley transformer to power incandescent lamps at 23 businesses over 4,000 feet (1,200 m).[12] This practical demonstration of a transformer and alternating current lighting system led Westinghouse to begin installing AC systems later that year.[11] In 1888 the first designs for an AC motor appeared. These were induction motors running on polyphase current, independently invented by Galileo Ferraris and Nikola Tesla. Westinghouse licensed Tesla's design. Practical three-phase motors were designed by Mikhail Dolivo-Dobrovolsky and Charles Eugene Lancelot Brown.[13] Widespread use of such motors were delayed many years by development problems and the scarcity of polyphase power systems needed to power them.[14][15] Westinghouse alternating current polyphase generators on display at the 1893 World's Fair in Chicago, part of their Tesla Poly-phase System. Such polyphase innovations revolutionized transmission. In the late 1880s and early 1890s smaller electric companies merged into larger corporations such as Ganz and AEG in Europe and General Electric and Westinghouse Electric in the US. These companies developed AC systems, but the technical difference between direct and alternating current systems required a much longer technical merger.[16] Alternating current's economies of scale with large generating plants and long-distance transmission slowly added the ability to link all the loads. These included single phase AC systems, poly-phase AC systems, low voltage incandescent lighting, high-voltage arc lighting, and existing DC motors in factories and street cars. In what became a universal system, these technological differences were temporarily bridged via the rotary converters and motor-generators that allowed the legacy systems to connect to the AC grid.[16][17] These stopgaps were slowly replaced as older systems were retired or upgraded. The first transmission of single-phase alternating current using high voltage came in Oregon in 1890 when power was delivered from a hydroelectric plant at Willamette Falls to the city of Portland 14 miles (23 km) down river.[18] The first three-phase alternating current using high voltage took place in 1891 during the international electricity exhibition in Frankfurt. A 15 kV transmission line, approximately 175 km long, connected Lauffen on the Neckar and Frankfurt.[10][19] Transmission voltages increased throughout the 20th century. By 1914, fifty-five transmission systems operating at more than 70 kV were in service. The highest voltage then used was 150 kV.[20] Interconnecting multiple generating plants over a wide area reduced costs. The most efficient plants could be used to supply varying loads during the day. Reliability was improved and capital costs were reduced, because stand-by generating capacity could be shared over many more customers and a wider area. Remote and low-cost sources of energy, such as hydroelectric power or mine-mouth coal, could be exploited to further lower costs.[7][10] The 20th century's rapid industrialization made electrical transmission lines and grids critical infrastructure. Interconnection of local generation plants and small distribution networks was spurred by World War I, when large electrical generating plants were built by governments to power munitions factories.[21] Bulk transmission A transmission substation decreases the voltage of incoming electricity, allowing it to connect from long-distance high-voltage transmission, to local lower voltage distribution. It also reroutes power to other transmission lines that serve local markets. This is the PacifiCorp Hale Substation, Orem, Utah, US. These networks use components such as power lines, cables, circuit breakers, switches and transformers. The transmission network is usually administered on a regional basis by an entity such as a regional transmission organization or transmission system operator.[22] Transmission efficiency is improved at higher voltage and lower current. The reduced current reduces heating losses. Joule's first law states that energy losses are proportional to the square of the current. Thus, reducing the current by a factor of two lowers the energy lost to conductor resistance by a factor of four for any given size of conductor. The optimum size of a conductor for a given voltage and current can be estimated by Kelvin's law for conductor size, which states that size is optimal when the annual cost of energy wasted in resistance is equal to the annual capital charges of providing the conductor. At times of lower interest rates and low commodity costs, Kelvin's law indicates that thicker wires are optimal. Otherwise, thinner conductors are indicated. Since power lines are designed for long-term use, Kelvin's law is used in conjunction with long-term estimates of the price of copper and aluminum as well as interest rates. Higher voltage is achieved in AC circuits by using a step-up transformer. High-voltage direct current (HVDC) systems require relatively costly conversion equipment that may be economically justified for particular projects such as submarine cables and longer distance high capacity point-to-point transmission. HVDC is necessary for sending energy between unsynchronized grids. A transmission grid is a network of power stations, transmission lines, and substations. Energy is usually transmitted within a grid with three-phase AC. Single-phase AC is used only for distribution to end users since it is not usable for large polyphase induction motors. In the 19th century, two-phase transmission was used but required either four wires or three wires with unequal currents. Higher order phase systems require more than three wires, but deliver little or no benefit. The synchronous grids of Europe While the price of generating capacity is high, energy demand is variable, making it often cheaper to import needed power than to generate it locally. Because loads often rise and fall together across large areas, power often comes from distant sources. Because of the economic benefits of load sharing, wide area transmission grids may span countries and even continents. Interconnections between producers and consumers enables power to flow even if some links are inoperative. The slowly varying portion of demand is known as the base load and is generally served by large facilities with constant operating costs, termed firm power. Such facilities are nuclear, coal or hydroelectric, while other energy sources such as concentrated solar thermal and geothermal power have the potential to provide firm power. Renewable energy sources, such as solar photovoltaics, wind, wave, and tidal, are, due to their intermittency, not considered to be firm. The remaining or peak power demand, is supplied by peaking power plants, which are typically smaller, faster-responding, and higher cost sources, such as combined cycle or combustion turbine plants typically fueled by natural gas. Long-distance transmission (hundreds of kilometers) is cheap and efficient, with costs of US$0.005–0.02 per kWh, compared to annual averaged large producer costs of US$0.01–0.025 per kWh, retail rates upwards of US$0.10 per kWh, and multiples of retail for instantaneous suppliers at unpredicted high demand moments.[23] New York often buys over 1000 MW of low-cost hydropower from Canada.[24] Local sources (even if more expensive and infrequently used) can protect the power supply from weather and other disasters that can disconnect distant suppliers. A high-power electrical transmission tower, 230 kV, double-circuit, also double-bundled Hydro and wind sources cannot be moved closer to big cities, and solar costs are lowest in remote areas where local power needs are nominal. Connection costs can determine whether any particular renewable alternative is economically realistic. Costs can be prohibitive for transmission lines, but high capacity, long distance super grid transmission network costs could be recovered with modest usage fees. Grid input This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) At power stations, power is produced at a relatively low voltage between about 2.3 kV and 30 kV, depending on the size of the unit. The voltage is then stepped up by the power station transformer to a higher voltage (115 kV to 765 kV AC) for transmission. In the United States, power transmission is, variously, 230 kV to 500 kV, with less than 230 kV or more than 500 kV as exceptions. The Western Interconnection has two primary interchange voltages: 500 kV AC at 60 Hz, and ±500 kV (1,000 kV net) DC from North to South (Columbia River to Southern California) and Northeast to Southwest (Utah to Southern California). The 287.5 kV (Hoover Dam to Los Angeles line, via Victorville) and 345 kV (Arizona Public Service (APS) line) are local standards, both of which were implemented before 500 kV became practical. Losses Transmitting electricity at high voltage reduces the fraction of energy lost to Joule heating, which varies by conductor type, the current, and the transmission distance. For example, a 100 miles (160 km) span at 765 kV carrying 1000 MW of power can have losses of 0.5% to 1.1%. A 345 kV line carrying the same load across the same distance has losses of 4.2%.[25] For a given amount of power, a higher voltage reduces the current and thus the resistive losses. For example, raising the voltage by a factor of 10 reduces the current by a corresponding factor of 10 and therefore the losses by a factor of 100, provided the same sized conductors are used in both cases. Even if the conductor size (cross-sectional area) is decreased ten-fold to match the lower current, the losses are still reduced ten-fold using the higher voltage. While power loss can also be reduced by increasing the wire's conductance (by increasing its cross-sectional area), larger conductors are heavier and more expensive. And since conductance is proportional to cross-sectional area, resistive power loss is only reduced proportionally with increasing cross-sectional area, providing a much smaller benefit than the squared reduction provided by multiplying the voltage. Long-distance transmission is typically done with overhead lines at voltages of 115 to 1,200 kV. At higher voltages, where more than 2,000 kV exists between conductor and ground, corona discharge losses are so large that they can offset the lower resistive losses in the line conductors. Measures to reduce corona losses include larger conductor diameter, hollow cores[26] or conductor bundles. Factors that affect resistance and thus loss include temperature, spiraling, and the skin effect. Resistance increases with temperature. Spiraling, which refers to the way stranded conductors spiral about the center, also contributes to increases in conductor resistance. The skin effect causes the effective resistance to increase at higher AC frequencies. Corona and resistive losses can be estimated using a mathematical model.[27] US transmission and distribution losses were estimated at 6.6% in 1997,[28] 6.5% in 2007[28] and 5% from 2013 to 2019.[29] In general, losses are estimated from the discrepancy between power produced (as reported by power plants) and power sold; the difference constitutes transmission and distribution losses, assuming no utility theft occurs. As of 1980, the longest cost-effective distance for DC transmission was 7,000 kilometres (4,300 miles). For AC it was 4,000 kilometres (2,500 miles), though US transmission lines are substantially shorter.[23] In any AC line, conductor inductance and capacitance can be significant. Currents that flow solely in reaction to these properties, (which together with the resistance define the impedance) constitute reactive power flow, which transmits no power to the load. These reactive currents, however, cause extra heating losses. The ratio of real power transmitted to the load to apparent power (the product of a circuit's voltage and current, without reference to phase angle) is the power factor. As reactive current increases, reactive power increases and power factor decreases. For transmission systems with low power factor, losses are higher than for systems with high power factor. Utilities add capacitor banks, reactors and other components (such as phase-shifters; static VAR compensators; and flexible AC transmission systems, FACTS) throughout the system help to compensate for the reactive power flow, reduce the losses in power transmission and stabilize system voltages. These measures are collectively called 'reactive support'. Transposition This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) Current flowing through transmission lines induces a magnetic field that surrounds the lines of each phase and affects the inductance of the surrounding conductors of other phases. The conductors' mutual inductance is partially dependent on the physical orientation of the lines with respect to each other. Three-phase lines are conventionally strung with phases separated vertically. The mutual inductance seen by a conductor of the phase in the middle of the other two phases is different from the inductance seen on the top/bottom. Unbalanced inductance among the three conductors is problematic because it may force the middle line to carry a disproportionate amount of the total power transmitted. Similarly, an unbalanced load may occur if one line is consistently closest to the ground and operates at a lower impedance. Because of this phenomenon, conductors must be periodically transposed along the line so that each phase sees equal time in each relative position to balance out the mutual inductance seen by all three phases. To accomplish this, line position is swapped at specially designed transposition towers at regular intervals along the line using various transposition schemes. Subtransmission A 115 kV subtransmission line in the Philippines, along with 20 kV distribution lines and a street light, all mounted on a wood subtransmission pole 115 kV H-frame transmission tower This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) Subtransmission runs at relatively lower voltages. It is uneconomical to connect all distribution substations to the high main transmission voltage, because that equipment is larger and more expensive. Typically, only larger substations connect with this high voltage. Voltage is stepped down before the current is sent to smaller substations. Subtransmission circuits are usually arranged in loops so that a single line failure does not stop service to many customers for more than a short time. Loops can be normally closed, where loss of one circuit should result in no interruption, or normally open where substations can switch to a backup supply. While subtransmission circuits are usually carried on overhead lines, in urban areas buried cable may be used. The lower-voltage subtransmission lines use less right-of-way and simpler structures; undergrounding is less difficult. No fixed cutoff separates subtransmission and transmission, or subtransmission and distribution. Their voltage ranges overlap. Voltages of 69 kV, 115 kV, and 138 kV are often used for subtransmission in North America. As power systems evolved, voltages formerly used for transmission were used for subtransmission, and subtransmission voltages became distribution voltages. Like transmission, subtransmission moves relatively large amounts of power, and like distribution, subtransmission covers an area instead of just point-to-point.[30] Transmission grid exit Substation transformers reduce the voltage to a lower level for distribution to customers. This distribution is accomplished with a combination of sub-transmission (33 to 138 kV) and distribution (3.3 to 25 kV). Finally, at the point of use, the energy is transformed to end-user voltage (100 to 4160 volts). Advantage of high-voltage transmission See also: Ideal transformer This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) High-voltage power transmission allows for lesser resistive losses over long distances. This efficiency delivers a larger proportion of the generated power to the loads. Electrical grid without a transformer Electrical grid with a transformer In a simplified model, the grid delivers electricity from an ideal voltage source with voltage , delivering a power) to a single point of consumption, modelled by a resistance , when the wires are long enough to have a significant resistance . If the resistances are in series with no intervening transformer, the circuit acts as a voltage divider, because the same current runs through the wire resistance and the powered device. As a consequence, the useful power (at the point of consumption) is: Should an ideal transformer convert high-voltage, low-current electricity into low-voltage, high-current electricity with a voltage ratio of (i.e., the voltage is divided by and the current is multiplied by in the secondary branch, compared to the primary branch), then the circuit is again equivalent to a voltage divider, but the wires now have apparent resistance of only . The useful power is then: For (i.e. conversion of high voltage to low voltage near the consumption point), a larger fraction of the generator's power is transmitted to the consumption point and a lesser fraction is lost to Joule heating. Modeling Main article: Performance and modelling of AC transmission This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) "Black box" model for transmission line The terminal characteristics of the transmission line are the voltage and current at the sending (S) and receiving (R) ends. The transmission line can be modeled as a black box and a 2 by 2 transmission matrix is used to model its behavior, as follows: The line is assumed to be a reciprocal, symmetrical network, meaning that the receiving and sending labels can be switched with no consequence. The transmission matrix T has the properties: The parameters A, B, C, and D differ depending on how the desired model handles the line's resistance (R), inductance (L), capacitance (C), and shunt (parallel, leak) conductance G. The four main models are the short line approximation, the medium line approximation, the long line approximation (with distributed parameters), and the lossless line. In such models, a capital letter such as R refers to the total quantity summed over the line and a lowercase letter such as c refers to the per-unit-length quantity. Lossless line The lossless line approximation is the least accurate; it is typically used on short lines where the inductance is much greater than the resistance. For this approximation, the voltage and current are identical at the sending and receiving ends. Voltage on sending and receiving ends for lossless line The characteristic impedance is pure real, which means resistive for that impedance, and it is often called surge impedance. When a lossless line is terminated by surge impedance, the voltage does not drop. Though the phase angles of voltage and current are rotated, the magnitudes of voltage and current remain constant along the line. For load > SIL, the voltage drops from sending end and the line consumes VARs. For load < SIL, the voltage increases from the sending end, and the line generates VARs. Short line The short line approximation is normally used for lines shorter than 80 km (50 mi). There, only a series impedance Z is considered, while C and G are ignored. The final result is that A = D = 1 per unit, B = Z Ohms, and C = 0. The associated transition matrix for this approximation is therefore: Medium line The medium line approximation is used for lines running between 80 and 250 km (50 and 155 mi). The series impedance and the shunt (current leak) conductance are considered, placing half of the shunt conductance at each end of the line. This circuit is often referred to as a nominal π (pi) circuit because of the shape (π) that is taken on when leak conductance is placed on both sides of the circuit diagram. The analysis of the medium line produces: Counterintuitive behaviors of medium-length transmission lines: voltage rise at no load or small current (Ferranti effect) receiving-end current can exceed sending-end current Long line The long line model is used when a higher degree of accuracy is needed or when the line under consideration is more than 250 km (160 mi) long. Series resistance and shunt conductance are considered to be distributed parameters, such that each differential length of the line has a corresponding differential series impedance and shunt admittance. The following result can be applied at any point along the transmission line, where is the propagation constant. To find the voltage and current at the end of the long line, should be replaced with (the line length) in all parameters of the transmission matrix. This model applies the Telegrapher's equations. High-voltage direct current Main article: High-voltage direct current High-voltage direct current (HVDC) is used to transmit large amounts of power over long distances or for interconnections between asynchronous grids. When electrical energy is transmitted over very long distances, the power lost in AC transmission becomes appreciable and it is less expensive to use direct current instead. For a long transmission line, these lower losses (and reduced construction cost of a DC line) can offset the cost of the required converter stations at each end. HVDC is used for long submarine cables where AC cannot be used because of cable capacitance.[31] In these cases special high-voltage cables are used. Submarine HVDC systems are often used to interconnect the electricity grids of islands, for example, between Great Britain and continental Europe, between Great Britain and Ireland, between Tasmania and the Australian mainland, between the North and South Islands of New Zealand, between New Jersey and New York City, and between New Jersey and Long Island. Submarine connections up to 600 kilometres (370 mi) in length have been deployed.[32] HVDC links can be used to control grid problems. The power transmitted by an AC line increases as the phase angle between source end voltage and destination ends increases, but too large a phase angle allows the systems at either end to fall out of step. Since the power flow in a DC link is controlled independently of the phases of the AC networks that it connects, this phase angle limit does not exist, and a DC link is always able to transfer its full rated power. A DC link therefore stabilizes the AC grid at either end, since power flow and phase angle can then be controlled independently. As an example, to adjust the flow of AC power on a hypothetical line between Seattle and Boston would require adjustment of the relative phase of the two regional electrical grids. This is an everyday occurrence in AC systems, but one that can become disrupted when AC system components fail and place unexpected loads on the grid. With an HVDC line instead, such an interconnection would: Convert AC in Seattle into HVDC; Use HVDC for the 3,000 miles (4,800 km) of cross-country transmission; and Convert the HVDC to locally synchronized AC in Boston, (and possibly in other cooperating cities along the transmission route). Such a system could be less prone to failure if parts of it were suddenly shut down. One example of a long DC transmission line is the Pacific DC Intertie located in the Western United States. Capacity This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) The amount of power that can be sent over a transmission line varies with the length of the line. The heating of short line conductors due to line losses sets a thermal limit. If too much current is drawn, conductors may sag too close to the ground, or conductors and equipment may overheat. For intermediate-length lines on the order of 100 kilometres (62 miles), the limit is set by the voltage drop in the line. For longer AC lines, system stability becomes the limiting factor. Approximately, the power flowing over an AC line is proportional to the cosine of the phase angle of the voltage and current at the ends. This angle varies depending on system loading. It is undesirable for the angle to approach 90 degrees, as the power flowing decreases while resistive losses remain. The product of line length and maximum load is approximately proportional to the square of the system voltage. Series capacitors or phase-shifting transformers are used on long lines to improve stability. HVDC lines are restricted only by thermal and voltage drop limits, since the phase angle is not material. Understanding the temperature distribution along the cable route became possible with the introduction of distributed temperature sensing (DTS) systems that measure temperatures all along the cable. Without them maximum current was typically set as a compromise between understanding of operation conditions and risk minimization. This monitoring solution uses passive optical fibers as temperature sensors, either inside a high-voltage cable or externally mounted on the cable insulation. For overhead cables the fiber is integrated into the core of a phase wire. The integrated Dynamic Cable Rating (DCR)/Real Time Thermal Rating (RTTR) solution makes it possible to run the network to its maximum. It allows the operator to predict the behavior of the transmission system to reflect major changes to its initial operating conditions. Reconductoring Some utilities have embraced reconductoring to handle the increase in electricity production. Reconductoring is the replacement-in-place of existing transmission lines with higher-capacity lines. Adding transmission lines is difficult due to cost, permit intervals, and local opposition. Reconductoring has the potential to double the amount of electricity that can travel across a transmission line.[33] A 2024 report found the United States behind countries like Belgium and the Netherlands in adoption of this technique to accommodate electrification and renewable energy. [34] In April 2022, the Biden Administration streamlined environmental reviews for such projects, and in May 2022 announced competitive grants for them funded by the 2021 Bipartisan Infrastructure Law and 2022 Inflation Reduction Act.[35] The rate of transmission expansion needs to double to support ongoing electrification and reach emission reduction targets. As of 2022, more than 10,000 power plant and energy storage projects were awaiting permission to connect to the US grid — 95% were zero-carbon resources. New power lines can take 10 years to plan, permit, and build.[33] Traditional power lines use a steel core surrounded by aluminum strands (Aluminium-conductor steel-reinforced cable). Replacing the steel with a lighter, stronger composite material such as carbon fiber (ACCC conductor) allows lines to operate at higher temperatures, with less sag, and doubled transmission capacity. Lowering line sag at high temperatures can prevent wildfires from starting when power lines touch dry vegetation.[34] Although advanced lines can cost 2-4x more than steel, total reconductoring costs are less than half of a new line, given savings in time, land acquisition, permitting, and construction.[33] A reconductoring project in southeastern Texas upgraded 240 miles of transmission lines at a cost of $900,000 per mile, versus a 3,600-mile greenfield project that averaged $1.9 million per mile.[33] Control This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) To ensure safe and predictable operation, system components are controlled with generators, switches, circuit breakers and loads. The voltage, power, frequency, load factor, and reliability capabilities of the transmission system are designed to provide cost effective performance. Load balancing The transmission system provides for base load and peak load capability, with margins for safety and fault tolerance. Peak load times vary by region largely due to the industry mix. In hot and cold climates home air conditioning and heating loads affect the overall load. They are typically highest in the late afternoon in the hottest part of the year and in mid-mornings and mid-evenings in the coldest part of the year. Power requirements vary by season and time of day. Distribution system designs always take the base load and the peak load into consideration. The transmission system usually does not have a large buffering capability to match loads with generation. Thus generation has to be kept matched to the load, to prevent overloading generation equipment. Multiple sources and loads can be connected to the transmission system and they must be controlled to provide orderly transfer of power. In centralized power generation, only local control of generation is necessary. This involves synchronization of the generation units. In distributed power generation the generators are geographically distributed and the process to bring them online and offline must be carefully controlled. The load control signals can either be sent on separate lines or on the power lines themselves. Voltage and frequency can be used as signaling mechanisms to balance the loads. In voltage signaling, voltage is varied to increase generation. The power added by any system increases as the line voltage decreases. This arrangement is stable in principle. Voltage-based regulation is complex to use in mesh networks, since the individual components and setpoints would need to be reconfigured every time a new generator is added to the mesh. In frequency signaling, the generating units match the frequency of the power transmission system. In droop speed control, if the frequency decreases, the power is increased. (The drop in line frequency is an indication that the increased load is causing the generators to slow down.) Wind turbines, vehicle-to-grid, virtual power plants, and other locally distributed storage and generation systems can interact with the grid to improve system operation. Internationally[where?], a slow move from a centralized to decentralized power systems have taken place. The main draw of locally distributed generation systems is that they reduce transmission losses by leading to consumption of electricity closer to where it was produced.[36] Failure protection Under excess load conditions, the system can be designed to fail incrementally rather than all at once. Brownouts occur when power supplied drops below the demand. Blackouts occur when the grid fails completely. Rolling blackouts (also called load shedding) are intentionally engineered electrical power outages, used to distribute insufficient power to various loads in turn. Communications This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) Grid operators require reliable communications to manage the grid and associated generation and distribution facilities. Fault-sensing protective relays at each end of the line must communicate to monitor the flow of power so that faulted conductors or equipment can be quickly de-energized and the balance of the system restored. Protection of the transmission line from short circuits and other faults is usually so critical that common carrier telecommunications are insufficiently reliable, while in some remote areas no common carrier is available. Communication systems associated with a transmission project may use: Microwaves Power-line communication Optical fibers Rarely, and for short distances, pilot-wires are strung along the transmission line path. Leased circuits from common carriers are not preferred since availability is not under control of the operator. Transmission lines can be used to carry data: this is called power-line carrier, or power-line communication (PLC). PLC signals can be easily received with a radio in the long wave range. High-voltage pylons carrying additional optical fibre cable in Kenya Optical fibers can be included in the stranded conductors of a transmission line, in the overhead shield wires. These cables are known as optical ground wire (OPGW). Sometimes a standalone cable is used, all-dielectric self-supporting (ADSS) cable, attached to the transmission line cross arms. Some jurisdictions, such as Minnesota, prohibit energy transmission companies from selling surplus communication bandwidth or acting as a telecommunications common carrier. Where the regulatory structure permits, the utility can sell capacity in extra dark fibers to a common carrier. Market structure Main article: Electricity market Electricity transmission is generally considered to be a natural monopoly, but one that is not inherently linked to generation.[37][38][39] Many countries regulate transmission separately from generation. Spain was the first country to establish a regional transmission organization. In that country, transmission operations and electricity markets are separate. The transmission system operator is Red Eléctrica de España (REE) and the wholesale electricity market operator is Operador del Mercado Ibérico de Energía – Polo Español, S.A. (OMEL) OMEL Holding | Omel Holding. Spain's transmission system is interconnected with those of France, Portugal, and Morocco. The establishment of RTOs in the United States was spurred by the FERC's Order 888, Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities, issued in 1996.[40] In the United States and parts of Canada, electric transmission companies operate independently of generation companies, but in the Southern United States vertical integration is intact. In regions of separation, transmission owners and generation owners continue to interact with each other as market participants with voting rights within their RTO. RTOs in the United States are regulated by the Federal Energy Regulatory Commission. Merchant transmission projects in the United States include the Cross Sound Cable from Shoreham, New York to New Haven, Connecticut, Neptune RTS Transmission Line from Sayreville, New Jersey, to New Bridge, New York, and Path 15 in California. Additional projects are in development or have been proposed throughout the United States, including the Lake Erie Connector, an underwater transmission line proposed by ITC Holdings Corp., connecting Ontario to load serving entities in the PJM Interconnection region.[41] Australia has one unregulated or market interconnector – Basslink – between Tasmania and Victoria. Two DC links originally implemented as market interconnectors, Directlink and Murraylink, were converted to regulated interconnectors.[42] A major barrier to wider adoption of merchant transmission is the difficulty in identifying who benefits from the facility so that the beneficiaries pay the toll. Also, it is difficult for a merchant transmission line to compete when the alternative transmission lines are subsidized by utilities with a monopolized and regulated rate base.[43] In the United States, the FERC's Order 1000, issued in 2010, attempted to reduce barriers to third party investment and creation of merchant transmission lines where a public policy need is found.[44] Transmission costs The cost of high voltage transmission is comparatively low, compared to all other costs constituting consumer electricity bills. In the UK, transmission costs are about 0.2 p per kWh compared to a delivered domestic price of around 10 p per kWh.[45] The level of capital expenditure in the electric power T&D equipment market was estimated to be $128.9 bn in 2011.[46] Health concerns Main article: Electromagnetic radiation and health Mainstream scientific evidence suggests that low-power, low-frequency, electromagnetic radiation associated with household currents and high transmission power lines does not constitute a short- or long-term health hazard. Some studies failed to find any link between living near power lines and developing any sickness or diseases, such as cancer. A 1997 study reported no increased risk of cancer or illness from living near a transmission line.[47] Other studies, however, reported statistical correlations between various diseases and living or working near power lines. No adverse health effects have been substantiated for people not living close to power lines.[48] The New York State Public Service Commission conducted a study[49] to evaluate potential health effects of electric fields. The study measured the electric field strength at the edge of an existing right-of-way on a 765 kV transmission line. The field strength was 1.6 kV/m, and became the interim maximum strength standard for new transmission lines in New York State. The opinion also limited the voltage of new transmission lines built in New York to 345 kV. On September 11, 1990, after a similar study of magnetic field strengths, the NYSPSC issued their Interim Policy Statement on Magnetic Fields. This policy established a magnetic field standard of 200 mG at the edge of the right-of-way using the winter-normal conductor rating. As a comparison with everyday items, a hair dryer or electric blanket produces a 100 mG – 500 mG magnetic field.[50][51] Applications for a new transmission line typically include an analysis of electric and magnetic field levels at the edge of rights-of-way. Public utility commissions typically do not comment on health impacts. Biological effects have been established for acute high level exposure to magnetic fields above 100 μT (1 G) (1,000 mG). In a residential setting, one study reported "limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals", in particular, childhood leukemia, associated with average exposure to residential power-frequency magnetic field above 0.3 μT (3 mG) to 0.4 μT (4 mG). These levels exceed average residential power-frequency magnetic fields in homes, which are about 0.07 μT (0.7 mG) in Europe and 0.11 μT (1.1 mG) in North America.[52][53] The Earth's natural geomagnetic field strength varies over the surface of the planet between 0.035 mT and 0.07 mT (35 μT – 70 μT or 350 mG – 700 mG) while the international standard for continuous exposure is set at 40 mT (400,000 mG or 400 G) for the general public.[52] Tree growth regulators and herbicides may be used in transmission line right of ways,[54] which may have health effects. Specialized transmission Grids for railways Main article: Traction power network In some countries where electric locomotives or electric multiple units run on low frequency AC power, separate single phase traction power networks are operated by the railways. Prime examples are countries such as Austria, Germany and Switzerland that utilize AC technology based on 16 2/3 Hz. Norway and Sweden also use this frequency but use conversion from the 50 Hz public supply; Sweden has a 16 2/3 Hz traction grid but only for part of the system. Superconducting cables High-temperature superconductors (HTS) promise to revolutionize power distribution by providing lossless transmission. The development of superconductors with transition temperatures higher than the boiling point of liquid nitrogen has made the concept of superconducting power lines commercially feasible, at least for high-load applications.[55] It has been estimated that waste would be halved using this method, since the necessary refrigeration equipment would consume about half the power saved by the elimination of resistive losses. Companies such as Consolidated Edison and American Superconductor began commercial production of such systems in 2007.[56] Superconducting cables are particularly suited to high load density areas such as the business district of large cities, where purchase of an easement for cables is costly.[57] HTS transmission lines[58] Location Length (km) Voltage (kV) Capacity (GW) Date Carrollton, Georgia 2000 Albany, New York[59] 0.35 34.5 0.048 2006 Holbrook, Long Island[60] 0.6 138 0.574 2008 Tres Amigas 5 Proposed 2013 Manhattan: Project Hydra Proposed 2014 Essen, Germany[61][62] 1 10 0.04 2014 Single-wire earth return Main article: Single-wire earth return This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) Single-wire earth return (SWER) or single-wire ground return is a single-wire transmission line for supplying single-phase electrical power to remote areas at low cost. It is principally used for rural electrification, but also finds use for larger isolated loads such as water pumps. Single-wire earth return is also used for HVDC over submarine power cables. Wireless power transmission Main article: Wireless power transfer This section does not cite any sources. Please help improve this section by adding citations to reliable sources. Unsourced material may be challenged and removed. (November 2022) (Learn how and when to remove this message) Both Nikola Tesla and Hidetsugu Yagi attempted to devise systems for large scale wireless power transmission in the late 1800s and early 1900s, without commercial success. In November 2009, LaserMotive won the NASA 2009 Power Beaming Challenge by powering a cable climber 1 km vertically using a ground-based laser transmitter. The system produced up to 1 kW of power at the receiver end. In August 2010, NASA contracted with private companies to pursue the design of laser power beaming systems to power low earth orbit satellites and to launch rockets using laser power beams. Wireless power transmission has been studied for transmission of power from solar power satellites to the earth. A high power array of microwave or laser transmitters would beam power to a rectenna. Major engineering and economic challenges face any solar power satellite project. Security The examples and perspective in this article may not represent a worldwide view of the subject. You may improve this article, discuss the issue on the talk page, or create a new article, as appropriate. (March 2013) (Learn how and when to remove this message) The federal government of the United States stated that the American power grid was susceptible to cyber-warfare.[63][64] The United States Department of Homeland Security works with industry to identify vulnerabilities and to help industry enhance the security of control system networks.[65] In June 2019, Russia conceded that it was "possible" its electrical grid is under cyber-attack by the United States.[66] The New York Times reported that American hackers from the United States Cyber Command planted malware potentially capable of disrupting the Russian electrical grid.[67] Records Highest capacity system: 12 GW Zhundong–Wannan (准东-皖南)±1100 kV HVDC.[68][69] Highest transmission voltage (AC): planned: 1.20 MV (Ultra-High Voltage) on Wardha-Aurangabad line (India), planned to initially operate at 400 kV.[70] worldwide: 1.15 MV (Ultra-High Voltage) on Ekibastuz-Kokshetau line (Kazakhstan) Largest double-circuit transmission, Kita-Iwaki Powerline (Japan). Highest towers: Yangtze River Crossing (China) (height: 345 m or 1,132 ft) Longest power line: Inga-Shaba (Democratic Republic of Congo) (length: 1,700 kilometres or 1,056 miles) Longest span of power line: 5,376 m (17,638 ft) at Ameralik Span (Greenland, Denmark) Longest submarine cables: North Sea Link, (Norway/United Kingdom) – (length of submarine cable: 720 kilometres or 447 miles) NorNed, North Sea (Norway/Netherlands) – (length of submarine cable: 580 kilometres or 360 miles) Basslink, Bass Strait, (Australia) – (length of submarine cable: 290 kilometres or 180 miles, total length: 370.1 kilometres or 230 miles) Baltic Cable, Baltic Sea (Germany/Sweden) – (length of submarine cable: 238 kilometres or 148 miles, HVDC length: 250 kilometres or 155 miles, total length: 262 kilometres or 163 miles) Longest underground cables: Murraylink, Riverland/Sunraysia (Australia) – (length of underground cable: 170 kilometres or 106 miles) See also Energy portal Dynamic demand (electric power) Demand response List of energy storage power plants Traction power network Backfeeding Conductor marking lights Double-circuit transmission line Electromagnetic Transients Program (EMTP) Flexible AC transmission system (FACTS) Geomagnetically induced current, (GIC) Graphene-clad wire Grid-tied electrical system List of high-voltage underground and submarine cables Load profile National Grid (disambiguation) Power-line communications (PLC) Power system simulation Radio frequency power transmission Wheeling (electric power transmission) References encyclopedia An electrical grid may have many types of generators and loads; generators must be controlled to maintain stable operation of the system. In an electric power system, automatic generation control (AGC) is a system for adjusting the power output of multiple generators at different power plants, in response to changes in the load. Since a power grid requires that generation and load closely balance moment by moment, frequent adjustments to the output of generators are necessary. The balance can be judged by measuring the system frequency; if it is increasing, more power is being generated than used, which causes all the machines in the system to accelerate. If the system frequency is decreasing, more load is on the system than the instantaneous generation can provide, which causes all generators to slow down. History Before the use of automatic generation control, one generating unit in a system would be designated as the regulating unit and would be manually adjusted to control the balance between generation and load to maintain system frequency at the desired value. The remaining units would be controlled with speed droop to share the load in proportion to their ratings. With automatic systems, many units in a system can participate in regulation, reducing wear on a single unit's controls and improving overall system efficiency, stability, and economy. Where the grid has tie interconnections to adjacent control areas, automatic generation control helps maintain the power interchanges over the tie lines at the scheduled levels. With computer-based control systems and multiple inputs, an automatic generation control system can take into account such matters as the most economical units to adjust, the coordination of thermal, hydroelectric, and other generation types, and even constraints related to the stability of the system and capacity of interconnections to other power grids.[1] Types Turbine-governor control Turbine generators in a power system have stored kinetic energy due to their large rotating masses. All the kinetic energy stored in a power system in such rotating masses is a part of the grid inertia. When system load increases, grid inertia is initially used to supply the load. This, however, leads to a decrease in the stored kinetic energy of the turbine generators. Since the mechanical power of these turbines correlates with the delivered electrical power, the turbine generators have a decrease in angular velocity, which is directly proportional to a decrease in frequency in synchronous generators. Steady state frequency-power relation for a turbine governor The purpose of the turbine-governor control (TGC) is to maintain the desired system frequency by adjusting the mechanical power output of the turbine.[2] These controllers have become automated and at steady state, the frequency-power relation for turbine-governor control is, where, is the change in turbine mechanical power output is the change in a reference power setting is the regulation constant which quantifies the sensitivity of the generator to a change in frequency is the change in frequency. For steam turbines, steam turbine governing adjusts the mechanical output of the turbine by increasing or decreasing the amount of steam entering the turbine via a throttle valve. Load-frequency control Load-frequency control (LFC) is employed to allow an area to first meet its own load demands, then to assist in returning the steady-state frequency of the system, Δf, to zero.[3] Load-frequency control operates with a response time of a few seconds to keep system frequency stable. Economic dispatch The goal of economic dispatch is to minimize total operating costs in an area by determining how the real power output of each generating unit will meet a given load.[4] Generating units have different costs to produce a unit of electrical energy, and incur different costs for the losses in transmitting energy to the load. An economic dispatch algorithm will run every few minutes to select the combination of generating unit power setpoints that minimizes overall cost, subject to the constraints of transmission limitation or security of the system against failures.[5] Further constraints may be imposed by the water supply of hydroelectric generation, or by the availability of sun and wind power. "Grid storage" redirects here. For data storage with grid computing, see Grid-oriented storage. Energy from fossil or nuclear power plants and renewable sources is stored for use by customers. Diagram showing flow of energy between energy storage facilities and power grids, as a function of time over a 24 hour period Grid energy storage, also known as large-scale energy storage, are technologies connected to the electrical power grid that store energy for later use. These systems help balance supply and demand by storing excess electricity from variable renewables such as solar and inflexible sources like nuclear power, releasing it when needed. They further provide essential grid services, such as helping to restart the grid after a power outage. As of 2023, the largest form of grid storage is pumped-storage hydroelectricity, with utility-scale batteries and behind-the-meter batteries coming second and third.[1] Lithium-ion batteries are highly suited for shorter duration storage up to 8 hours. Flow batteries and compressed air energy storage may provide storage for medium duration. Two forms of storage are suited for long-duration storage: green hydrogen, produced via electrolysis and thermal energy storage.[2] Energy storage is one option to making grids more flexible. An other solution is the use of more dispatchable power plants that can change their output rapidly, for instance peaking power plants to fill in supply gaps. Demand response can shift load to other times and interconnections between regions can balance out fluctuations in renewables production.[3] The price of storage technologies typically goes down with experience. For instance, lithium-ion batteries have been getting some 20% cheaper for each doubling of worldwide capacity.[4] Systems with under 40% variable renewables need only short-term storage. At 80%, medium-duration storage becomes essential and beyond 90%, long-duration storage does too. The economics of long-duration storage is challenging, and alternative flexibility options like demand response may be more economic. Roles in the power grid Any electrical power grid must match electricity production to consumption, both of which vary significantly over time. Energy derived from solar and wind sources varies with the weather on time scales ranging from less than a second to weeks or longer. Nuclear power is less flexible than fossil fuels, meaning it cannot easily match the variations in demand. Thus, low-carbon electricity without storage presents special challenges to electric utilities.[5] Electricity storage is one of the three key ways to replace flexibility from fossil fuels in the grid. Other options are demand-side response, in which consumers change when they use electricity or how much they use. For instance, households may have cheaper night tariffs to encourage them to use electricity at night. Industry and commercial consumers can also change their demand to meet supply. Improved network interconnection smooths the variations of renewables production and demand. When there is little wind in one location, another might have a surplus of production. Expansion of transmission lines usually takes a long time.[6] Potential roles of energy storage in the grid[7][8] Consumption Network Generation Short-term flexibility Increased use rooftop solar, cost reductions from time-based rates Congestion relief Renewables integration (smoothing, arbitrage) Essential grid services Backup power during outages Frequency regulation Black start System reliability and planning Creation of mini-grids Savings in transmission and distribution network Meeting peak demand Energy storage has a large set of roles in the electricity grid and can therefore provide many different services. For instance, it can arbitrage by keeping it until the electricity price rises, it can help make the grid more stable, and help reduce investment into transmission infrastructure.[9] The type of service provided by storage depends on who manages the technology, whether the technology is based alongside generation of electricity, within the network, or at the side of consumption.[8] Providing short-term flexibility is a key role for energy storage. On the generation side, it can help with the integration of variable renewable energy, storing it when there is an oversupply of wind and solar and electricity prices are low. More generally, it can exploit the changes in prices of electricity over time in the wholesale market, charging when electricity is cheap and selling when it is expensive. It can further help with grid congestion (where there is insufficient capacity on transmission lines). Consumers can use storage to use more of their self-produced electricity (for instance from rooftop solar power).[8][7] Storage can also be used to provide essential grid services. On the generation side, storage can smooth out the variations in production, for instance for solar and wind. It can assist in a black start after a power outage. On the network side, these include frequency regulation (continuously) and frequency response (after unexpected changes in supply or demand). On the consumption side, storage can help to improve the quality of the delivered electricity in less stable grids.[8][10] Investment in storage may make some investments in the transmission and distribution network unnecessary, or may allow them to be scaled down. Additionally, storage can ensure there is sufficient capacity to meet peak demand within the electricity grid. Finally, in off-grid home systems or mini-grids, electricity storage can help provide energy access in areas that were previously not connected to the electricity grid.[8] Forms Energy from sunlight or other renewable energy is converted to potential energy for storage in devices such as electric batteries. The stored potential energy is later converted to electricity that is added to the power grid, even when the original energy source is not available. In daytime, different renewable sources provide different amounts of power to the grid. At night, energy is provided by batteries that were charged during the day when renewable energy exceeded customer demand. Electricity can be stored directly for a short time in capacitors, somewhat longer electrochemically in batteries, and much longer chemically (e.g. hydrogen), mechanically (e.g. pumped hydropower) or as heat.[11] The first pumped hydroelectricity was constructed at the end of the 19th century around the Alps in Italy, Austria, and Switzerland. The technique rapidly expanded during the 1960s to 1980s nuclear boom, due to nuclear power's inability to quickly adapt to changes in electricity demand. In the 21st century, interest in storage surged due to the rise of sustainable energy sources, which are often weather-dependent.[12] Commercial batteries have been available for over a century,[13] their widespread use in the power grid is more recent, with only 1 GW available in 2013.[14] Batteries Main article: Battery energy storage system A 900 watt direct current light plant using 16 separate lead acid battery cells (32 volts) from 1917.[15] Lithium-ion batteries Lithium-ion batteries are the most commonly used batteries for grid applications, as of 2024, following the application of batteries in electric vehicles (EVs). In comparison with EVs, grid batteries require less energy density, meaning that more emphasis can be put on costs, the ability to charge and discharge often and lifespan. This has led to a shift towards lithium iron phosphate batteries (LFP batteries), which are cheaper and last longer than traditional lithium-ion batteries.[16] Costs of batteries are declining rapidly; from 2010 to 2023 costs fell by 90%.[17] As of 2024, utility-scale systems account for two thirds of added capacity, and home applications (behind-the-meter) for one third.[18] Lithium-ion batteries are highly suited to short-duration storage (50%), the temperature ratio between the two must reach a factor of 5.[61] Thermal energy storage is also used in combination with concentrated solar power (CSP). In CSP, solar energy is first converted into heat, and then either directly converted into electricity or first stored. The energy is released when there is little or no sunshine.[62] This means that CSP can be used as a dispatchable (flexible) form of generation. The energy in a

CSP system can for instance be stored in molten salts or in a solid medium such as sand.[63] Finally, heating and cooling systems in buildings can be controlled to store thermal energy in either the building's mass or dedicated thermal storage tanks. This thermal storage can provide load-shifting or even more complex ancillary services by increasing power consumption (charging the storage) during off-peak times and lowering power consumption (discharging the storage) during higher-priced peak times.[64] Economics Costs Experience curve of lithium-ion batteries: the price of batteries dropped by 97% in three decades.[65][66] The levelized cost of storing electricity (LCOS) is a measure of the lifetime costs of storing electricity per MWh of electricity discharged. It includes investment costs, but also operational costs and charging costs.[67] It depends highly on storage type and purpose; as subsecond-scale frequency regulation, minute/hour-scale peaker plants, or day/week-scale season storage.[68][69][70] For power applications (for instance around ancillary services or black starts), a similar metric is the annuitized capacity cost (ACC), which measures the lifetime costs per kW. ACC is lowest when there are few cycles (<300) and when the discharge is less than one hour. This is because the technology is reimbursed only when it provides spare capacity, not when it is discharged.[71] The cost of storage is coming down following technology-dependent experience curves, the price drop for each doubling in cumulative capacity (or experience). Lithium-ion battery prices fast: the price utitlities pay for them falls 19% with each doubling of capacity. Hydrogen production via electrolysis has a similar learning rate, but it is much more uncertain. Vanadium-flow batteries typically get 14% cheaper for each doubling of capacity. Pumped hydropower has not seen prices fall much with increased experience.[4] Market and system value There are four categories of services which provide economic value for storage: those related to power quality (such as frequency regulation), reliability (ensuring peak demand can be met), better use of assets in the system (e.g. avoiding transmission investments) and arbitrage (exploiting price differences over time). Before 2020, most value for storage was in providing power quality services. Arbitrage is the service with the largest economic potential for storage applications.[72] Storage requirements based on the share of variable renewable energy (VRE). For energy storage, this is the energy stored at a given time, not the total over the year[73] VRE share Power (% of peak demand) Energy storage (% of annual demand) 50% Less than 20% 0.02% 80% 20–50% 0.03–0.1% 90% 25–75% 0.05–0.2% In systems with under 40% of variable renewables, only short-term storage (of less than 4 hours) is needed for integration. When the share of variable renewables climbs to 80%, medium-duration storage (between 4 and 16 hours, for instance compressed air) is needed. Above 90%, large-scale long-duration storage is required.[74] The economics of long-duration storage is challenging even then, as the costs are high. Alternative flexibility options, such as demand response, network expansions or flexible generation (geothermal or fossil gas with carbon capture and storage) may be lower-cost.[75] Like with renewables, storage will "cannibalise" its own income, but even more strongly. That is, with more storage on the market, there is less of an opportunity to do arbitrage or deliver other services to the grid.[76] How markets are designed impacts revenue potential too. The income from arbitrage is quite variable between years, whereas markets that have capacity payments likely show less volatility.[77] Electricity storage is not 100% efficient, so more electricity needs to be bought than can be sold. This implies that if there is only a small variation in price, it may not be economical to charge and discharge. For instance, if the storage application is 75% efficient, the price at which the electricity is sold needs to be at least 1.33 higher than the price for which it was bought.[78] Typically, electricity prices vary most between day and night, which means that storage up to 8 hours has relatively high potential for profit. Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia Diagram comparing losses from conventional generation vs. cogeneration Part of a series on Sustainable energy Energy conservation Renewable energy Sustainable transport Category Renewable energy portal v t e Cogeneration or combined heat and power (CHP) is the use of a heat engine[1] or power station to generate electricity and useful heat at the same time. Cogeneration is a more efficient use of fuel or heat, because otherwise-wasted heat from electricity generation is put to some productive use. Combined heat and power (CHP) plants recover otherwise wasted thermal energy for heating. This is also called combined heat and power district heating. Small CHP plants are an example of decentralized energy.[2] By-product heat at moderate temperatures (100–180 °C (212–356 °F) can also be used in absorption refrigerators for cooling. The supply of high-temperature heat first drives a gas or steam turbine-powered generator. The resulting low-temperature waste heat is then used for water or space heating. At smaller scales (typically below 1 MW), a gas engine or diesel engine may be used. Cogeneration is also common with geothermal power plants as they often produce relatively low grade heat. Binary cycles may be necessary to reach acceptable thermal efficiency for electricity generation at all. Cogeneration is less commonly employed in nuclear power plants as NIMBY and safety considerations have often kept them further from population centers than comparable chemical power plants and district heating is less efficient in lower population density areas due to transmission losses. Cogeneration was practiced in some of the earliest installations of electrical generation. Before central stations distributed power, industries generating their own power used exhaust steam for process heating. Large office and apartment buildings, hotels, and stores commonly generated their own power and used waste steam for building heat. Due to the high cost of early purchased power, these CHP operations continued for many years after utility electricity became available.[3] Overview Masnedø CHP power station in Denmark. This station burns straw as fuel. The adjacent greenhouses are heated by district heating from the plant. Many process industries, such as chemical plants, oil refineries and pulp and paper mills, require large amounts of process heat for such operations as chemical reactors, distillation columns, steam driers and other uses. This heat, which is usually used in the form of steam, can be generated at the typically low pressures used in heating, or can be generated at much higher pressure and passed through a turbine first to generate electricity. In the turbine the steam pressure and temperature is lowered as the internal energy of the steam is converted to work. The lower-pressure steam leaving the turbine can then be used for process heat. Steam turbines at thermal power stations are normally designed to be fed high-pressure steam, which exits the turbine at a condenser operating a few degrees above ambient temperature and at a few millimeters of mercury absolute pressure. (This is called a condensing turbine.) For all practical purposes this steam has negligible useful energy before it is condensed. Steam turbines for cogeneration are designed for extraction of some steam at lower pressures after it has passed through a number of turbine stages, with the un-extracted steam going on through the turbine to a condenser. In this case, the extracted steam causes a mechanical power loss in the downstream stages of the turbine. Or they are designed, with or without extraction, for final exhaust at back pressure (non-condensing).[4][5] The extracted or exhaust steam is used for process heating. Steam at ordinary process heating conditions still has a considerable amount of enthalpy that could be used for power generation, so cogeneration has an opportunity cost. A typical power generation turbine in a paper mill may have extraction pressures of 160 and 60 psi (1.10 and 0.41 MPa). A typical back pressure may be 60 psi (0.41 MPa). In practice these pressures are custom designed for each facility. Conversely, simply generating process steam for industrial purposes instead of high enough pressure to generate power at the top end also has an opportunity cost (See: Steam supply and exhaust conditions). The capital and operating cost of high-pressure boilers, turbines, and generators is substantial. This equipment is normally operated continuously, which usually limits self-generated power to large-scale operations. A cogeneration plant in Metz, France. The 45 MW boiler uses waste wood biomass as an energy source, providing electricity and heat for 30,000 dwellings. A combined cycle (in which several thermodynamic cycles produce electricity), may also be used to extract heat using a heating system as condenser of the power plant's bottoming cycle. For example, the RU-25 MHD generator in Moscow heated a boiler for a conventional steam powerplant, whose condensate was then used for space heat. A more modern system might use a gas turbine powered by natural gas, whose exhaust powers a steam plant, whose condensate provides heat. Cogeneration plants based on a combined cycle power unit can have thermal efficiencies above 80%. The viability of CHP (sometimes termed utilisation factor), especially in smaller CHP installations, depends on a good baseload of operation, both in terms of an on-site (or near site) electrical demand and heat demand. In practice, an exact match between the heat and electricity needs rarely exists. A CHP plant can either meet the need for heat (heat driven operation) or be run as a power plant with some use of its waste heat, the latter being less advantageous in terms of its utilisation factor and thus its overall efficiency. The viability can be greatly increased where opportunities for trigeneration exist. In such cases, the heat from the CHP plant is also used as a primary energy source to deliver cooling by means of an absorption chiller. CHP is most efficient when heat can be used on-site or very close to it. Overall efficiency is reduced when the heat must be transported over longer distances. This requires heavily insulated pipes, which are expensive and inefficient; whereas electricity can be transmitted along a comparatively simple wire, and over much longer distances for the same energy loss. A car engine becomes a CHP plant in winter when the reject heat is useful for warming the interior of the vehicle. The example illustrates the point that deployment of CHP depends on heat uses in the vicinity of the heat engine. Thermally enhanced oil recovery (TEOR) plants often produce a substantial amount of excess electricity. After generating electricity, these plants pump leftover steam into heavy oil wells so that the oil will flow more easily, increasing production. Cogeneration plants are commonly found in district heating systems of cities, central heating systems of larger buildings (e.g. hospitals, hotels, prisons) and are commonly used in the industry in thermal production processes for process water, cooling, steam production or CO2 fertilization. Rostock Power Station, a bituminous coal-fired combined heat and power plant in Germany Trigeneration or combined cooling, heat and power (CCHP) refers to the simultaneous generation of electricity and useful heating and cooling from the combustion of a fuel or a solar heat collector. The terms cogeneration and trigeneration can also be applied to the power systems simultaneously generating electricity, heat, and industrial chemicals (e.g., syngas). Trigeneration differs from cogeneration in that the waste heat is used for both heating and cooling, typically in an absorption refrigerator. Combined cooling, heat, and power systems can attain higher overall efficiencies than cogeneration or traditional power plants. In the United States, the application of trigeneration in buildings is called building cooling, heating, and power. Heating and cooling output may operate concurrently or alternately depending on need and system construction. Types of plants Hanasaari Power Plant, a coal-fired cogeneration power plant in Helsinki, Finland Topping cycle plants primarily produce electricity from a steam turbine. Partly expanded steam is then condensed in a heating condensor at a temperature level that is suitable e.g. district heating or water desalination. Bottoming cycle plants produce high temperature heat for industrial processes, then a waste heat recovery boiler feeds an electrical plant. Bottoming cycle plants are only used in industrial processes that require very high temperatures such as furnaces for glass and metal manufacturing, so they are less common. Large cogeneration systems provide heating water and power for an industrial site or an entire town. Common CHP plant types are: Gas turbine CHP plants using the waste heat in the flue gas of gas turbines. The fuel used is typically natural gas. Gas engine CHP plants use a reciprocating gas engine, which is generally more competitive than a gas turbine up to about 5 MW. The gaseous fuel used is normally natural gas. These plants are generally manufactured as fully packaged units that can be installed within a plantroom or external plant compound with simple connections to the site's gas supply, electrical distribution network and heating systems. Typical outputs and efficiencies see [6] Typical large example see [7] Biofuel engine CHP plants use an adapted reciprocating gas engine or diesel engine, depending upon which biofuel is being used, and are otherwise very similar in design to a Gas engine CHP plant. The advantage of using a biofuel is one of reduced fossil fuel consumption and thus reduced carbon emissions. These plants are generally manufactured as fully packaged units that can be installed within a plantroom or external plant compound with simple connections to the site's electrical distribution and heating systems. Another variant is the wood gasifier CHP plant whereby a wood pellet or wood chip biofuel is gasified in a zero oxygen high temperature environment; the resulting gas is then used to power the gas engine. Combined cycle power plants adapted for CHP Molten-carbonate fuel cells and solid oxide fuel cells have a hot exhaust, very suitable for heating. Steam turbine CHP plants that use the heating system as the steam condenser for the steam turbine Nuclear power plants, similar to other steam turbine power plants, can be fitted with extractions in the turbines to bleed partially expanded steam to a heating system. With a heating system temperature of 95 °C it is possible to extract about 10 MW heat for every MW electricity lost. With a temperature of 130 °C the gain is slightly smaller, about 7 MW for every MWe lost.[8] A review of cogeneration options is in [9] Czech research team proposed a "Teplator" system where heat from spent fuel rods is recovered for the purpose of residential heating.[10] Smaller cogeneration units may use a reciprocating engine or Stirling engine. The heat is removed from the exhaust and radiator. The systems are popular in small sizes because small gas and diesel engines are less expensive than small gas- or oil-fired steam-electric plants. Some cogeneration plants are fired by biomass,[11] or industrial and municipal solid waste (see incineration). Some CHP plants use waste gas as the fuel for electricity and heat generation. Waste gases can be gas from animal waste, landfill gas, gas from coal mines, sewage gas, and combustible industrial waste gas.[12] Some cogeneration plants combine gas and solar photovoltaic generation to further improve technical and environmental performance.[13] Such hybrid systems can be scaled down to the building level[14] and even individual homes.[15] MicroCHP Micro combined heat and power or 'Micro cogeneration" is a so-called distributed energy resource (DER). The installation is usually less than 5 kWe in a house or small business. Instead of burning fuel to merely heat space or water, some of the energy is converted to electricity in addition to heat. This electricity can be used within the home or business or, if permitted by the grid management, sold back into the electric power grid. Delta-ee consultants stated in 2013 that with 64% of global sales the fuel cell micro-combined heat and power passed the conventional systems in sales in 2012.[16] 20,000 units were sold in Japan in 2012 overall within the Ene Farm project. With a Lifetime of around 60,000 hours. For PEM fuel cell units, which shut down at night, this equates to an estimated lifetime of between ten and fifteen years.[17] For a price of $22,600 before installation.[18] For 2013 a state subsidy for 50,000 units is in place.[17] MicroCHP installations use five different technologies: microturbines, internal combustion engines, stirling engines, closed-cycle steam engines, and fuel cells. One author indicated in 2008 that MicroCHP based on Stirling engines is the most cost-effective of the so-called microgeneration technologies in abating carbon emissions.[19] A 2013 UK report from Ecuity Consulting stated that MCHP is the most cost-effective method of using gas to generate energy at the domestic level.[20][21] However, advances in reciprocation engine technology are adding efficiency to CHP plants, particularly in the biogas field.[22] As both MiniCHP and CHP have been shown to reduce emissions [23] they could play a large role in the field of CO2 reduction from buildings, where more than 14% of emissions can be saved using CHP in buildings.[24] The University of Cambridge reported a cost-effective steam engine MicroCHP prototype in 2017 which has the potential to be commercially competitive in the following decades.[25] Quite recently, in some private homes, fuel cell micro-CHP plants can now be found, which can operate on hydrogen, or other fuels as natural gas or LPG.[26][27] When running on natural gas, it relies on steam reforming of natural gas to convert the natural gas to hydrogen prior to use in the fuel cell. This hence still emits CO2 (see reaction) but (temporarily) running on this can be a good solution until the point where the hydrogen is starting to be distributed through the (natural gas) piping system. Another MicroCHP example is a natural gas or propane fueled Electricity Producing Condensing Furnace. It combines the fuel saving technique of cogeneration meaning producing electric power and useful heat from a single source of combustion. The condensing furnace is a forced-air gas system with a secondary heat exchanger that allows heat to be extracted from combustion products down to the ambient temperature along with recovering heat from the water vapor. The chimney is replaced by a water drain and vent to the side of the building. Trigeneration Trigeneration cycle A plant producing electricity, heat and cold is called a trigeneration[28] or polygeneration plant. Cogeneration systems linked to absorption chillers or adsorption chillers use waste heat for refrigeration.[29] Combined heat and power district heating See also: District heating In the United States, Consolidated Edison distributes 66 billion kilograms of 350 °F (177 °C) steam each year through its seven cogeneration plants to 100,000 buildings in Manhattan—the biggest steam district in the United States. The peak delivery is 10 million pounds per hour (or approximately 2.5 GW).[30][31] Industrial CHP Cogeneration is still common in pulp and paper mills, refineries and chemical plants. In this "industrial cogeneration/CHP", the heat is typically recovered at higher temperatures (above 100 °C) and used for process steam or drying duties. This is more valuable and flexible than low-grade waste heat, but there is a slight loss of power generation. The increased focus on sustainability has made industrial CHP more attractive, as it substantially reduces carbon footprint compared to generating steam or burning fuel on-site and importing electric power from the grid. Smaller industrial co-generation units have an output capacity of 5–25 MW and represent a viable off-grid option for a variety of remote applications to reduce carbon emissions.[32] Utility pressures versus self generated industrial Industrial cogeneration plants normally operate at much lower boiler pressures than utilities. Among the reasons are: Cogeneration plants face possible contamination of returned condensate. Because boiler feed water from cogeneration plants has much lower return rates than 100% condensing power plants, industries usually have to treat proportionately more boiler make up water. Boiler feed water must be completely oxygen free and de-mineralized, and the higher the pressure the more critical the level of purity of the feed water.[5] Utilities are typically larger scale power than industry, which helps offset the higher capital costs of high pressure. Utilities are less likely to have sharp load swings than industrial operations, which deal with shutting down or starting up units that may represent a significant percent of either steam or power demand. Heat recovery steam generators A heat recovery steam generator (HRSG) is a steam boiler that uses hot exhaust gases from the gas turbines or reciprocating engines in a CHP plant to heat up water and generate steam. The steam, in turn, drives a steam turbine or is used in industrial processes that require heat. HRSGs used in the CHP industry are distinguished from conventional steam generators by the following main features: The HRSG is designed based upon the specific features of the gas turbine or reciprocating engine that it will be coupled to. Since the exhaust gas temperature is relatively low, heat transmission is accomplished mainly through convection. The exhaust gas velocity is limited by the need to keep head losses down. Thus, the transmission coefficient is low, which calls for a large heating surface area. Since the temperature difference between the hot gases and the fluid to be heated (steam or water) is low, and with the heat transmission coefficient being low as well, the evaporator and economizer are designed with plate fin heat exchangers. Cogeneration using biomass Biomass refers to any plant or animal matter in which it is possible to be reused as a source of heat or electricity, such as sugarcane, vegetable oils, wood, organic waste and residues from the food or agricultural industries. Brazil is now considered a world reference in terms of energy generation from biomass.[33] A growing sector in the use of biomass for power generation is the sugar and alcohol sector, which mainly uses sugarcane bagasse as fuel for thermal and electric power generation.[34] Power cogeneration in the sugar and alcohol sector In the sugarcane industry, cogeneration is fueled by the bagasse residue of sugar refining, which is burned to produce steam. Some steam can be sent through a turbine that turns a generator, producing electric power.[35] Energy cogeneration in sugarcane industries located in Brazil is a practice that has been growing in last years. With the adoption of energy cogeneration in the sugar and alcohol sector, the sugarcane industries are able to supply the electric energy demand needed to operate, and generate a surplus that can be commercialized.[36][37] Advantages of the cogeneration using sugarcane bagasse In comparison with the electric power generation by means of fossil fuel-based thermoelectric plants, such as natural gas, the energy generation using sugarcane bagasse has environmental advantages due to the reduction of CO2 emissions.[38] In addition to the environmental advantages, cogeneration using sugarcane bagasse presents advantages in terms of efficiency comparing to thermoelectric generation, through the final destination of the energy produced. While in thermoelectric generation, part of the heat produced is lost, in cogeneration this heat has the possibility of being used in the production processes, increasing the overall efficiency of the process.[38] Disadvantages of the cogeneration using sugarcane bagasse In sugarcane cultivation, is usually used potassium source's containing high concentration of chlorine, such as potassium chloride (KCl). Considering that KCl is applied in huge quantities, sugarcane ends up absorbing high concentrations of chlorine.[39] Due to this absorption, when the sugarcane bagasse is burned in the power cogeneration, dioxins [39] and methyl chloride [40] ends up being emitted. In the case of dioxins, these substances are considered very toxic and cancerous.[41][42][43] In the case of methyl chloride, when this substance is emitted and reaches the stratosphere, it ends up being very harmful for the ozone layer, since chlorine when combined with the ozone molecule generates a catalytic reaction leading to the breakdown of ozone links.[40] After each reaction, chlorine starts a destructive cycle with another ozone molecule. In this way, a single chlorine atom can destroy thousands of ozone molecules. As these molecules are being broken, they are unable to absorb the ultraviolet rays. As a result, the UV radiation is more intense on Earth and there is a worsening of global warming.[40] Comparison with a heat pump A heat pump may be compared with a CHP unit as follows. If, to supply thermal energy, the exhaust steam from the turbo-generator must be taken at a higher temperature than the system would produce most electricity at, the lost electrical generation is as if a heat pump were used to provide the same heat by taking electrical power from the generator running at lower output temperature and higher efficiency.[44] Typically for every unit of electrical power lost, then about 6 units of heat are made available at about 90 °C (194 °F). Thus CHP has an effective Coefficient of Performance (COP) compared to a heat pump of 6.[45] However, for a remotely operated heat pump, losses in the electrical distribution network would need to be considered, of the order of 6%. Because the losses are proportional to the square of the current, during peak periods losses are much higher than this and it is likely that widespread (i.e. citywide application of heat pumps) would cause overloading of the distribution and transmission grids unless they were substantially reinforced. It is also possible to run a heat driven operation combined with a heat pump, where the excess electricity (as heat demand is the defining factor on se[clarification needed]) is used to drive a heat pump. As heat demand increases, more electricity is generated to drive the heat pump, with the waste heat also heating the heating fluid. As the efficiency of heat pumps depends on the difference between hot end and cold end temperature (efficiency rises as the difference decreases) it may be worthwhile to combine even relatively low grade waste heat otherwise unsuitable for home heating with heat pumps. For example, a large enough reservoir of cooling water at 15 °C (59 °F) can significantly improve efficiency of heat pumps drawing from such a reservoir compared to air source heat pumps drawing from cold air during a −20 °C (−4 °F) night. In the summer when there's both demand for air conditioning and warm water, the same water may even serve as both a "dump" for the waste heat rejected by a/c units and as a "source" for heat pumps providing warm water. Those considerations are behind what is sometimes called "cold district heating" using a "heat" source whose temperature is well below those usually employed in district heating.[46] Distributed generation Most industrial countries generate the majority of their electrical power needs in large centralized facilities with capacity for large electrical power output. These plants benefit from economy of scale, but may need to transmit electricity across long distances causing transmission losses. Cogeneration or trigeneration production is subject to limitations in the local demand and thus may sometimes need to reduce (e.g., heat or cooling production to match the demand). An example of cogeneration with trigeneration applications in a major city is the New York City steam system. Thermal efficiency Every heat engine is subject to the theoretical efficiency limits of the Carnot cycle or subset Rankine cycle in the case of steam turbine power plants or Brayton cycle in gas turbine with steam turbine plants. Most of the efficiency loss with steam power generation is associated with the latent heat of vaporization of steam that is not recovered when a turbine exhausts its low temperature and pressure steam to a condenser. (Typical steam to condenser would be at a few millimeters absolute pressure and on the order of 5 °C (41 °F) hotter than the cooling water temperature, depending on the condenser capacity.) In cogeneration this steam exits the turbine at a higher temperature where it may be used for process heat, building heat or cooling with an absorption chiller. The majority of this heat is from the latent heat of vaporization when the steam condenses. Thermal efficiency in a cogeneration system is defined as: Where: = Thermal efficiency = Total work output by all systems = Total heat input into the system Heat output may also be used for cooling (for example, in summer), thanks to an absorption chiller. If cooling is achieved in the same time, thermal efficiency in a trigeneration system is defined as: Where: = Thermal efficiency = Total work output by all systems = Total heat input into the system Typical cogeneration models have losses as in any system. The energy distribution below is represented as a percent of total input energy:[47] Electricity = 45% Heat + Cooling = 40% Heat losses = 13% Electrical line losses = 2% Conventional central coal- or nuclear-powered power stations convert about 33–45% of their input heat to electricity.[48][5] Brayton cycle power plants operate at up to 60% efficiency. In the case of conventional power plants, approximately 10-15% of this heat is lost up the stack of the boiler. Most of the remaining heat emerges from the turbines as low-grade waste heat with no significant local uses, so it is usually rejected to the environment, typically to cooling water passing through a condenser.[5] Because turbine exhaust is normally just above ambient temperature, some potential power generation is sacrificed in rejecting higher-temperature steam from the turbine for cogeneration purposes.[49] For cogeneration to be practical power generation and end use of heat must be in relatively close proximity (<2 km typically). Even though the efficiency of a small distributed electrical generator may be lower than a large central power plant, the use of its waste heat for local heating and cooling can result in an overall use of the primary fuel supply as great as 80%.[48] This provides substantial financial and environmental benefits. Costs See also: Cost of electricity by source Typically, for a gas-fired plant the fully installed cost per kW electrical is around £400/kW (US$577), which is comparable with large central power stations.[50] History Cogeneration in Europe A cogeneration thermal power plant in Ferrera Erbognone (PV), Italy This section needs to be updated. Please help update this article to reflect recent events or newly available information. (May 2021) The EU has actively incorporated cogeneration into its energy policy via the CHP Directive. In September 2008 at a hearing of the European Parliament's Urban Lodgment Intergroup, Energy Commissioner Andris Piebalgs is quoted as saying, “security of supply really starts with energy efficiency.”[51] Energy efficiency and cogeneration are recognized in the opening paragraphs of the European Union's Cogeneration Directive 2004/08/EC. This directive intends to support cogeneration and establish a method for calculating cogeneration abilities per country. The development of cogeneration has been very uneven over the years and has been dominated throughout the last decades by national circumstances. The European Union generates 11% of its electricity using cogeneration.[52] However, there is large difference between Member States with variations of the energy savings between 2% and 60%. Europe has the three countries with the world's most intensive cogeneration economies: Denmark, the Netherlands and Finland.[53] Of the 28.46 TWh of electrical power generated by conventional thermal power plants in Finland in 2012, 81.80% was cogeneration.[54] Other European countries are also making great efforts to increase efficiency. Germany reported that at present, over 50% of the country's total electricity demand could be provided through cogeneration. So far, Germany has set the target to double its electricity cogeneration from 12.5% of the country's electricity to 25% of the country's electricity by 2020 and has passed supporting legislation accordingly.[55] The UK is also actively supporting combined heat and power. In light of UK's goal to achieve a 60% reduction in carbon dioxide emissions by 2050, the government has set the target to source at least 15% of its government electricity use from CHP by 2010.[56] Other UK measures to encourage CHP growth are financial incentives, grant support, a greater regulatory framework, and government leadership and partnership. According to the IEA 2008 modeling of cogeneration expansion for the G8 countries, the expansion of cogeneration in France, Germany, Italy and the UK alone would effectively double the existing primary fuel savings by 2030. This would increase Europe's savings from today's 155.69 Twh to 465 Twh in 2030. It would also result in a 16% to 29% increase in each country's total cogenerated electricity by 2030. Governments are being assisted in their CHP endeavors by organizations like COGEN Europe who serve as an information hub for the most recent updates within Europe's energy policy. COGEN is Europe's umbrella organization representing the interests of the cogeneration industry. The European public–private partnership Fuel Cells and Hydrogen Joint Undertaking Seventh Framework Programme project ene.field deploys in 2017[57] up 1,000 residential fuel cell Combined Heat and Power (micro-CHP) installations in 12 states. Per 2012 the first 2 installations have taken place.[58][59][60] Cogeneration in the United Kingdom In the United Kingdom, the Combined Heat and Power Quality Assurance scheme regulates the combined production of heat and power. It was introduced in 1996. It defines, through calculation of inputs and outputs, "Good Quality CHP" in terms of the achievement of primary energy savings against conventional separate generation of heat and electricity. Compliance with Combined Heat and Power Quality Assurance is required for cogeneration installations to be eligible for government subsidies and tax incentives.[61] Cogeneration in the United States The 250 MW Kendall Cogeneration Station plant in Cambridge, Massachusetts Perhaps the first modern use of energy recycling was done by Thomas Edison. His 1882 Pearl Street Station, the world's first commercial power plant, was a combined heat and power plant, producing both electricity and thermal energy while using waste heat to warm neighboring buildings.[62] Recycling allowed Edison's plant to achieve approximately 50 percent efficiency. By the early 1900s, regulations emerged to promote rural electrification through the construction of centralized plants managed by regional utilities. These regulations not only promoted electrification throughout the countryside, but they also discouraged decentralized power generation, such as cogeneration. By 1978, Congress recognized that efficiency at central power plants had stagnated and sought to encourage improved efficiency with the Public Utility Regulatory Policies Act (PURPA), which encouraged utilities to buy power from other energy producers. Cogeneration plants proliferated, soon producing about 8% of all energy in the United States.[63] However, the bill left implementation and enforcement up to individual states, resulting in little or nothing being done in many parts of the country.[citation needed] The United States Department of Energy has an aggressive goal of having CHP constitute 20% of generation capacity by 2030.[citation needed] Eight Clean Energy Application Centers[64] have been established across the nation. Their mission is to develop the required technology application knowledge and educational infrastructure necessary to lead "clean energy" (combined heat and power, waste heat recovery, and district energy) technologies as viable energy options and reduce any perceived risks associated with their implementation. The focus of the Application Centers is to provide an outreach and technology deployment program for end users, policymakers, utilities, and industry stakeholders. High electric rates in New England and the Middle Atlantic make these areas of the United States the most beneficial for cogeneration.[65][66] ISBN 978-0-8493-2274-7 v t e Electricity delivery Concepts Automatic generation control Backfeeding Base load Demand factor Droop speed control Electric power Electric power quality Electrical fault Energy demand management Energy return on investment Grid code Grid energy storage Grid strength Home energy storage Load-following Merit order Nameplate capacity Peak demand Power factor Power-flow study Repowering Utility frequency Variability Vehicle-to-grid Sources Non-renewable Fossil fuel power station Coal Natural gas Oil shale Petroleum Nuclear Renewable Biofuel Biogas Biomass Geothermal Hydro Marine Current Osmotic Thermal Tidal Wave Solar Sustainable biofuel Wind Generation AC power Cogeneration Combined cycle Cooling tower Induction generator Micro CHP Microgeneration Rankine cycle Three-phase electric power Virtual power plant Transmission and distribution Demand response Distributed generation Dynamic demand Electric power distribution Electric power system Electric power transmission Electrical busbar system Electrical grid Electrical substation Electricity retailing High-voltage direct current High-voltage shore connection Interconnector Load management Mains electricity by country Overhead power line Power station Pumped hydro Single-wire earth return Smart grid Super grid Transformer Transmission system operator (TSO) Transmission tower Utility pole Failure modes Black start Brownout Cascading failure Power outage Rolling blackout Protective devices Arc-fault circuit interrupter Circuit breaker Earth-leakage Sulfur hexafluoride Generator interlock kit Numerical relay Power system protection Protective relay Residual-current device (GFI) Economics and policies Availability factor Capacity factor Carbon offsets and credits Cost of electricity by source Energy subsidies Environmental tax Feed-in tariff Fossil fuel phase-out Load factor Net metering Pigouvian tax Renewable Energy Certificates Renewable energy commercialization Renewable Energy Payments Spark/Dark/Quark/Bark spread Statistics and production Electric energy consumption List of electricity sectors Contents · (Top) · Types · Protecting the power system from outages · Protecting computer systems from power outages · Restoring power after a wide-area outage · Blackout inevitability and electric sustainability Self-organized criticality OPA model Mitigation of power outage frequency Key performance indicators See also References External links Power outage Article Talk Read Edit View history Tools Appearance Text Small Standard Large Width Standard Wide Color (beta) Automatic Light Dark From Wikipedia, the free encyclopedia This article is about accidental power failures. For intentionally engineered ones, see rolling blackout. For other uses, see Power Outage (disambiguation). "Power cut" redirects here. For the 2012 Punjabi film, see Power Cut. Vehicle lights provided the only illumination during the 2009 Ecuador electricity crisis. A power outage, also called a powercut, a power out, a power failure, a power blackout, a power loss, a blackout or a power drought — is the loss of the electrical power network supply to an end user. There are many causes of power failures in an electricity network. Examples of these causes include faults at power stations, damage to electric transmission lines, substations or other parts of the distribution system, a short circuit, cascading failure, fuse or circuit breaker operation. Power failures are particularly critical at sites where the environment and public safety are at risk. Institutions such as hospitals, sewage treatment plants, and mines will usually have backup power sources such as standby generators, which will automatically start up when electrical power is lost. Other critical systems, such as telecommunication, are also required to have emergency power. The battery room of a telephone exchange usually has arrays of lead–acid batteries for backup and also a socket for connecting a generator during extended periods of outage. During a power outage, there is a disruption in the supply of electricity, resulting in a loss of power to homes, businesses, and other facilities. Power outages can occur for various reasons, including severe weather conditions (e.g. storms, hurricanes, or blizzards), earthquakes, equipment failure, grid overload, or planned maintenance. Types Blackout Transient fault Power outages are categorized into three different phenomena, relating to the duration and effect of the outage: A transient fault is a loss of power typically caused by a fault on a power line, e.g. a short circuit or flashover. Power is automatically restored once the fault is cleared. A brownout is a drop in voltage in an electrical power supply. The term brownout comes from the dimming experienced by incandescent lighting when the voltage sags. Brownouts can cause poor performance of equipment or even incorrect operation. A blackout is the total loss of power to a wider area and of long duration.[1] It is the most severe form of power outage that can occur. Blackouts which result from or result in power stations tripping are particularly difficult to recover from quickly. Outages may last from a few minutes to a few weeks depending on the nature of the blackout and the configuration of the electrical network. Rolling blackouts occur when demand for electricity exceeds supply, and allow some customers to receive power at the required voltage at the expense of other customers who get no power at all. They are a common occurrence in developing countries, and may be scheduled in advance or occur without warning. They have also occurred in developed countries, for example in the California electricity crisis of 2000–2001, when government deregulation destabilized the wholesale electricity market. Blackouts are also used as a public safety measure, such as to prevent a gas leak from catching fire (for example, power was cut to several towns in response to the Merrimack Valley gas explosions), or to prevent wildfires around poorly maintained transmission lines (such as during the 2019 California power shutoffs). Protecting the power system from outages Tree limbs creating a short circuit in power lines during a storm. This typically results in a power outage in the area supplied by these lines In power supply networks, the power generation and the electrical load (demand) must be very close to equal every second to avoid overloading of network components, which can severely damage them. Protective relays and fuses are used to automatically detect overloads and to disconnect circuits at risk of damage. Under certain conditions, a network component shutting down can cause current fluctuations in neighboring segments of the network leading to a cascading failure of a larger section of the network. This may range from a building, to a block, to an entire city, to an entire electrical grid. Modern power systems are designed to be resistant to this sort of cascading failure, but it may be unavoidable (see below). Moreover, since there is no short-term economic benefit to preventing rare large-scale failures, researchers have expressed concern that there is a tendency to erode the resilience of the network over time, which is only corrected after a major failure occurs. [citation needed] In a 2003 publication, Carreras and co-authors claimed that reducing the likelihood of small outages only increases the likelihood of larger ones.[2] In that case, the short-term economic benefit of keeping the individual customer happy increases the likelihood of large-scale blackouts. The Senate Committee on Energy and Natural Resources held a hearing in October 2018 to examine "black start", the process of restoring electricity after a system-wide power loss. The hearing's purpose was for Congress to learn about what the backup plans are in the electric utility industry in the case that the electric grid is damaged. Threats to the electrical grid include cyberattacks, solar storms, and severe weather, among others. For example, the "Northeast Blackout of 2003" was caused when overgrown trees touched high-voltage power lines. Around 55 million people in the U.S. and Canada lost power, and restoring it cost around $6 billion.[3] Protecting computer systems from power outages Computer systems and other electronic devices containing logic circuitry are susceptible to data loss or hardware damage that can be caused by the sudden loss of power. These can include data networking equipment, video projectors, alarm systems as well as computers. To protect computer systems against this, the use of an uninterruptible power supply or 'UPS' can provide a constant flow of electricity if a primary power supply becomes unavailable for a short period of time. To protect against surges (events where voltages increase for a few seconds), which can damage hardware when power is restored, a special device called a surge protector that absorbs the excess voltage can be used. Restoring power after a wide-area outage Restoring power after a wide-area outage can be difficult, as power stations need to be brought back online. Normally, this is done with the help of power from the rest of the grid. In the total absence of grid power, a so-called black start needs to be performed to bootstrap the power grid into operation. The means of doing so will depend greatly on local circumstances and operational policies, but typically transmission utilities will establish localized 'power islands' which are then progressively coupled together. To maintain supply frequencies within tolerable limits during this process, demand must be reconnected at the same pace that generation is restored, requiring close coordination between power stations, transmission and distribution organizations. Blackout inevitability and electric sustainability Comparison of duration of power outages (SAIDI value), in 2014. Self-organized criticality Further information: Self-organized criticality control It has been argued on the basis of historical data[4] and computer modeling[5][6] that power grids are self-organized critical systems. These systems exhibit unavoidable[7] disturbances of all sizes, up to the size of the entire system. This phenomenon has been attributed to steadily increasing demand/load, the economics of running a power company, and the limits of modern engineering.[8] While blackout frequency has been shown to be reduced by operating it further from its critical point, it generally is not economically feasible, causing providers to increase the average load over time or upgrade less often resulting in the grid moving itself closer to its critical point. Conversely, a system past the critical point will experience too many blackouts leading to system-wide upgrades moving it back below the critical point. The term critical point of the system is used here in the sense of statistical physics and nonlinear dynamics, representing the point where a system undergoes a phase transition; in this case the transition from a steady reliable grid with few cascading failures to a very sporadic unreliable grid with common cascading failures. Near the critical point the relationship between blackout frequency and size follows a power-law distribution.[6][8] Cascading failure becomes much more common close to this critical point. The power-law relationship is seen in both historical data and model systems.[8] The practice of operating these systems much closer to their maximum capacity leads to magnified effects of random, unavoidable disturbances due to aging, weather, human interaction etc. While near the critical point, these failures have a greater effect on the surrounding components due to individual components carrying a larger load. This results in the larger load from the failing component having to be redistributed in larger quantities across the system, making it more likely for additional components not directly affected by the disturbance to fail, igniting costly and dangerous cascading failures.[8] These initial disturbances causing blackouts are all the more unexpected and unavoidable due to actions of the power suppliers to prevent obvious disturbances (cutting back trees, separating lines in windy areas, replacing aging components etc.). The complexity of most power grids often makes the initial cause of a blackout extremely hard to identify. Leaders are dismissive of system theories that conclude that blackouts are inevitable, but do agree that the basic operation of the grid must be changed. The Electric Power Research Institute champions the use of smart grid features such as power control devices employing advanced sensors to coordinate the grid.[9] Others advocate greater use of electronically controlled high-voltage direct current (HVDC) firebreaks to prevent disturbances from cascading across AC lines in a wide area grid.[10] OPA model In 2002, researchers at Oak Ridge National Laboratory (ORNL), Power System Engineering Research Center of the University of Wisconsin (PSerc),[11] and the University of Alaska Fairbanks proposed a mathematical model for the behavior of electrical distribution systems.[12][13] This model has become known as the OPA model, a reference to the names of the authors' institutions. OPA is a cascading failure model. Other cascading failure models include Manchester, Hidden failure, CASCADE, and Branching.[14] The OPA model was quantitatively compared with a complex networks model of a cascading failure – Crucitti–Latora–Marchiori (CLM) model,[15] showing that both models exhibit similar phase transitions in the average network damage (load shed/demand in OPA, path damage in CLM), with respect to transmission capacity.[16] Mitigation of power outage frequency The effects of trying to mitigate cascading failures near the critical point in an economically feasible fashion are often shown to not be beneficial and often even detrimental. Four mitigation methods have been tested using the OPA blackout model:[2] Increase critical number of failures causing cascading blackouts – Shown to decrease the frequency of smaller blackouts but increase that of larger blackouts. Increase individual power line max load – Shown to increase the frequency of smaller blackouts and decrease that of larger blackouts. Combination of increasing critical number and max load of lines – Shown to have no significant effect on either size of blackout. The resulting minor reduction in the frequency of blackouts is projected to not be worth the cost of the implementation. Increase the excess power available to the grid – Shown to decrease the frequency of smaller blackouts but increase that of larger blackouts. In addition to the finding of each mitigation strategy having a cost-benefit relationship with regards to frequency of small and large blackouts, the total number of blackout events was not significantly reduced by any of the above-mentioned mitigation measures.[2] A complex network-based model to control large cascading failures (blackouts) using local information only was proposed by A. E. Motter.[17] In 2015, one of the solutions proposed to reduce the impact of power outage was introduced by M. S. A smart meter is an electronic device that records information—such as consumption of electric energy, voltage levels, current, and power factor—and communicates the information to the consumer and electricity suppliers. Advanced metering infrastructure (AMI) differs from automatic meter reading (AMR) in that it enables two-way communication between the meter and the supplier. Description The term smart meter often refers to an electricity meter, but it also may mean a device measuring natural gas, water or district heating consumption.[1][2] More generally, a smart meter is an electronic device that records information such as consumption of electric energy, voltage levels, current, and power factor. Smart meters communicate the information to the consumer for greater clarity of consumption behavior, and electricity suppliers for system monitoring and customer billing. Smart meters typically record energy near real-time, and report regularly, in short intervals throughout the day.[3] Smart meters enable two-way communication between the meter and the central system. Smart meters may be part of a smart grid, but do not themselves constitute a smart grid.[4] Such an advanced metering infrastructure (AMI) differs from automatic meter reading (AMR) in that it enables two-way communication between the meter and the supplier. Communications from the meter to the network may be wireless, or via fixed wired connections such as power line carrier (PLC). Wireless communication options in common use include cellular communications, Wi-Fi (readily available), wireless ad hoc networks over Wi-Fi, wireless mesh networks, low power long-range wireless (LoRa), Wize (high radio penetration rate, open, using the frequency 169 MHz) Zigbee (low power, low data rate wireless), and Wi-SUN (Smart Utility Networks). Similar meters, usually referred to as interval or time-of-use meters, have existed for years, but smart meters usually involve real-time or near real-time sensors, power outage notification, and power quality monitoring. These additional features are more than simple automated meter reading (AMR). They are similar in many respects to Advanced Metering Infrastructure (AMI) meters. Interval and time-of-use meters historically have been installed to measure commercial and industrial customers, but may not have automatic reading.[citation needed] Research by the UK consumer group Which?, showed that as many as one in three confuse smart meters with energy monitors, also known as in-home display monitors.[5][when?] History In 1972, Theodore Paraskevakos, while working with Boeing in Huntsville, Alabama, developed a sensor monitoring system that used digital transmission for security, fire, and medical alarm systems as well as meter reading capabilities. This technology was a spin-off from the automatic telephone line identification system, now known as Caller ID. In 1974, Paraskevakos was awarded a U.S. patent for this technology.[6] In 1977, he launched Metretek, Inc.,[7] which developed and produced the first smart meters.[8] Since this system was developed pre-Internet, Metretek utilized the IBM series 1 mini-computer. For this approach, Paraskevakos and Metretek were awarded multiple patents.[9] The installed base of smart meters in Europe at the end of 2008 was about 39 million units, according to analyst firm Berg Insight.[10] Globally, Pike Research found that smart meter shipments were 17.4 million units for the first quarter of 2011.[11] Visiongain determined that the value of the global smart meter market would reach US$7 billion in 2012.[12] H.M. Zahid Iqbal, M. Waseem, and Dr. Tahir Mahmood, researchers of University of Engineering & Technology Taxila, Pakistan, introduced the concept of Smart Energy Meters in 2013. Their article, "Automatic Energy Meter Reading using Smart Energy Meter" outlined the key features of Smart Energy Meter including Automatic remote meter reading via GSM for utility companies and customers, Real-time monitoring of a customer's running load, Remote disconnection and reconnection of customer connections by the utility company and Convenient billing, eliminating the need of meter readers to physically visit the customers for billing. As of January 2018, over 99 million electricity meters were deployed across the European Union, with an estimated 24 million more to be installed by the end of 2020. The European Commission DG Energy estimates the 2020 installed base to have required €18.8 billion in investment, growing to €40.7 billion by 2030, with a total deployment of 266 million smart meters.[13] By the end of 2018, the U.S. had over 86 million smart meters installed.[14] In 2017, there were 665 million smart meters installed globally.[15] Revenue generation is expected to grow from $12.8 billion in 2017 to $20 billion by 2022.[16] Purpose Since the inception of electricity deregulation and market-driven pricing throughout the world, utilities have been looking for a means to match consumption with generation. Non-smart electrical and gas meters only measure total consumption, providing no information of when the energy was consumed.[17] Smart meters provide a way of measuring electricity consumption in near real-time. This allows utility companies to charge different prices for consumption according to the time of day and the season.[18] It also facilitates more accurate cash-flow models for utilities. Since smart meters can be read remotely, labor costs are reduced for utilities. Smart metering offers potential benefits to customers. These include, a) an end to estimated bills, which are a major source of complaints for many customers b) a tool to help consumers better manage their energy purchases—smart meters with a display outside their homes could provide up-to-date information on gas and electricity consumption and in doing so help people to manage their energy use and reduce their energy bills. With regards to consumption reduction, this is critical for understanding the benefits of smart meters because the relatively small percentage benefits in terms of savings are multiplied by millions of users.[19] Smart meters for water consumption can also provide detailed and timely information about customer water use and early notification of possible water leaks in their premises.[20] Electricity pricing usually peaks at certain predictable times of the day and the season. In particular, if generation is constrained, prices can rise if power from other jurisdictions or more costly generation is brought online. Proponents assert that billing customers at a higher rate for peak times encourages consumers to adjust their consumption habits to be more responsive to market prices and assert further, that regulatory and market design agencies hope these "price signals" could delay the construction of additional generation or at least the purchase of energy from higher-priced sources, thereby controlling the steady and rapid increase of electricity prices.[citation needed] An academic study based on existing trials showed that homeowners' electricity consumption on average is reduced by approximately 3-5% when provided with real-time feedback.[21] Another advantage of smart meters that benefits both customers and the utility is the monitoring capability they provide for the whole electrical system. As part of an AMI, utilities can use the real-time data from smart meters measurements related to current, voltage, and power factor to detect system disruptions more quickly, allowing immediate corrective action to minimize customer impact such as blackouts. Smart meters also help utilities understand the power grid needs with more granularity than legacy meters. This greater understanding facilitates system planning to meet customer energy needs while reducing the likelihood of additional infrastructure investments, which eliminates unnecessary spending or energy cost increases.[22] Though the task of meeting national electricity demand with accurate supply is becoming ever more challenging as intermittent renewable generation sources make up a greater proportion of the energy mix, the real-time data provided by smart meters allow grid operators to integrate renewable energy onto the grid in order to balance the networks. As a result, smart meters are considered an essential technology to the decarbonisation of the energy system.[23] Advanced metering infrastructure Advanced metering infrastructure (AMI) refers to systems that measure, collect, and analyze energy usage, and communicate with metering devices such as electricity meters, gas meters, heat meters, and water meters, either on request or on a schedule. These systems include hardware, software, communications, consumer energy displays and controllers, customer associated systems, meter data management software, and supplier business systems. Government agencies and utilities are turning toward advanced metering infrastructure (AMI) systems as part of larger "smart grid" initiatives. AMI extends automatic meter reading (AMR) technology by providing two-way meter communications, allowing commands to be sent toward the home for multiple purposes, including time-based pricing information, demand-response actions, or remote service disconnects. Wireless technologies are critical elements of the neighborhood network, aggregating a mesh configuration of up to thousands of meters for back haul to the utility's IT headquarters. The network between the measurement devices and business systems allows the collection and distribution of information to customers, suppliers, utility companies, and service providers. This enables these businesses to participate in demand response services. Consumers can use the information provided by the system to change their normal consumption patterns to take advantage of lower prices. Pricing can be used to curb the growth of peak demand consumption. AMI differs from traditional automatic meter reading (AMR) in that it enables two-way communications with the meter. Systems only capable of meter readings do not qualify as AMI systems.[24] Typical smart meter ami diagram AMI implementation relies on four key components: Physical Layer Connectivity, which establishes connections between smart meters and networks, Communication Protocols to ensure secure and efficient data transmission, Server Infrastructure, which consists of centralized or distributed servers to store, process, and manage data for billing, monitoring, and demand response; and Data Analysis, where analytical tools provide insights, load forecasting, and anomaly detection for optimized energy management. Together, these components help utilities and consumers monitor and manage energy use efficiently, supporting smarter grid management.[25] Physical Layer Connectivity Physical layer connectivity is a cornerstone of smart meter technology, enabling reliable and secure communication between smart meters and central systems. However, the diversity of environments in which smart meters operate presents significant challenges. Solutions to these challenges encompass a range of communication methods[26] including Power-line communication[27] (PLC), Cellular network,[28] Wireless mesh network,[29] Short-range,[29] and satellite[citation needed]: Power-line communication for Smart Metering Power Line Communication (PLC)[a] stands out among smart metering connectivity technologies because it leverages existing electrical power infrastructure for data transmission. Unlike cellular, radio-frequency (RF), or Wi-Fi-based solutions, PLC does not require building or maintaining separate communication networks, making it inherently more cost-effective and easier to scale. Two major PLC standards in smart metering are G3-PLC and the PRIME Alliance protocol.[27] G3-PLC supports IPv6-based communications and adaptive data rates, providing robust performance even in noisy environments, while PRIME (PowerRline Intelligent Metering Evolution) focuses on efficient, high-speed communication with low-cost implementation. PLC-based smart metering is deployed extensively in regions [30][31] like Europe, South America, and parts of Asia where dense infrastructure supports its use. Utilities favor PLC for its reliability in urban environments and for connecting large numbers of meters within smart grid networks. An important feature of G3-PLC and PRIME is their ability to enable mesh networking (also called multi-hop), where smart meters act as repeaters for other meters in the network. This functionality allows meters to relay data from neighboring meters to ensure that the information reaches the Data Concentrator Unit (DCU), even if direct communication is not possible due to distance or signal obstructions. This approach enhances network reliability and coverage, particularly in dense urban environments or geographically challenging areas.[32] Cellular Network (GPRS, NB-IoT, LTE-M): "Cellular technologies are highly scalable and secure. With national coverage, cellular connectivity can support a large number of meters in densely populated areas as well as reach those in remote locations."[28] Wireless mesh network (e.g. Wirepas[33] and Wi-Sun[34]): Ideal for urban areas, where devices can relay data to optimize coverage and reliability. It is mostly used for Water Meter and Gas Meter Short-range: such as Wireless M-Bus (WMBUS) are commonly used in smart metering applications to enable reliable, low-power communication between utility meters and local data collectors within buildings or neighborhoods. Hybrid PLC/RF PRIME and G3-PLC standards defines an integrated approach for seamless integration of PLC and wireless communication, enhancing reliability and flexibility in smart grids.[35] Additional options, such as Wi-Fi[citation needed] and internet-based networks, are also in use. However, no single communication solution is universally optimal. The challenges faced by rural utilities differ significantly from those of urban counterparts or utilities in remote, mountainous, or poorly serviced areas. Smart meters often extend their functionality through integration into Home Area Networks (HANs). These networks enable communication within the household and may include: In-Premises Displays: Providing real-time energy usage insights for consumers. Hubs: Interfacing multiple meters with the central head-end system.[citation needed] Technologies used in HANs vary globally but typically include PLC, wireless ad hoc networks, and Zigbee. By leveraging appropriate connectivity solutions, smart meters can address diverse environmental and infrastructural needs while delivering seamless communication and enhanced functionality.[citation needed] Smart meters used as a gateway for water and gas meters Electricity smart meters start to be utilized as gateways for gas and water meters, creating integrated smart metering systems.[36] In this configuration, gas and water meters communicate with the electricity meter using Wireless M-Bus (Wireless Meter-Bus), a European standard (EN 13757-4) designed for secure and efficient data transmission between utility meters and data collectors. The electricity meter then aggregates this data and transmits it to the central utility network via Power Line Communication (PLC), which leverages existing electrical wiring for data transfer. Communication Protocols Smart meter communication protocols are essential for enabling reliable, efficient, and secure data exchange between meters, utilities, and other components of advanced metering infrastructure (AMI). These protocols address the diverse requirements of global markets, supporting various communication methods, from optical ports and serial connections to power line communication (PLC) and wireless networks. Below is an overview of key protocols, including ANSI standards widely used in North America, IEC protocols prevalent in Europe, the globally recognized OSGP for smart grid applications, and the PLC-focused Meters and More, each designed to meet specific needs in energy monitoring and management. Typical communication stacks from Smart Meter to DC IEC 62056 "IEC 62056 is the most widely adopted protocol"[37] for smart meter communication, enabling reliable, two-way data exchange within Advanced Metering Infrastructure (AMI) systems. It encompasses the DLMS/COSEM protocol for structuring and managing metering data. "It is widely used because of its flexibility, scalability, and ability to support different communication media such as Power Line Communication (PLC), TCP/IP, and wireless networks.".[37] It also supports data transmission over serial connections using ASCII or binary formats, with physical media options such as modulated light (via LED and photodiode) or wired connections (typically EIA-485).[38] ANSI C12.18 ANSI C12.18 is an ANSI Standard that describes a protocol used for two-way communications with a meter, mostly used in North American markets. The C12.18 Standard is written specifically for meter communications via an ANSI Type 2 Optical Port, and specifies lower-level protocol details. ANSI C12.19 specifies the data tables that are used. ANSI C12.21 is an extension of C12.18 written for modem instead of optical communications, so it is better suited to automatic meter reading. ANSI C12.22 is the communication protocol for remote communications.[39] OSGP The Open Smart Grid Protocol (OSGP) is a family of specifications published by the European Telecommunications Standards Institute (ETSI) used in conjunction with the ISO/IEC 14908 control networking standard for smart metering and smart grid applications. Millions of smart meters based on OSGP are deployed worldwide.[40] On July 15, 2015, the OSGP Alliance announced the release of a new security protocol (OSGP-AES-128-PSK) and its availability from OSGP vendors.[41] This deprecated the original OSGP-RC4-PSK security protocol which had been identified to be vulnerable.[42][43] Meters and More "Meters and More was created in 2010 from the coordinated work between Enel and Endesa to adopt, maintain and evolve the field-proven Meters and More open communication protocol for smart grid solutions." .[44] In 2010, the Meters and More Association was established to promote the protocol globally, ensuring interoperability and efficiency in power line communication (PLC)-based smart metering systems. Meters and More is an open communication protocol designed for advanced metering infrastructure (AMI). It facilitates reliable, high-speed data exchange over PLC networks, focusing on energy monitoring, demand response, and secure two-way communication between utilities and consumers. Unlike DLMS/COSEM, which is a globally standardized and versatile protocol supporting multiple utilities (electricity, gas, and water), Meters and More is tailored specifically for PLC-based systems, emphasizing efficiency, reliability, and ease of deployment in electricity metering. There is a growing trend toward the use of TCP/IP technology as a common communication platform for Smart Meter applications, so that utilities can deploy multiple communication systems, while using IP technology as a common management platform.[45][46] A universal metering interface would allow for development and mass production of smart meters and smart grid devices prior to the communication standards being set, and then for the relevant communication modules to be easily added or switched when they are. This would lower the risk of investing in the wrong standard as well as permit a single product to be used globally even if regional communication standards vary.[47] Server Infrastructure for Smart Meter AMI In Advanced Metering Infrastructure (AMI), the server infrastructure is crucial for managing, storing, and processing the large volumes of data generated by smart meters. This infrastructure ensures seamless communication between smart meters, utility providers, and end-users, supporting real-time monitoring, billing, and grid management. Key Components of AMI Server Infrastructure Data Concentrator A Data Concentrator Unit (DCU) aggregates data from multiple smart meters within a localized area (e.g., a neighborhood or building) before transmitting it to the central server. Data concentrators reduce the communication load on the network and help overcome connectivity challenges by acting as intermediaries between smart meters and the head-end system (HES). They typically support communication protocols like IEC 62056, DLMS/COSEM[48] Head-End System (HES) The HES is responsible for collecting, validating, and managing data received from data concentrators and smart meters. It serves as the central communication hub, facilitating two-way communication between the smart meters and the utility's central servers. The HES supports meter configuration, firmware updates, and real-time data retrieval, ensuring data integrity and security.[49] Meter Data Management System (MDMS) The MDMS is a specialized software platform that stores and processes large volumes of meter data collected by the HES. Key functions of the MDMS include data validation, estimation, and editing, as well as billing preparation, load analysis, and anomaly detection. The MDMS integrates with other utility systems, such as billing, customer relationship management (CRM), and demand response systems, to enable efficient energy management.[50] Data Analytics Data analytics for smart meters leverages machine learning to extract insights from energy consumption data. Key applications include demand forecasting, dynamic pricing, Energy Disaggregation, and fault detection, enabling optimized grid performance and personalized energy management. These techniques drive efficiency, cost savings, and sustainability in modern energy systems. "Energy Disaggregation, or the breakdown of your energy use based on specific appliances or devices",[51] is an exploratory technique for analyzing energy consumption in households, commercial buildings, and industrial settings. By using data from a single energy meter, it employs algorithms and machine learning to estimate individual appliance usage without separate monitors. Known as Non-Intrusive Load Monitoring (NILM), this emerging method offers insights into energy efficiency, helping users optimize usage and reduce costs. While promising, energy disaggregation is still being refined for accuracy and scalability as part of smart energy management innovations.[52] Data management The other critical technology for smart meter systems is the information technology at the utility that integrates the Smart Meter networks with utility applications, such as billing and CIS. This includes the Meter Data Management system. This section may contain material not related to the topic of the article. Please help improve this section or discuss this issue on the talk page. (December 2024) (Learn how and when to remove this message) It also is essential for smart grid implementations that power line communication (PLC) technologies used within the home over a Home Area Network (HAN), are standardized and compatible. The HAN allows HVAC systems and other household appliances to communicate with the smart meter, and from there to the utility. Currently there are several broadband or narrowband standards in place, or being developed, that are not yet compatible. To address this issue, the National Institute for Standards and Technology (NIST) established the PAP15 group, which studies and recommends coexistence mechanisms with a focus on the harmonization of PLC Standards for the HAN. The objective of the group is to ensure that all PLC technologies selected for the HAN coexist as a minimum. The two leading broadband PLC technologies selected are the HomePlug AV / IEEE 1901 and ITU-T G.hn technologies.[53] Technical working groups within these organizations are working to develop appropriate coexistence mechanisms. The HomePlug Powerline Alliance has developed a new standard for smart grid HAN communications called the HomePlug Green PHY specification. It is interoperable and coexistent with the widely deployed HomePlug AV technology and with the latest IEEE 1901 global Standard and is based on Broadband OFDM technology. ITU-T commissioned in 2010 a new project called G.hnem, to address the home networking aspects of energy management, built upon existing Low Frequency Narrowband OFDM technologies. Opposition and concerns Some groups have expressed concerns regarding the cost, health, fire risk,[54] security and privacy effects of smart meters[55] and the remote controllable "kill switch" that is included with most of them. Many of these concerns regard wireless-only smart meters with no home energy monitoring or control or safety features. Metering-only solutions, while popular with utilities because they fit existing business models and have cheap up-front capital costs, often result in such "backlash". Often the entire smart grid and smart building concept is discredited in part by confusion about the difference between home control and home area network technology and AMI. The (now former) attorney general of Connecticut has stated that he does not believe smart meters provide any financial benefit to consumers,[56] however, the cost of the installation of the new system is absorbed by those customers. Security Smart meters expose the power grid to cyberattacks that could lead to power outages, both by cutting off people's electricity[57] and by overloading the grid.[58] However many cyber security experts state that smart meters of UK and Germany have relatively high cybersecurity and that any such attack there would thus require extraordinarily high efforts or financial resources.[59][60][61] The EU Cyber security Act took effect in June 2019, which includes Directive on Security Network and Information Systems establishing notification and security requirements for operators of essential services.[62] Through the Smartgrid Cybersecurity Committee, the U.S. Department of Energy published cybersecurity guidelines for grid operators in 2010 and updated them in 2014. The guidelines "...present an analytical framework that organizations can use to develop effective cybersecurity strategies..."[63] Implementing security protocols that protect these devices from malicious attacks has been problematic, due to their limited computational resources and long operational life.[64] The current version of IEC 62056 includes the possibility to encrypt, authenticate, or sign the meter data. One proposed smart meter data verification method involves analyzing the network traffic in real-time to detect anomalies using an Intrusion Detection System (IDS). By identifying exploits as they are being leveraged by attackers, an IDS mitigates the suppliers' risks of energy theft by consumers and denial-of-service attacks by hackers.[65] Energy utilities must choose between a centralized IDS, embedded IDS, or dedicated IDS depending on the individual needs of the utility. Researchers have found that for a typical advanced metering infrastructure, the centralized IDS architecture is superior in terms of cost efficiency and security gains.[64] In the United Kingdom, the Data Communication Company, which transports the commands from the supplier to the smart meter, performs an additional anomaly check on commands issued (and signed) by the energy supplier. As Smart Meter devices are Intelligent Measurement Devices which periodically record the measured values and send the data encrypted to the Service Provider, therefore in Switzerland these devices need to be evaluated by an evaluation Laboratory, and need to be certified by METAS from 01.01.2020 according to Prüfmethodologie (Test Methodology for Execution of Data Security Evaluation of Swiss Smart Metering Components). According to a report published by Brian Krebs, in 2009 a Puerto Rico electricity supplier asked the FBI to investigate large-scale thefts of electricity related to its smart meters. The FBI found that former employees of the power company and the company that made the meters were being paid by consumers to reprogram the devices to show incorrect results, as well as teaching people how to do it themselves.[66] Several hacking tools that allow security researchers and penetration testers verify the security of electric utility smart meters have been released so far.[67] Health Most health concerns about the meters arise from the pulsed radiofrequency (RF) radiation emitted by wireless smart meters.[68] Members of the California State Assembly asked the California Council on Science and Technology (CCST) to study the issue of potential health impacts from smart meters, in particular whether current FCC standards are protective of public health.[69] The CCST report in April 2011 found no health impacts, based both on lack of scientific evidence of harmful effects from radio frequency (RF) waves and that the RF exposure of people in their homes to smart meters is likely to be minuscule compared to RF exposure to cell phones and microwave ovens.[70] Daniel Hirsch, retired director of the Program on Environmental and Nuclear Policy at UC Santa Cruz, criticized the CCST report on the grounds that it did not consider studies that suggest the potential for non-thermal health effects such as latent cancers from RF exposure. Hirsch also stated that the CCST report failed to correct errors in its comparison to cell phones and microwave ovens and that, when these errors are corrected, smart meters "may produce cumulative whole-body exposures far higher than that of cell phones or microwave ovens."[71] The Federal Communications Commission (FCC) has adopted recommended Permissible Exposure Limit (PEL) for all RF transmitters (including smart meters) operating at frequencies of 300 kHz to 100 GHz. These limits, based on field strength and power density, are below the levels of RF radiation that are hazardous to human health.[72] Other studies substantiate the finding of the California Council on Science and Technology (CCST). In 2011, the Electric Power Research Institute performed a study to gauge human exposure to smart meters as compared to the FCC PEL. The report found that most smart meters only transmit RF signals 1% of the time or less. At this rate, and at a distance of 1 foot from the meter, RF exposure would be at a rate of 0.14% of the FCC PEL.[73] An indirect potential for harm to health by smart meters is that they enable energy companies to disconnect consumers remotely, typically in response to difficulties with payment. This can cause health problems to vulnerable people in financial difficulty; in addition to denial of heat, lighting, and use of appliances, there are people who depend on power to use medical equipment essential for life. While there may be legal protections in place to protect the vulnerable, many people in the UK were disconnected in violation of the rules.[74] Safety Issues surrounding smart meters causing fires have been reported, particularly involving the manufacturer Sensus. In 2012. PECO Energy Company replaced the Sensus meters it had deployed in the Philadelphia, US region after reports that a number of the units had overheated and caused fires. In July 2014, SaskPower, the province-run utility company of the Canadian province of Saskatchewan, halted its roll-out of Sensus meters after similar, isolated incidents were discovered. Shortly afterward, Portland General Electric announced that it would replace 70,000 smart meters that had been deployed in the state of Oregon after similar reports. The company noted that it had been aware of the issues since at least 2013, and they were limited to specific models it had installed between 2010 and 2012.[75] On July 30, 2014, after a total of eight recent fire incidents involving the meters, SaskPower was ordered by the Government of Saskatchewan to immediately end its smart meter program, and remove the 105,000 smart meters it had installed.[76] Privacy concerns One technical reason for privacy concerns is that these meters send detailed information about how much electricity is being used each time. More frequent reports provide more detailed information. Infrequent reports may be of little benefit for the provider, as it doesn't allow as good demand management in the response of changing needs for electricity. On the other hand, widespread reports would allow the utility company to infer behavioral patterns for the occupants of a house, such as when the members of the household are probably asleep or absent.[77] Furthermore, the fine-grained information collected by smart meters raises growing concerns of privacy invasion due to personal behavior exposure (private activity, daily routine, etc.).[20] Current trends are to increase the frequency of reports. A solution that benefits both provider and user privacy would be to adapt the interval dynamically.[78] Another solution involves energy storage installed at the household used to reshape the energy consumption profile.[79][80] In British Columbia the electric utility is government-owned and as such must comply with privacy laws that prevent the sale of data collected by smart meters; many parts of the world are serviced by private companies that are able to sell their data.[81] In Australia debt collectors can make use of the data to know when people are at home.[82] Used as evidence in a court case in Austin, Texas, police agencies secretly collected smart meter power usage data from thousands of residences to determine which used more power than "typical" to identify marijuana growing operations.[83] Smart meter power data usage patterns can reveal much more than how much power is being used. Research has demonstrated that smart meters sampling power levels at two-second intervals can reliably identify when different electrical devices are in use.[84][85][86][87][88][89][90][91] Ross Anderson wrote about privacy concerns "It is not necessary for my meter to tell the power company, let alone the government, how much I used in every half-hour period last month"; that meters can provide "targeting information for burglars"; that detailed energy usage history can help energy companies to sell users exploitative contracts; and that there may be "a temptation for policymakers to use smart metering data to target any needed power cuts."[92] Opt-out options Reviews of smart meter programs, moratoriums, delays, and "opt-out" programs are some responses to the concerns of customers and government officials. In response to residents who did not want a smart meter, in June 2012 a utility in Hawaii changed its smart meter program to "opt out".[93] The utility said that once the smart grid installation project is nearing completion, KIUC may convert the deferral policy to an opt-out policy or program and may charge a fee to those members to cover the costs of servicing the traditional meters. Any fee would require approval from the Hawaii Public Utilities Commission. After receiving numerous complaints about health, hacking, and privacy concerns with the wireless digital devices, the Public Utility Commission of the US state of Maine voted to allow customers to opt-out of the meter change at the cost of $12 a month.[94] In Connecticut, another US state to consider smart metering, regulators declined a request by the state's largest utility, Connecticut Light & Power, to install 1.2 million of the devices, arguing that the potential savings in electric bills do not justify the cost. CL&P already offers its customers time-based rates. The state's Attorney General George Jepsen was quoted as saying the proposal would cause customers to spend upwards of $500 million on meters and get few benefits in return, a claim that Connecticut Light & Power disputed.[95] Abuse of dynamic pricing Smart meters allow dynamic pricing; it has been pointed out that, while this allows prices to be reduced at times of low demand, it can also be used to increase prices at peak times if all consumers have smart meters.[96] Additionally smart meters allow energy suppliers to switch customers to expensive prepay tariffs instantly in case of difficulties paying. In the UK during a period of very high energy prices from 2022, companies were remotely switching smart meters from a credit tariff to an expensive prepay tariff which disconnects supplies unless credit has been purchased. While regulations do not permit this without appropriate precautions to help those in financial difficulties and to protect the vulnerable, the rules were often flouted.[74] (Prepaid tariffs could also be levied without smart meters, but this required a dedicated prepay meter to be installed.) In 2022, 3.2 million people were left without power at some point after running out of prepay credit.[97] Limited benefits There are questions about whether electricity is or should be primarily a "when you need it" service where the inconvenience/cost-benefit ratio of time-shifting of loads is poor. In the Chicago area, Commonwealth Edison ran a test installing smart meters on 8,000 randomly selected households together with variable rates and rebates to encourage cutting back during peak usage.[98] In Crain's Chicago Business article "Smart grid test underwhelms. In the pilot, few power down to save money.", it was reported that fewer than 9% exhibited any amount of peak usage reduction and that the overall amount of reduction was "statistically insignificant".[98] This was from a report by the Electric Power Research Institute, a utility industry think tank who conducted the study and prepared the report. Susan Satter, senior assistant Illinois attorney general for public utilities said "It's devastating to their plan......The report shows zero statistically different result compared to business as usual." [98] By 2016, the 7 million smart meters in Texas had not persuaded many people to check their energy data as the process was too complicated.[99] A report from a parliamentary group in the UK suggests people who have smart meters installed are expected to save an average of £11 annually on their energy bills, much less than originally hoped.[100] The 2016 cost-benefit analysis was updated in 2019 and estimated a similar average saving.[101] The Australian Victorian Auditor-General found in 2015 that 'Victoria's electricity consumers will have paid an estimated $2.239 billion for metering services, including the rollout and connection of smart meters. In contrast, while a few benefits have accrued to consumers, benefits realisation is behind schedule and most benefits are yet to be realised'[102] Erratic demand Smart meters can allow real-time pricing, and in theory this could help smooth power consumption as consumers adjust their demand in response to price changes. However, modelling by researchers at the University of Bremen suggests that in certain circumstances, "power demand fluctuations are not dampened but amplified instead."[103] In the media In 2013, Take Back Your Power, an independent Canadian documentary directed by Josh del Sol was released describing "dirty electricity" and the aforementioned issues with smart meters.[104] The film explores the various contexts of the health, legal, and economic concerns. It features narration from the mayor of Peterborough, Ontario, Daryl Bennett, as well as American researcher De-Kun Li, journalist Blake Levitt,[105] and Dr. Sam Milham. It won a Leo Award for best feature-length documentary and the Annual Humanitarian Award from Indie Fest the following year. UK roll-out criticism In a 2011 submission to the Public Accounts Committee, Ross Anderson wrote that Ofgem was "making all the classic mistakes which have been known for years to lead to public-sector IT project failures" and that the "most critical part of the project—how smart meters will talk to domestic appliances to facilitate demand response—is essentially ignored."[106] Citizens Advice said in August 2018 that 80% of people with smart meters were happy with them. Still, it had 3,000 calls in 2017 about problems. These related to first-generation smart meters losing their functionality, aggressive sales practices, and still having to send smart meter readings.[107] Ross Anderson of the Foundation for Information Policy Research has criticised the UK's program on the grounds that it is unlikely to lower energy consumption, is rushed and expensive, and does not promote metering competition. Anderson writes, "the proposed architecture ensures continued dominance of metering by energy industry incumbents whose financial interests are in selling more energy rather than less," and urged ministers "to kill the project and instead promote competition in domestic energy metering, as the Germans do – and as the UK already has in industrial metering. Every consumer should have the right to appoint the meter operator of their choice."[108] The high number of SMETS1 meters installed has been criticized by Peter Earl, head of energy at the price comparison website comparethemarket.com. He said, "The Government expected there would only be a small number of the first-generation of smart meters before Smets II came in, but the reality is there are now at least five million and perhaps as many as 10 million Smets I meters."[109] UK smart meters in southern England and the Midlands use the mobile phone network to communicate, so they do not work correctly when phone coverage is weak. A solution has been proposed, but was not operational as of March 2017.[109] In March 2018 the National Audit Office (NAO), which watches over public spending, opened an investigation into the smart meter program, which had cost £11bn by then, paid for by electricity users through higher bills.[110][111] The National Audit Office published the findings of its investigation in a report titled "Rolling out smart meters" published in November 2018.[112] The report, amongst other findings, indicated that the number of smart meters installed in the UK would fall materially short of the Department for Business, Energy & Industrial Strategy (BEIS) original ambitions of all UK consumers having a smart meter installed by 2020. In September 2019, smart meter rollout in the UK was delayed for four years.[113] Ross Anderson and Alex Henney wrote that "Ed Miliband cooked the books" to make a case for smart meters appear economically viable. They say that the first three cost-benefit analyses of residential smart meters found that it would cost more than it would save, but "ministers kept on trying until they got a positive result... To achieve 'profitability' the previous government stretched the assumptions shamelessly".[114] A counter-fraud officer at Ofgem with oversight of the roll-out of the smart meter program who raised concerns with his manager about many millions of pounds being misspent was threatened in 2018 with imprisonment under section 105 of the Utilities Act 2000, prohibiting disclosure of some information relevant to the energy sector, with the intention of protecting national security.[115][116] The Employment Appeal Tribunal found that the law was in contravention of the European Convention on Human Rights.[117] Main Suppliers Top ten smart electricity meters suppliers depends on the ranking method[118] Among them Landis+Gyr Itron Xylem (formerly Sensus) Sagemcom [fr] Honeywell / Elster Kamstrup A/S [da] Wasion Holdings Limited [zh] Holley Technology Ltd Gallery Newer retrofitted U.S. domestic digital electricity meter Elster REX[119] with 900 MHz[120] mesh network topology for automatic meter reading and "EnergyAxis" time-of-use metering.[121][122][123] Each local mesh networked smart meter has a hub such as this Elster A3 Type A30, which interfaces 900MHz smart meters to the metering automation server via a landline.[124] Itron OpenWay electricity Smart meter with two-way communications for remote reading in use by DTE Energy om Wikipedia, the free encyclopedia (Redirected from Electric energy) Electrical energy is the energy transferred as electric charges move between points with different electric potential, that is, as they move across a potential difference. As electric potential is lost or gained, work is done changing the energy of some system. The amount of work in joules is given by the product of the charge that has moved, in coulombs, and the potential difference that has been crossed, in volts.[1] Electrical energy is usually sold by the kilowatt hour (1 kW·h = 3.6 MJ) which is the product of the power in kilowatts multiplied by running time in hours. Electric utilities measure energy using an electricity meter, which keeps a running total of the electrical energy delivered to a customer. Electric heating is an example of converting electrical energy into thermal energy. The simplest and most common type of electric heater uses electrical resistance to convert the energy. There are other ways to use electrical energy. Electric charges moves as a current the heater element which has a potential difference between the ends: energy is transferred from the charges to the element, increasing the element's temperature and thermal energy as the charges lose potential energy. Electricity generation Main article: Electricity generation Electricity generation is the process of generating electrical energy from other forms of energy. The fundamental principle of electricity generation was discovered during the 1820s and early 1830s by the British scientist Michael Faraday. His basic method is still used today: electric current is generated by the movement of a loop of wire, or disc of copper between the poles of a magnet.[2] For electrical utilities, it is the first step in the delivery of electricity to consumers. The other processes, electricity transmission, distribution, and electrical energy storage and recovery using pumped-storage methods are normally carried out by the electric power industry.[3] Electricity is most often generated at a power station by electromechanical generators, primarily driven by heat engines fueled by chemical combustion or nuclear fission but also by other means such as the kinetic energy of flowing water and wind. There are M-Bus or Meter-Bus is a European standard (EN 13757-2 physical and link layer, EN 13757-3 application layer) for the remote reading of water, gas or electricity meters. M-Bus is also usable for other types of consumption meters, such as heating systems or water meters. The M-Bus interface is made for communication on two wires, making it cost-effective. A radio variant of M-Bus Wireless M-Bus is also specified in EN 13757–4. The M-Bus was developed to fill the need for a system for the networking and remote reading of utility meters, for example to measure the consumption of gas or water in the home. This bus fulfills the special requirements of remotely powered or battery-driven systems, including consumer utility meters. When interrogated, the meters deliver the data they have collected to a common master, such as a hand-held computer, connected at periodic intervals to read all utility meters of a building. An alternative method of collecting data centrally is to transmit meter readings via a modem. Other applications for the M-Bus such as alarm systems, flexible illumination installations, heating control, etc. are suitable. Relation to the OSI model Since no bus system was available for the requirements of meter reading, the M-Bus was developed by Horst Ziegler of the University of Paderborn in cooperation with Texas Instruments Deutschland GmbH and Techem GmbH [de]. The concept was based on the ISO-OSI Reference Model, in order to realize an open system which could use almost any desired protocol. Since the M-Bus is not a network, and therefore does not - among other things - need a transport or session layer, the levels four to six of the OSI model are empty. Therefore, only the physical, the data link, the network and the application layer are provided with functions. OSI Model Data unit Layer Standard Host layers Data 7. Application EN1434-3 6. Presentation Empty 5. Session Empty Segment/Datagram 4. Transport Empty Media layers Packet 3. Network Optional Frame 2. Data link IEC 60870 Bit 1. Physical M-Bus Physical wire and connectors M-Bus connection is called M-Bus or HAN (Home Area Network) consumer connection. M-Bus uses two-wire telephone cable (JYStY 1x2x0.8 mm or similar, 73 ohm/km, 120 nF/km) maximum length of 350 meters when using nominal transfer speeds 300 and 9600 baud. Lowering the speed up to 1000 meter cable can be used. There is no standardized connector, but RJ11 and RJ12 Modular connectors are used by meter manufacturers.[1] The master communication uses voltage signaling, where 1 (idle state, mark) is the bus nominal 36 volts, 0 (space) drops the voltage to 24 volts. As bus voltage can vary with length and load, the signal is specified as 1 for bus voltage drop less than 5.5V, 0 for drop higher than 8.2 volts. Slaves communicate by current consumption, where 1 (idle state, mark) is less than 1.5 milliamperes, 0 (space) raises current to 11-20 mA. The signal is specified as the at least 11 mA current increase. The slaves are connected via diode bridge and can use either polarity of the wires. To protect the bus against shortcircuited slaves, a 430 ohm is connected in series at each slave (or, two 215 ohm resistors, one for each wire). A M-bus load unit is 1.5 mA. Most slaves use at most this, some can need two units (3 mA). Masters can provide type-dependent number of load units, and usually visually indicate overload. Data link protocol The data link protocol is described by IEC 870-5, or its updated version, IEC 60870-5. The data are sent in serial form, at speed between 300 and 9600 bit/s (some variants may operate up to 19200 or 38400 bit/s), using one start bit, one stop bit, and even parity (8e1). The least significant bit is sent first. When sending packets ("telegrams"), there is no pause between stop and subsequent start bit. Suggested speeds are 300, 2400, 9600, and with newer hardware 38400 bit/s, while 2400 bit/s is most common. Devices with different baudrates can coexist on the same bus. Some devices use autobauding[clarification needed]. There are four kinds of packets: single character - 0xE5 - acknowledgement short frame, 5 bytes - 0x10, C-field, A-field, checksum, 0x16 - sending simple commands control frame, 9 bytes - 0x68, 0x03, 0x03, 0x68, C-field, A-field, CI-field, checksum, 0x16 The control frame is a long frame with no payload. long frame, 9+ bytes - 0x68, length, length, 0x68, C-field, A-field, CI-field, [0..252 payload bytes], checksum, 0x16 C-field is the control/function field. The sequence, from bit 7, is: bit 7: 0 bit 6: 1 for master-to-slave, 0 for slave reply bit 5: from master: FCB, frame count bit - indicates request to repeat message when reply was not received from slave: ACD, access demand - 1 when slave wishes to transmit class-1 data, priority data (class-2 data is ordinary non-priority) - the master then should request the class-1 data transfer bit 4: from master: FCV, frame count valid - when 0, slave should ignore FCB from slave: DFC, data flow control - when 1, slave can not accept further data bit 3,2,1,0: F3,F2,F1,F0, function code - eg. for short frame, 0 is for initialization of slave, xA is for class-1 (priority) data read, xB is for class-2 (normal) read. For long/control frame, x3 is sending data to slave, x8 is data reply from slave. A-field is the address field. It is a 8-bit number: 0x00 - unset address, assigned at manufacture time, some meters fixed at this 0x01..0xFA - slave addresses 0xFB, 0xFC - reserved 0xFD - "broadcast" for secondary addressing, addressing done on network layer instead of on data link layer 0xFE - test broadcast, all slaves reply (collisions will happen, use for testing with a single slave; slave replies with its own address in A-field), also possible to use when there is only one slave on the bus 0xFF - broadcast, no reply from slaves CI-field is the control information field. Defined at application layer.[2] Length field in control/long frame is sent twice. Both bytes have to be equal. Minimum value is 0x03, as C-field, A-field and CI-field are mandatory parts of the payload. Slaves respond only to correctly formed packets that match their address. Any fault is indicated by lack of response. Absence of response is defined as no response for 330 bit periods (35 ms for 9600 bit/s, 1.1 s for 300 bit/s) plus 50 ms.[3] Numerical values are usually sent in BCD format.[4] Electric energy consumption is energy consumption in the form of electrical energy.[2] About a fifth of global energy is consumed as electricity: for residential, industrial, commercial, transportation and other purposes.[2] The global electricity consumption in 2022 was 24,398 terawatt-hour (TWh), almost exactly three times the amount of consumption in 1981 (8,132 TWh).[3][failed verification] China, the United States, and India accounted for more than half of the global share of electricity consumption. Japan and Russia followed with nearly twice the consumption of the remaining industrialized countries.[3] Overview Electric energy is most often measured either in joules (J), or in watt hours (W·h).[4] 1 W·s = 1 J 1 W·h = 3,600 W·s = 3,600 J 1 kWh = 3,600 kWs = 1,000 Wh = 3.6 million W·s = 3.6 million J Electric and electronic devices consume electric energy to generate desired output (light, heat, motion, etc.). During operation, some part of the energy is lost depending on the electrical efficiency.[5] Electricity has been generated in power stations since 1882.[6] The invention of the steam turbine in 1884 to drive the electric generator led to an increase in worldwide electricity consumption.[7] In 2022, the total worldwide electricity production was nearly 29,000 TWh.[8] Total primary energy is converted into numerous forms, including, but not limited to, electricity, heat and motion.[9] Some primary energy is lost during the conversion to electricity, as seen in the United States, where a little more than 60% was lost in 2022.[9] Electricity accounted for more than 20% of worldwide final energy consumption in 2022, with oil being less than 40%, coal being less than 9%, natural gas being less than 15%, biofuels and waste less than 10%, and other sources (such as heat, solar electricity, wind electricity and geothermal) being more than 5%.[10] The total final electricity consumption in 2022 was split unevenly between the following sectors: industry (42.2%), residential (26.8%), commercial and public services (21.1%), transport (1.8%), and other (8.1%; i.e., agriculture and fishing).[10] In 1981, the final electricity consumption continued to decrease in the industrial sector and increase in the residential, commercial and public services sectors.[10] A sensitivity analysis on an adaptive neuro-fuzzy network model for electric demand estimation shows that employment is the most critical factor influencing electrical consumption.[11] The study used six parameters as input data, employment, GDP, dwelling, population, heating degree day and cooling degree day, with electricity demand as output variable.[11] World electricity consumption See also: List of countries by electricity consumption The table lists 45 electricity-consuming countries, which used about 22,000 TWh. These countries comprise about 90% of the final consumption of 190+ countries. The final consumption to generate this electricity is provided for every country. The data is from 2022.[8][12] In 2022, OECD's final electricity consumption was over 10,000 TWh.[3] In that year, the industrial sector consumed about 42.2% of the electricity, with the residential sector consuming nearly 26.8%, the commercial and public services sectors consuming about 21.1%, the transport sector consuming nearly 1.8%, and the other sectors (such as agriculture and fishing) consuming nearly 8.1%.[10] In recent decades, the consumption in the residential and commercial and public services sectors has grown, while the industry consumption has declined.[3] More recently, the transport sector has witnessed an increase in consumption with the growth in the electric vehicle market.[3] Electricity consumption of selected countries (OECD, 2022)[8][12] Rank Country Final consumption (TWh) Population (millions) Per capita consumption (MWh) — WORLD 24,398 7,960 3.07 1 China 7,214 1,443 5 2 United States 4,272 336 12.71 3 India 1,403 1,401 1 4 Japan 1,132 126 8.98 5 Russia 934 146 6.4 6 Canada 595 38.1 15.62 7 South Korea 553 51.2 10.8 8 Brazil 550 215 2.56 9 Germany 539 82.2 6.55 10 France 463 67.7 6.84 11 Saudi Arabia 317 36 8.81 12 United Kingdom 312 68.4 4.56 13 Indonesia 308 276 1.17 14 Italy 300 60 5 15 Mexico 296 127 2.33 16 Iran 280 83.3 3.36 17 Turkey 264 84 3.14 18 Taiwan 257 23.8[13] 10.8 19 Spain 246 46.8 5.26 20 South Africa 233 60 3.88 21 Australia 225 26 8.65 22 Vietnam 220 100 2.2 23 Thailand 203 70 2.9 24 Malaysia 170 33.2 5.12 25 Egypt 168 105 1.6 26 Poland 156 37.5 4.17 27 Ukraine 154 43.2 3.56 28 Sweden 147 10.2 14.4 29 Argentina 138 46 3 30 United Arab Emirates 136 10.2 13.33 31 Norway 128 5.5 23.27 32 Pakistan 124 226 0.55 33 Netherlands 120 17.5 6.86 34 Belgium 98 11.8 8.33 35 Finland 90 5.6 16.03 36 Chile 84 19.2 4.38 37 Kazakhstan 75 18.7 4 38 Austria 73 9.1 8.02 39 Venezuela 72 28.1 2.56 40 Algeria 66 44 1.5 41 Switzerland 62 9.3 6.67 42 Israel 59 9.4 6.27 43 New Zealand 43 5 8.6 44 Denmark 35 5.8 6.02 45 Ireland 28 5.5 5.1 Consumption per capita The final consumption divided by the number of inhabitants provides a country's consumption per capita. In Western Europe, this is between 4 and 8 MWh/year.[8] (1 MWh = 1,000 kWh) In Scandinavia, the United States, Canada, Taiwan, South Korea, Australia, Japan and the United Kingdom, the per capita consumption is higher; however, in developing countries, it is much lower.[8] The world's average was about 3 MWh/year in 2022.[8] Very low consumption levels, such as those in Philippines, not included in the table, indicate that many inhabitants are not connected to the electricity grid, and that is the reason why some of the world's most populous countries, including Nigeria and Bangladesh, do not appear in the table.[12] Electricity generation and GDP The table lists 30 countries, which represent about 76% of the world population, 84% of the world GDP, and 85% of the world electricity generation.[8][12][14][15] Productivity per electricity generation (concept similar to energy intensity) can be measured by dividing GDP over the electricity generated. The data is from 2019.[8][12][14][15] Electricity generation (2019) and GDP (PPP) (2019) Country Population, millions rank* GDP (PPP), billions (USD) rank* GDP (PPP) per capita rank* Electricity generation (GWh/yr) rank* GDP (PPP) /kWh* China 1,407 1 $14,280 2 $10,149 15 7,503,428 1 $1.9 India 1,366 2 $2,871 6 $2,102 26 1,603,675 3 $1.8 USA 328 3 $21,433 1 $65,345 1 4,411,159 2 $4.9 Indonesia 270.6 4 $1,119 16 $4,135 20 278,942 17 $4.0 Brazil 211 6 $1,878 9 $8,900 18 626,328 7 $3.0 Pakistan 216.6 5 $279 26 $1,288 28 138,626 24 $2.0 Bangladesh 163 8 $302 25 $1,853 27 89,672 27 $3.4 Nigeria 201 7 $448 22 $2,229 25 33,552[16] 28 $13.4 Russia 144 9 $1,687 11 $11,715 14 1,118,143 4 $1.5 Japan 126 11 $5,149 3 $40,865 7 1,030,286 5 $5.0 Mexico 127.6 10 $1,269 15 $9,945 16 322,584 13 $3.9 Philippines 108 13 $377 23 $3,491 21 106,041 26 $3.6 Vietnam 96.5 15 $262 27 $2,715 24 227,461 21 $1.2 Ethiopia 112 12 $96 29 $857 29 14,553[17] 29 $6.6 Egypt 100.4 14 $303 24 $3,018 23 200,563 22 $1.5 Germany 83 18 $3,888 4 $46,843 4 609,406 8 $6.4 Turkey 83.5 17 $761 19 $9,114 17 303,898 15 $2.5 DR Congo 86.8 16 $50 30 $576 30 9,990[18] 30 $5.0 Iran 83 19 $258 28 $3,108 22 318,696 14 $0.8 Thailand 69.6 20 $544 21 $7,816 19 186,503 23 $2.9 France 67.3 21 $2,729 7 $40,550 8 562,842 10 $4.8 UK 66.8 22 $2,879 5 $43,099 6 324,761 12 $8.9 Italy 59.7 23 $2,009 8 $33,652 9 293,853 16 $6.8 South Korea 51.7 24 $1,651 12 $31,934 10 585,301 9 $2.8 Spain 47.1 25 $1,393 13 $29,575 11 267,501 19 $5.2 Canada 37.6 26 $1,742 10 $46,330 5 648,676 6 $2.7 Saudi Arabia 34.3 27 $793 18 $23,120 13 343,661 11 $2.3 Taiwan 23.6[13] 28 $605[19] 20 $25,636 12 274,059 18 $2.2 Australia 25.4 29 $1,392 14 $54,803 2 265,901 20 $5.2 Netherlands 17.3 30 $910 17 $52,601 3 121,062 25 $7.5 World 7,683 — $87,555 — $11,395 — 27,044,191 — $3.5 Population data is from the World Bank[12] GDP data is from the World Bank[14] Electricity data is from BP Global[15] rank* of Population, GDP, and Electricity generation are rankings within this list GDP (PPP) / kWh is the amount of GDP (PPP) (USD) produced per kilowatt-hour Electricity consumption by sector The table below lists the 15 countries with the highest final electricity consumption, which comprised more than 70% of the global consumption in 2022.[8] Electricity final consumption by sector (2022) Country/ Geographical region Total (TWh) Industry Transport Commercial /Public services Residential Agriculture /Forestry Other China 7,214 59.9% 2.4% 7.3% 16.4% 2.2% 11.8% United States 4,272 19.9% 0.6% 35.2% 37.4% 2.1% 4.8% India 1,403 37.7% 11.2% 7.8% 21.7% 15.9% 5.7% Japan 1,132 37% 1.8% 33.7% 27.1% 0.3% 0.1% Russia 934 44.8% 11.1% 20.4% 21.1% 2.5% 0.1% Canada 595 35.9% 1.5% 28.1% 32.5% 2.0% 0% South Korea 553 52.3% 0.6% 31.4% 12.7% 2.5% 0.5% Brazil 550 38.3% 0.7% 27.3% 27.7% 6% 0% Germany 539 44.8% 2.3% 26.4% 25.4% 1.1% 0% France 463 26.9% 2.4% 31.5% 37% 1.9% 0.3% Saudi Arabia 317 33.7% 3.9% 28.3% 25% 4.1% 5% United Kingdom 312 18.3% 2.2% 38.2% 39.1% 2% 0.2% Italy 300 30% 5% 32% 30% 1% 2% Mexico 296 29% 4% 33% 30% 3% 1% Iran 280 24% 6% 37% 25% 5% 3% World 24,398 42.2% 1.8% 21.1% 26.8% 3.1% 5% Electricity outlook This section needs to be updated. Please help update this article to reflect recent events or newly available information. (February 2022) Looking forward, increasing energy efficiency will result in less electricity needed for a given demand in power, but demand will increase strongly on the account of:[20] Economic growth in developing countries,[20] and Electrification of transport and heating. Combustion engines are replaced by electric drive and for heating less gas and oil, but more electricity is used, if possible with heat pumps.[20] The International Energy Agency expects revisions of subsidies for fossil fuels which amounted to $550 billion in 2013, more than four times renewable energy subsidies. In this scenario,[21] almost half of the increase in 2040 of electricity consumption is covered by more than 80% growth of renewable energy. Many new nuclear plants will be constructed, mainly to replace old ones. The nuclear part of electricity generation will increase from 11 to 12%. The renewable part goes up much more, from 21 to 33%. The IEA warns that in order to restrict global warming to 2 °C, carbon dioxide emissions[22] must not exceed 1000 gigaton (Gt) from 2014. This limit is reached in 2040 and emissions will not drop to zero ever. The World Energy Council[23] sees world electricity consumption increasing to more than 40,000 TWh/a in 2040. The fossil part of generation depends on energy policy. It can stay around 70% in the so-called "Jazz" scenario where countries rather independently "improvise" but it can also decrease to around 40% in the "Symphony" scenario if countries work "orchestrated" for more climate friendly policy. Carbon dioxide emissions, 32 Gt/a in 2012, will increase to 46 Gt/a in Jazz but decrease to 26 Gt/a in Symphony. Accordingly, until 2040 the renewable part of generation will stay at about 20% in Jazz but increase to about 45% in Symphony. An EU survey conducted on climate and energy consumption in 2022 found that 63% of people in the European Union want energy costs to be dependent on use, with the greatest consumers paying more. This is compared to 83% in China, 63% in the UK and 57% in the US.[24][25] 24% of Americans surveyed believing that people and businesses should do more to cut their own usage (compared to 20% in the UK, 19% in the EU, and 17% in China).[26][27] Nearly half of those polled in the European Union (47%) and the United Kingdom (45%) want their government to focus on the development of renewable energies. This is compared to 37% in both the United States and China when asked to list their priorities on energy.[26][28][29] The United States is on track to break electricity consumption records in 2025 and 2026, according to the U.S. Energy Information Administration’s (EIA) Short-Term Energy Outlook, released in February 2025. With demand from data centers powering artificial intelligence and cryptocurrency operations, alongside rising electricity use in homes and businesses for heating and transportation, the EIA projects total power consumption will hit 4,179 billion kilowatt-hours (kWh) in 2025 and 4,239 billion kWh in 2026—both surpassing the current record of 4,082 billion kWh set in 2024. The forecasted increase can be broken down as follows: residential electricity sales will climb to 1,524 billion kWh in 2025, commercial demand to 1,458 billion kWh, and industrial usage to 1,054 billion kWh. This would mark new highs for the commercial sector, which set its current record of 1,421 billion kWh in 2024, and for residential consumers, whose last peak was 1,509 billion kWh in 2022. Meanwhile, the industrial sector—historically the largest consumer of electricity—remains just below its all-time high of 1,064 billion kWh set in 2000. As AI, cryptocurrency mining, and electrification continue to drive demand, the U.S. power grid faces mounting pressure to keep pace with this record surge in electricity consumption.[30] Topic 2 experimental company theory practical 2.1 .Overview : Keyword description Update Regarding Your Application Inbox Eaton TalentHub 11:43 AM (1 hour ago) to me Hi Fiston, Thank you for applying for the position of Area Sales Manager - Industrial Sales – 40445. We appreciate you considering a career at Eaton. After careful review, we have decided to move forward with other candidates who more closely match the current needs for this team and position. We know that messages like this are disappointing, but we really hope you continue to pursue other opportunities at Eaton. Be sure to check out Eaton.com/careers, where you can find all our open jobs and set up a job alert. Thank you for your interest in Eaton and wish you all the best! 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Power Systems Controls 35679 Nov 14, 2024 No Longer Under Consideration Littleton, Colorado, USA, 80120 Regional Sales Leader Aftermarket Africa 35244 Nov 13, 2024 Application in Review Johannesburg, Gauteng, ZAF, 1619 Principal Design Engineer, Gas Insulated Switchgear (GIS) 24170 Oct 23, 2024 No Longer Under Consideration Greenwood, South Carolina, USA, 29649 EMEA Research & Development Senior Subject Matter Expert - Medium Voltage standards & applications 32409 Oct 20, 2024 No Longer Under Consideration Hengelo, NLD, 7559 Internship Program: Field Service Engineer 30657 Oct 8, 2024 Processed Moon Township, Pennsylvania, USA, 15108 Senior Project Engineer 33025 Oct 8, 2024 No Longer Under Consideration Nashville, Tennessee, USA, 37211 Service Centre Helpdesk Coordinator 33335 Sep 28, 2024 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Lead Design Engineer 33175 Sep 22, 2024 No Longer Under Consideration Louisville, Kentucky, USA, 40299 Field Services Engineer - UPS 32511 Sep 10, 2024 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Senior Field Service Representative 31161 Sep 5, 2024 No Longer Under Consideration Nashville, Tennessee, USA, 37211 Utility Service Sales Specialist 32009 Sep 5, 2024 No Longer Under Consideration Charlotte, North Carolina, USA, 28269 Senior Field Service Representative 31188 Aug 29, 2024 No Longer Under Consideration Nashville, Tennessee, USA, 37211 Skip to main content Home My Jobs Search Jobs 0 results FT My Applications Applications Saved Jobs Showing 53 Jobs Field Service Engineer 30764 Aug 29, 2024 Job Filled - 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UPS 20228 Mar 2, 2024 No Longer Under Consideration Durban, ZAF, 4017 Field Services Engineer - UPS 19852 Feb 10, 2024 No Longer Under Consideration Cape Town, ZAF, 7550 Quality Auditor, Training program, 3rd Shift 19275 Feb 9, 2024 Processed Rumford, Rhode Island, USA, 02916 Lead Power Systems Engineer 19197 Jan 31, 2024 No Longer Under Consideration El Paso, Texas, USA, 79912 Product Manager - Electrical Working Training & Remote Services 18926 Jan 31, 2024 No Longer Under Consideration Moon Township, Pennsylvania, USA, 15108 Finance Early Talent Leadership Development Program (m/w/d) 18647 Jan 31, 2024 No Longer Under Consideration Bonn, DEU, 53115 Finance Early Talent Leadership Development Program 18817 Jan 31, 2024 No Longer Under Consideration Budapest, HUN, 1123 Site Manager South Africa - Customer Projects 12131 Dec 16, 2023 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Engineering Technician - Mechanical 13241 Dec 11, 2023 No Longer Under Consideration Wilsonville, Oregon, USA, 97070-8247 Lead Engineer Power Conversion 14106 Dec 10, 2023 No Longer Under Consideration Bonn, DEU, 53115 Powered by #WhatsNextForYou Skip to main content Home My Jobs Search Jobs 0 results FT My Applications Applications Saved Jobs Showing 53 Jobs Senior Power Electronics HW Engineer 5488 Dec 10, 2023 No Longer Under Consideration Bonn, DEU, 53115 Mechanical Design Engineer - 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Customer Projects 12134 Dec 1, 2023 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Project Manager South Africa - Customer Projects 12130 Dec 1, 2023 No Longer Under Consideration Johannesburg, Gauteng, ZAF, 1619 Field Service Engineer - UPS 15094 Dec 1, 2023 No Longer Under Consideration Durban, ZAF, 4017 Training Transcript 4. 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From arc flash protection to UL/IEC cybersecurity accreditation, safety and security is built into the foundation of everything we make. Scale easier and get to market faster Realize the value of your investment sooner with accelerated, data-driven design and project management services, easy implementation, pre-tested solutions and expert support. Lower costs, increase revenue and ensure always-on reliability Reduce total cost of ownership and open new revenue streams with flexible, reliable power solutions that support the bi-directional flow of energy and enable you to sell power back to the grid. All while maintaining constant uptime. Knowledge center Turn information into insights. Access our Knowledge center and explore success stories, white papers and more to take your data center into the future. Success story Building data centers to exceed big expectations } Success story Building data centers to exceed big expectations Data center Visualize our solutions in our 3D environment } Data center Visualize our solutions in our 3D environment An explosion 4x hotter than the sun The mere drop of a tool or accidental contact with electrical systems can set off an arc flash and instantly generate an energy explosion releasing temperatures in excess of 36,000°F. That's four times hotter than the sun. Why arc flashes occur An arc flash is the explosive energy released when an electrical fault, for instance a short circuit, causes an arc. The dangers associated with an arc flash event include heat, flying debris, sound, UV radiation and more. 2 3 5 7 6 4 1 Power intensive environments are especially vulnerable In heavy power, continuous operation industries, arc flash poses a very real threat. Environments operating with 125 kVA or larger transformers call for special safety measures. Protecting personnel and equipment is everyone's responsibility. 8 Employees require education Electrical workers must be trained and should understand the risks of arc flash safety. This includes reading and understanding arc flash labels and wearing the proper personal protective equipment (PPE) to perform energized work. Codes and standards are always changing and it is imperative that your organization be in compliance. Arc flash labels provide advance warning Arc flash labels indicate two key pieces of information: The expected incident energy (measured in calories per cm2)—at a working distance of 18 inches or 24 inches—which drives the proper PPE required for protection. And the distance a worker without PPE must work to avoid a non-curable burn (typically measured in feet). Avoiding electrical disasters Time and distance are the most controllable variables reducing the risk of arc flash issues. Reducing the time that an event persists by tripping a breaker or blowing a fuse significantly reduces the arc flash incident energy. Increasing distance to the arc flash by remote operation, or with closed doors or protective barriers, protects workers in case an event occurs. Better equipment can help Installing the right equipment can help mitigate arc flash hazards. Specially designed low voltage motor control centers (MCCs) and switchgear can reduce the probability of electrical shock and arc flash energy during maintenance. As powerful as an 8-stick dynamite blast A 10,000A arc on a 480-volt circuit can have the explosive force of eight (8) sticks of dynamite. Another example of the energy in an arc flash: copper expands at 67,000 times its volume during an arc flash event—a small, pea-sized piece of copper would expand to fill the volume of a railroad car! 9 10 Good safety optimizes operational efficiency A sound safety policy incorporating arc flash safety solutions will protect your people and equipment, minimizing risk and increasing uptime. Human error is often to blame The most common cause of electrical accidents is human error. And the majority of those mistakes occur during routine maintenance of power system equipment or troubleshooting controls. Follow the Charge » to consider when designing your data center 10 THINGS ABOUT ARC FLASH SAFETYEach year, Eaton is performing discharge tests for over 300 000 batteries in Finland, where the EMEA UPS factory is located, to guarantee the safety and the functionality of the complete battery system. Eaton has a performing battery approval process, that leads to utilizing only the premium batteries on the market. In addition, regular audits are performed in all the facilities of the approved battery suppliers of Eaton Battery replacement service Batteries are the core element of any critical power protection system, hence they are assuring the backup time delivery. Most frequent cause of unplanned outages is premature end of life of few battery blocks. Handling batteries without proper training can lead to disastrous results of full UPS system investment 30-80% + - Continous quality monitoring Eaton is utilizing millions of batteries per year for UPS applications globally. Battery quality indeed plays the most critical role in battery selection criteria. >300 000 BATTERIES>1 000 000 Batteries utilized globally TESTED FOR EATON 3PH UPS IN EMEA PER YEAR As identical as possible battery performance between each battery blocks in the same string is crucial for the battery lifetime and battery string performance. In the graphs there are real test results from the same discharge test for 20 blocks of lower quality and 20 blocks of high quality batteries. With lower quality batteries there is much higher dispersion in the graphs than with high quality batteries. Eaton EMEA 3ph UPS service Good quality battery example Low quality battery example End of discharge Time Voltage Time Voltage End of discharge Changes to the products, to the information contained in this document, and to prices are reserved; so are errors and omissions. Only order confirmations and technical documentation by Eaton is binding. Photos and pictures also do not warrant a specific layout or functionality. Their use in whatever form is subject to prior approval by Eaton. The same applies to Trademarks (especially Eaton, Moeller, and Cutler-Hammer). The Terms and Conditions of Eaton apply, as referenced on Eaton Internet pages and Eaton order confirmations.Follow us on social media to get the latest product and support information.Eaton EMEA Headquarters Route de la Longeraie 7 1110 Morges, Switzerland Eaton.com © 2022 Eaton All Rights Reserved Publication No. SA161013EN June 2022Eaton is a registered trademark. All other trademarks are property of their respective owners. Safety ensured With over 50 years of experience in qualifying batteries for UPS applications, Eaton is replacing more than 200 000 blocks every year in EMEA. Eaton field service engineers and authorized partners are trained to perform the battery replacement according to the required safety procedures. In addition, Eaton's trained personnel is able to set and operate UPS and battery according to the site specific requirements, like environmental temperature and humidity, and Eaton UPS features like ABM, ESS and VMMS. This is crucial for safety and optimal UPS system performance. As an active steward of the environment, Eaton guarantees an efficient disposal of the end-of-life batteries. To benefit from battery replacement and other features, Eaton offers Service Level Agreements for maintaining the condition of your UPS to ensure its continuous performance while allowing you to accurately plan your budget. For more information about UPS services please visit https://www.eaton.com/gb/en-gb/services.html >200 000 BLOCKS REPLACED PER YEAR Years of expertise with UPS batteries 50+ >4000 A can be delivered from a battery cabinet ABM A correct set-up of the charging method promotes battery life Relevance A-Z Z-A Filters ________________________________ News and insights (3) Product (26) Resources (289) Multi-mode (6) Online (7) 13-19 kVA (2) 161-400 kVA (4) 20-40 kVA (5) 401-1200 kVA (3) 41-80 kVA (4) Data centre (6) Marine (2) Network closet (1) Server room (2) End of row (3) Facility level (3) Horizontal (2) Mounted with UPS (1) Tower (7) Basic (2) Configurable (1) Managed (1) Metered input (1) Switched (1) Single phase (2) Three phase (7) Articles (1) Brochures (48) Catalogues (33) Infographics and listicles (2) Presentations (1) Application notes (2) Certification reports (18) Drawings (45) Product notifications (1) Installation instructions (25) ________________________________ Eaton 93PM 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This energy transition is driven by the progressive replacement of carbon-based fuels with renewables, clean air regulation and the direct and indirect electrification of more applications. Today, energy flows through the grid in more directions and through more devices than ever before, and although that decentralisation creates more complexities and challenges, it also creates new potential. Everything as a Grid is our approach to reinventing the way power is distributed, stored and consumed. Our Everything as a Grid approach is shaping a future where homeowners and businesses can reduce the cost and environmental impact of energy. Flexible, intelligent power creates new opportunities for everyone. Energy transition: Everything as a Grid Our Everything as a Grid approach reinvents how power is distributed, stored and consumed worldwide. Because the world's energy needs are shifting, but what matters isn't. Eaton.com/EnergyTransition Watch the full story The transition to renewable power Global renewable adoption is on the rise; electricity demand is expected to reach 38,700 terawatt-hours by 2050 – with renewables providing 50% of that energy.1 The highly distributed nature of renewable energy is upending the traditional power delivery model. Electricity no longer flows in one direction from the utility that generates it to those who consume it. The new energy ecosystem comprises an intricate network of "prosumers" – consumers and businesses who produce their own energy locally, use what's needed and in many cases, are looking to export excess power back to the grid. Furthermore, the electrification of transport, building systems and industrial processes will drive considerable increases in demand for electrical power over the coming decades. Data centers, offices, factories and similar sites can participate in the transition via battery and thermal energy storage systems and grid-interactive uninterruptible power systems. This will give rise to vast bi-directional electricity flows requiring a network with the flexibility to cope with higher volatility and demand. 57 % Increase in global electricity demand by 2050 13X Growth in energy storage installed base by 2030 4X Growth of electricity required for data and computing by 2030 Planning for the shift to more electrical power The electrification of more areas of the economy, including transport, building systems and industry will drive a substantial increase in power demand by 2050. It is technically feasible to meet this extra demand with electricity generated from low or zero carbon sources. However, this will require concerted government support through policy and regulation as well as research and development to reduce the cost of new green energy sources like clean hydrogen. Decarbonisation: cleaner power Businesses and consumers are participating in cleaner power initiatives. Active corporate sourcing of renewable electricity reached 465 terawatt-hours (TWh), with production for self-consumption reaching 165TWh.2 On the consumer side, electric vehicle (EV) charging technology prices continue to fall, while charging point accessibility continues to rise. By facilitating the trading of self-generated clean electricity to reduce energy costs, we're enabling energy users, both consumers and businesses, to participate in demand response programmes where the utility can turn demand and/or on-site generation up or down in response to signals for real-time grid balancing needs. Democratisation: less reliance on the grid More homes, businesses and communities are becoming self-sufficient power producers that rely less on the utility grid. They generate, store and consume their own energy via renewable solar arrays, wind turbines, microgrids and battery storage. And they create a bi-directional flow that is changing the way power is managed and reducing the impact of sudden outages caused by rolling blackouts, cyberattacks and extreme weather events. These prosumers may also sell excess energy back to the grid and take advantage of demand response programmes to help reduce utility bills. Digitalisation: connectivity behind powerful decisions Digital innovation can be used to make smarter business or personal energy management decisions. It's the transformation of the data from appliances, equipment or processes into actionable insights that help consumers and businesses drive new efficiencies, maximise uptime and manage their energy footprint. Through technologies that support bi-directional power generation, storage and energy management, we're playing a critical role in helping meet demand growth and balance grid volatility. We are reimagining and rebuilding the electrical power value chain. Need help with the shift to more electrical power? Contact us Embracing the new power paradigm Homes, offices, stadiums, factories and data centres can now generate and store more of their own power to optimise energy costs, lower their carbon footprint and in some cases, reduce reliance on the grid. This is Everything as a Grid. Traditional electrical power infrastructures must be upgraded, with software and services optimising every process, to realise new energy benefits. We enable a systems approach to infrastructure integration and the technologies that help transform power generation and distribution for homes, buildings and utilities. Buildings as a grid Unlock the energy transition for your building See how the energy transition can help you seize the opportunity to improve the performance and expand functional use of your building infrastructure. Eaton introduces its Buildings as a Grid approach to energy transition Eaton introduces its Buildings as a Grid approach to help customers accelerate decarbonization, boost resilience, reduce energy costs and create new revenue streams. Responding to the high demand for low carbon Renewable and battery market shares continue to rise and play a larger role in the global power supply, even in the wake of the COVID-19 pandemic. The steady increase of competitiveness in renewables, along with their modularity, rapid scalability and job creation potential, make them highly attractive as countries and communities evaluate economic stimulus options.3 The challenge lies in balancing variable renewable power and storage options against the always-there, always-on power that users demand. By helping utilities, building managers and homeowners adopt renewable power and storage strategies, we're helping to make clean energy available when and where it's needed. Energy storage Capture renewable energy whenever it's available and use it on demand. You'll see immediate gains in reliability, realise greater independence from the utility grid and avoid dips in grid power supply due to brownouts, cyberattacks and weather-related events. This transformational technology revolutionises power for all, with energy storage available for the home, commercial and industrial buildings and even large-scale implementations for utilities. EnergyAware UPS Our EnergyAware technology helps applications like data centres to support energy providers by balancing sustainable power generation and consumption. The technology optimises power usage during peak demand hours and helps facilities earn additional revenues from currently deployed assets while maintaining complete control of deployed uninterruptible power systems and batteries. Electric vehicles Changing energy demands will affect infrastructure investments – and understanding that impact will be critical in enabling a resilient systems approach that seamlessly and flexibly integrates different assets and EV infrastructure. Power systems, EV manufacturers and charging infrastructure providers can then drive a deeper understanding of energy usage to maximise energy efficiency and lower operational costs to consumers. Microgrids Built to help isolate power from the main grid, microgrids balance multiple sources of on-site generation and demand to make energy available when it is needed. Grid modernisation Discover how utilities can adopt grid modernisation technologies to build resilient, efficient and secure power networks. Find out more about Eaton's global sustainability commitments, including carbon neutrality by 2030 Find out more Adapting to fast-changing regulations Regulators are starting to make important changes to incentivise services like demand response to reduce costs, encourage and integrate the uptake of clean energy and increase customer participation. However, we have far to go if we are to replicate best practices and further encourage innovation. This includes financial mechanisms that reward utilities and distribution companies for contracting with distributed energy providers in place of capital investments – a departure from traditional regulation in which the addition of new capital assets is the main source of profit. Through market data analysis and expert insights, we help companies and countries prepare for and embrace the regulatory changes needed to assure a reliable power mix. Ensuring cybersecurity throughout the transition Only 48% of utility executives feel they are prepared to handle the challenges of a cyberattack interruption.4 As utilities address the challenges of improving power reliability and efficiency, they must also contend with the near-constant barrage of security threats. We proactively address cyber threats via a system-wide defensive approach and an unwavering focus on the dangers malware, spyware and ransomware present across the globe. Our team members meet and exceed competencies recognised by international standards organisations like UL, IEC, ISA and others through rigorous, in-depth technical training programmes. Our "secure-by-design" philosophy, processes and secure development lifecycle are integrated into product development and guide our labs, procurement and design teams as the foundation of innovation. And our understanding of and influence in changing global standards help guide safer, more efficient energy infrastructures. Powering the energy transition The technologies that convert wind and sunlight to renewable energy have matured, allowing for more flexible power possibilities. The growth of renewables, localised electricity production and bi-directional energy helps more homes, businesses and communities produce their own clean, dependable energy for less reliance on the utility grid. Count on Eaton for the technologies and digital intelligence needed for you to join this energy transition. Through our Everything as a Grid approach, infrastructures can be re-vamped to manage and optimise renewable integration, so you can realise more efficient, sustainable power that costs less. MTL4500/MTL5500 range Analogue Input Modules with passive input for 4-wire separately powered transmitters MTL4541A, MTL4541AS, MTL5541A, MTL5541AS, MTL4544A, MTL4544AS, MTL5544A, MTL5544AS April 2024 SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 Safety manual MTL intrinsic safety solutions FUNCTIONAL SAFETY MANAGEMENT These products are for use as elements within a Safety System conforming to the requirements of IEC 61508:2010 and enable a Safety Integrity Level of up to SIL 2 to be achieved for the instrument loop in a simplex architecture. Eaton Electric Ltd, Luton is a certified Functional Safety Management company meeting the requirements of IEC61508:2010 Part 1, Clause 6. * * Subject to special conditions for detection of out-of-range signal currents. Refer to content of this manual for details. SIL IEC 61508:2010 2 2SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 This manual supports the application of the products in functional-safety related loops. It must be used in conjunction with other supporting documents to achieve correct installation, commissioning and operation. Specifically, the data sheet, instruction manual and applicable certificates for the particular product should be consulted, all of which are available on the MTL web site. In the interest of further technical developments, Eaton reserve the right to make design changes. Contents 1 Introduction 3 1.1 Application and function 3 1.2 Variant description 3 1.3 Product build revisions covered by this manual 4 2 System configuration 5 2.1 Associated system components 6 3 Selection of product and implications 6 4 Assessment of functional safety 6 4.1 Hardware Safety Integrity 6 4.2 Systematic Safety Integrity 7 4.3 SIL Capability 7 4.4 Example of use in a safety function 7 4.5 EMC 8 4.6 Environmental 8 5 Installation 8 6 Maintenance 9 7 Appendices 9 7.1 Appendix A: Summary of applicable standards 9 7.2 Appendix B: Proof Test Procedure, MTLx541A/AS, MTLx544A/AS Modules 10 - 12 Analogue Input Modules with passive input for 4-wire transmitters Hardware Fault Tolerance (HFT) † Module type 0, 1 MTL4541A, MTL4541AS, MTL5541A, MTL5541AS, MTL4544A, MTL4544AS, MTL5544A, MTL5544AS † These modules have an inherent fault tolerance of 0. SIL IEC 61508:2010 2 3SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 1 INTRODUCTION 1.1 Application and function The Analogue Input module types MTLx541A/MTLx541AS (single channel) and MTLx544A/MTLx544AS (dual channel) are intrinsic safety isolators that interface with process measurement transmitters located in a hazardous area of a process plant. They are also designed and assessed according to IEC 61508 for use in safety instrumented systems up to SIL 2. The MTLx541A provides an input for a separately-powered 4/20mA transmitter located in a hazardous area, and repeats the transmitter current into a load in the safe area. The MTLx544A supports two identical channels for use with two separate transmitters. The MTLx541AS and MTLx544AS versions act as a current sink for the safe area connection rather than driving the current into the load. All the modules allow bi–directional transmission of HART communication signals superimposed on the 4/20mA loop current, so that the transmitter can be interrogated either from the operator station or by a hand- held communicator (HHC). There are no configuration switches or operator controls to be set on the modules. These modules are members of the MTL4500 and MTL5500 range of products. 1.2 Variant Description Functionally the MTL4500 and MTL5500 range of modules are the same but differ in the following way: - the MTL4500 modules are designed for backplane mounted applications - the MTL5500 modules are designed for DIN-rail mounting. In both models the hazardous area field-wiring connections (terminals 1,2, and optionally 4,5) are made through the removable blue connectors, but the safe area and power connections for the MTL454xA/MTL454xAS modules are made through the connector on the base, while the MTL554xA/MTL554xAS modules use the removable grey connectors on the top and side of the module. Note that the safe-area connection terminal numbers differ between the backplane and the DIN-rail mounting models. The analogue input models covered by this manual are: Module type Number of channels Safe area connection MTL4541A and 5541A 1 Current source MTL4541AS and 5541AS 1 Current sink MTL4544A and 5544A 2 Current source MTL4544AS and 5544AS 2 Current sink Note: To avoid repetition, further use of MTLx54xA and MTLx54xAS in this document can be understood to include both DIN-rail and backplane models. Individual model numbers will be used only where there is a need to distinguish between them. All the module types described in this manual have the same connectivity for the field signals, supporting 4-wire process transmitters or currents sourced in the hazardous area. The connection of the repeated current signals into the input measurement channels for the safety logic system follows the arrangement shown in the following diagram. When the input channels of the Safety Instrumented System (SIS) are providing power for the loop, the ‘S’ variants of the isolator modules are used to ‘sink’ the measuring current. In the other cases the isolator modules ‘source’ the measuring current that flows into a load resistor inside the input card of the Safety Instrumented System. 4SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 2+ 1- Pwr 0V 24V Safety Instrumented System (SIS) Logic Solver with ‘Passive’ input MTLx541A/ MTLx544A (Safe area current source) B A 2+ 1- Pwr 0V 24V Safety Instrumented System (SIS) Logic Solver with 2-wire input A B Current limiter Output terminal MTL4541A, MTL4541AS MTL5541A, MTL5541AS A 8 11 B 9 12 4-wire Transmitter or current source Pwr Field wiring MTLx541AS/MTLx544AS (Safe area current sink) Figure 1.1 – Input and output connections 1.3 Product build revisions covered by this manual The information provided in this manual is valid for the product build revisions listed in the following table: Model Type Product build revision covered by this manual MTL4541A Up to and including 08 MTL4541AS Up to and including 08 MTL5541A Up to and including 08 MTL5541AS Up to and including 08 MTL4544A Up to and including 08 MTL4544AS Up to and including 08 MTL5544A Up to and including 08 MTL5544AS Up to and including 08 The product build revision is identified by the field ‘CC’ in the module Product Identification Number that appears at the bottom left-hand corner of the side label: The CC field immediately precedes the 7-digit Serial Number field, DDDDDDD. Example: 5SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 2 System configuration An MTLx54x module may be used in single-channel (1oo1) safety functions up to SIL 2. The worked example in this manual is for a SIL 2 application. The figure below shows the system configuration and specifies detailed interfaces to the safety-related and non safety-related system components. It does not aim to show all details of the internal module structure, but is intended to support understanding for the application. Figure 2 – System Configuration The MTLx54xA/MTLx54xAS modules are designed to receive an active 4-20mA signal from separately powered process transmitters in the hazardous area and to repeat the current flowing in the field loop to the safe-area load. The shaded area indicates the safety-related system connection, while the power supply con- nections are not safety-related. The term ‘Logic Solver’ has been used to denote the safety system performing the monitoring function of the process loop variable. Note: When using the MTLx544A/MTLx544AS dual-channel modules, it is not appropriate for both channels to be used in the same loop, or the same safety function, as this creates concerns regarding common-cause failures. Consideration must also be given to the effect of common-cause failures when both loops of a dual- channel module are used for different safety functions. Hazardous area Safe area Logic Solver (Safety related) Logic Solver (Safety related) Power supply (Not safety related) MTL5544A/MTL5544AS (2-channel version) shown. MTL5541A/MTL5541AS (single-channel version) omits Ch 2. 20 - 35V dc 6SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 2.1 Associated System Components There are many parallels between the loop components that must be assessed for intrinsic safety as well as functional safety. In both situations the contribution of each part is considered in relation to the whole. The MTLx54xA/MTLx54xAS modules are components in the signal path between safety-related process trans- mitters and safety-related control systems. The transmitter or other field device must be suitable for the process and have been assessed and independently verified for use in functional safety applications. The field instrument and Analogue input card of the Logic Solver shall have a normal operating range of 4-20mA but be capable of working over an extended range of 3 to 22mA for under- and over-range. The Logic Solver shall have the ability to detect and annunciate input currents higher than the threshold of 21mA and lower than the threshold of 3.6mA to determine out-of-range conditions. Note that the transmission of HART data is not considered as part of the safety function and is excluded from this analysis. However, for HART data communication to take place, the input impedance of the receiving equip- ment must be at least 240R. 3 Selection of product and implications The safe area output signal from the MTLx541A/AS and MTLx544A/AS modules is within the operating range of 4-20mA under normal conditions. If the field wiring to the transmitter or connection between the isolator and logic solver is open-circuit then the loop current will fall to less than 3.6mA and close to zero. If the field wiring connection between the transmitter and isolator is short-circuited, the loop current will also fall to below 3.6mA. For module types MTLx541A and MTLx544A that source the 4-20mA signal in the safe area circuit, then the current seen by the logic solver will fall to less than 3.6mA and close to zero if the connection between the isolator and logic solver is shorted. For module types MTLx541AS and MTLx544AS that sink the 4-20mA signal in the safe area circuit, then the current seen by the logic solver will rise to a value greater than 21mA if the connection between the isolator and logic solver is shorted. In both cases, the fault condition must be detected by the logic solver in Functional Safety applications. This should also include the detection of power supply failures which cause the output of the isolator to fall to zero mA. 4 Assessment of Functional Safety 4.1 Hardware Safety Integrity The hardware assessment shows that MTLx541A/MTLx541AS and MTLx544A/MTLx544AS modules: • have a hardware fault tolerance (HFT) of 0 • are classified as Type A devices (“non-complex” component with well-defined failure modes) • have no internal diagnostic elements The failure rates of these modules at an ambient temperature of 45°C are as follows: Failure mode Failure rate (FIT)* MTL4541A MTL5541A MTL4541AS MTL5541AS MTL4544A MTL5544A MTL4544AS MTL5544AS Output current >21mA (upscale) 3 3 3 14 Output current 2% in error 42 42 49 49 Output current correct within ±2% 73 73 80 81 *(FITs means failures per 109 hours or failures per thousand million hours) • Reliability data for this analysis is taken from IEC TR 62380:2004 Reliability Data Handbook. • Failure mode distributions are taken principally from IEC 62061:2005 Safety of Machinery. • Stated failure rates for dual-channel modules apply to a single channel. It is assumed that the module is powered from a nominal 24V dc supply and operating at a maximum ambient temperature of 45°C. 7SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 4.2 Systematic Safety Integrity The MTLx54x modules have a systematic safety integrity measure of SC 2. This has been established using compliance Route 1S, as described in IEC 61508-2: 2010, section 7.4.2.2 c. 4.3 SIL Capability Considering both the hardware safety integrity and the systematic capability, this allows the modules to be used in safety functions up to SIL 2 in a simplex architecture (HFT=0), provided SFF ≥60% is the case for the application. The hardware safety integrity assessment has been conducted according to compliance Route 1H, as described in IEC 61508-2:2010, section 7.4.4. (See example below). Note: • Independent of hardware architecture and systematic capability considerations, the hardware probability of failure for the entire safety function needs to be calculated for the application to ensure the required PFH (for a high or continuous demand safety function) or PFDAVG (for a low demand safety function) for the SIL is met. 4.4 Example of use in a safety function In this example, the application context is assumed to be: • the safety function is to repeat current within ±2% • the logic solver will diagnose currents above 21mA and below 3.6mA as faults and take appropriate action The failure modes shown above can then be defined as: Failure mode Category Output current >21mA (upscale) Dangerous detected, dd Output current 2% in error Dangerous undetected, du Output current correct within ±2% No effect, ne* The failure rates of the MTL4541A and MTL5541A for these categories are then (FITs): Model sd su dd du ne* MTL4541A or MTL5541A 0 0 227 42 73 In this example, the safe failure fraction (SFF) is 84.4%. * ne is not used in the calculation of SFF. Defining the “output current correct within ±2%” failure mode as ne represents a conservative approach to the calculation of SFF. Interpreting this failure mode as su (safe, undetected) may also be considered and yields an SFF value of 87.7%. Accordingly, the SFF of all module types described in this manual, when used in the same application, are as follows: Model sd su dd du ne SFF MTL4541A, MTL5541A, MTL4541AS, MTL5541AS 0 0 227 42 73 84.4% MTL4544A, MTL5544A 0 0 267 49 80 84.5% MTL5544AS, MTL5544AS 0 0 267 49 81 84.5% 8SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 4.5 EMC The MTL4500 and MTL5500 modules are designed for operation in normal industrial electromagnetic environ- ment but, to support good practice, modules should be mounted without being subjected to undue conducted or radiated interference, see Appendix A for applicable standards and levels. 4.6 Environmental The MTL4500 and MTL5500 modules operate over the temperature range from -20°C to +60°C, and at up to 95% non-condensing relative humidity. The modules are intended to be mounted in a normal industrial environment without excessive vibration, as specified for the MTL4500 & MTL5500 product ranges. See Appendix A for applicable standards and levels. Continued reliable operation will be assured if the exposure to temperature and vibration are within the values given in the specification. 5 Installation There are two particular aspects of safety that must be considered when installing the MTL4500 or MTL5500 modules and these are: • Functional safety • Intrinsic safety Reference must be made to the relevant sections within the instruction manual for MTL4500 range (INM4500) or MTL5500 range (INM5500) which contain basic guides for the installation of the interface equipment to meet the requirements of intrinsic safety. In many countries there are specific codes of practice, together with industry guidelines, which must also be adhered to. Provided that these installation requirements are followed then there are no additional factors to meet the needs of applying the products for functional safety use. To guard against the effects of dust and water the modules should be mounted in an enclosure providing at least IP54 protection degree, or the location of mounting should provide equivalent protection such as inside an equipment cabinet. In applications using MTL4500 range, where the environment has a high humidity, the mounting backplanes should be specified to include conformal coating. 9SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 6 Maintenance To follow the guidelines pertaining to operation and maintenance of intrinsically safe equipment in a hazardous area, yearly periodic audits of the installation are required by the various codes of practice. In addition, proof- testing of the loop operation to conform with functional safety requirements should be carried out at the intervals determined by safety case assessment. Proof testing must be carried out according to the application requirements, but it is recommended that this be carried out at least once every three years. Refer to Appendix B for the proof testing procedure of the MTLx541A/AS and MTLx544A/AS modules. Note that there may also be specific requirements laid down in the E/E/PE operational maintenance procedure for the complete installation. If an MTLx541A/AS and MTLx544A/AS module is found to be faulty during commissioning or during the normal lifetime of the product, then such failures should be reported to the local MTL office. When appropriate, a Cus- tomer Incident Report (CIR) will be notified by Eaton to enable the return of the unit to the factory for analysis. If the unit is within the warranty period then a replacement unit will be sent. Consideration should be given to the service lifetime for a device of this type, which is in the region of ten years. Operating an MTLx541A/AS and MTLx544A/AS module for longer than this period could invalidate the functional safety analysis, meaning that the overall safety function no longer meets its target SIL. If high failure rates of the MTL modules are detected, indicating that they have entered the ‘end of life phase’ of their service life, then they should be replaced promptly. 7 Appendices 7.1 Appendix A: Summary of applicable standards This annex lists all standards referred to in the previous sections of this document: IEC 61508:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems. Parts 1 and 2 as relevant EN 61131-2:2003 Programmable controllers – Part 2: Equipment requirement and tests (EMC requirements) EN 61326-1:2013 Electrical equipment for measurement, control and laboratory use – EMC requirements. (Criterion A) IEC 61326-3-1:2017 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for equipment performing or intended to perform safety related functions (functional safety) – General industrial applications. (Criterion FS) NE21:2007 Electromagnetic Compatibility of Industrial Process and Laboratory Control Equipment. (Criterion A) Lloyds Register Type Approval System: 2015, Test Specification Number 1. Specifically vibration: 1.0mm displacement @ 5 to 13.2Hz and EN 60068-2-27 Environmental testing. Test Ea and guidance. Shock. (Criterion FS) 10SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 7.2 Appendix B: Proof Test Procedure, MTLx541A/AS, MTLx544A/AS Modules Confirmation, through testing, that a safety function will operate as designed, is a necessary periodic activity to ensure that the probability of failure upon demand (PFDavg) is maintained. In some applications, the user may prefer to conduct a proof test on the overall safety instrumented function without dismantling or disconnecting the individual instrumentation components, in order to avoid disturbing the integrity of the installation. However, where it is deemed desirable to perform proof testing on the MTL modules individually, the following procedure may be used. Proof tests of the other components of the loop must then be conducted in accordance with their manufacturers’ instructions, to maintain the integrity of the overall safety function. Alternative proof tests may be devised and applied, provided they give a similar level of test coverage that is appropriate to the safety function. The tests described here - see Figure 7.1 - compare the output current of the MTL isolator with the input current (A1) over the required range of operation, and measure the “error current” i.e. the difference between the two - as indicated on A2. The tests should be employed per channel, as appropriate. Figure 7.1 - Basic test arrangement Ammeter A2 must be capable of measuring currents of either polarity. If it is not an auto-ranging instrument, set it to a high range before switch on, and then adjust sensitivity to obtain the required reading. Proof Test Procedure Test sequence: 1. System - Normal operation test 2. Input /Output characteristic functional safety test 3. System - Normal operation test ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ Modules types MTL4541A, MTL4544A, MTL5541A, MTL5544A Modules types MTL4541AS, MTL4544AS, MTL5541AS, MTL5544AS 11SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 1 System - Normal operation test Make sure that the module to be tested is operating normally in the target system, without errors and in an energised mode. If the module is in a faulty or de-energised loop, restore normal fault-free and energised operation before testing. 2 Input/Output characteristic functional safety test Observe normal anti-static precautions when handling equipment during device testing. Remove the unit from the target system and connect it as shown in Figure 7.2. This figure shows the arrangement for the MTLx541A/ AS single-channel modules; for equivalent connections for the MTLx544A/AS dual-channel modules, refer to the relevant product data sheets. Note that it is acceptable to leave the unit in the target system but only after ensuring that the all the hazardous area input and safe area output terminals have been disconnected from the system and are available for test. Alternatively, for the backplane-mounted MTL4500 range modules, a separate backplane can be used to provide access to the power and output connections. Note that the combination of the 24V power supply and variable resistor RV1 in the hazardous area connection can be provided by a suitable industrial current simulator, which is likely to be more readily available. Also, the 250R resistor does not need to be a precision type; any value in the range 200-300R is acceptable would suffice, such as a standard value of 240R. Where a second power supply is introduced for testing the MTLx541AS or MTLx544AS module variants, note that both power supplies must be floating and not share a common 0V connection. During testing, a 24V nominal system power supply in the range 20.0 to 35.0V should be connected between terminals 13 and 14 (+ve to terminal 14). Figure 7.2 - Connections for testing the MTL5541A/AS and MTL4541A/AS modules 1 2 3 4 5 6 Ch1 i/p Ch2 i/p Ch2 o/p Ch1 o/p MTL5541A 13(–) 14(+) 7 8 9 10 11 12 V VS Power supply + MTL5501-SR 13(-) 14(+) V S +– +– +– +– + – +– V + Ch1 i/p Ch2 i/p Insert 250R and 24V supply for MTLx54xS modules, otherwise use direct link to o/p(+) 14 13 12 11 1 0 9 8 7 MTL4541A 1 2 3 4 5 6 Ch1 i/p Ch2 i/p Ch2 o/p Ch1 o/p + – + – + – + – + – A 1 A1 250RRV 1 + 250R 24V dc 24V dc – – + – + – A1 A 1 250RRV 1 + 250R 24V dc 24V dc – – 12SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 Channel 1 Channel 2 Measurements Make the following measurements. It is recommended to record the results in a table such as that shown on the next page. 1. Adjust resistor RV1 to vary the loop current (measured by Ammeter A1) through the range 4 to 20mA. (Tests 1 - 5 in table) 2. The measured current imbalance (measured by Ammeter A2) over this range should not exceed ±50µA. 3. Adjust RV1 to vary the current (A1) to 3.5mA and then 21.5mA (tests 6 & 7 in table). 4. The measured current imbalance (A2) at these currents should not exceed ±200µA. 5. Record the supply voltage Vs. If appropriate, repeat these measurements for Channel 2. 3 System - Normal operation test Disconnect the test setup from the unit and reconnect the original system configuration. Make sure that the tested unit operates normally in the target system, as before, without errors and in energised mode. Date: ______/______/__________ Supply voltage Vs: ______________V dc Module type: ________________ Serial No: ____________________________ Test # Description Actual Target 1 Current imbalance (A2) at loop current (A1) = 4mA <±50µA 2 Current imbalance (A2) at loop current (A1) = 8mA <±50µA 3 Current imbalance (A2) at loop current (A1) = 12mA <±50µA 4 Current imbalance (A2) at loop current (A1) = 16mA <±50µA 5 Current imbalance (A2) at loop current (A1) = 20mA <±50µA 6 Current imbalance (A2) at loop current (A1) = 3.5mA <±200µA 7 Current imbalance (A2) at loop current (A1) = 21.5mA <±200µA Test Step# Description Actual Target 1 Current imbalance (A2) at loop current (A1) = 4mA <±50µA 2 Current imbalance (A2) at loop current (A1) = 8mA <±50µA 3 Current imbalance (A2) at loop current (A1) = 12mA <±50µA 4 Current imbalance (A2) at loop current (A1) = 16mA <±50µA 5 Current imbalance (A2) at loop current (A1) = 20mA <±50µA 6 Current imbalance (A2) at loop current (A1) = 3.5mA <±200µA 7 Current imbalance (A2) at loop current (A1) = 21.5mA 21mA (upscale) 3 3 3 14 Output current 2% in error 42 42 49 49 Output current correct within ±2% 73 73 80 81 *(FITs means failures per 109 hours or failures per thousand million hours) • Reliability data for this analysis is taken from IEC TR 62380:2004 Reliability Data Handbook. • Failure mode distributions are taken principally from IEC 62061:2005 Safety of Machinery. • Stated failure rates for dual-channel modules apply to a single channel. It is assumed that the module is powered from a nominal 24V dc supply and operating at a maximum ambient temperature of 45°C. 7SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 4.2 Systematic Safety Integrity The MTLx54x modules have a systematic safety integrity measure of SC 2. This has been established using compliance Route 1S, as described in IEC 61508-2: 2010, section 7.4.2.2 c. 4.3 SIL Capability Considering both the hardware safety integrity and the systematic capability, this allows the modules to be used in safety functions up to SIL 2 in a simplex architecture (HFT=0), provided SFF ≥60% is the case for the application. The hardware safety integrity assessment has been conducted according to compliance Route 1H, as described in IEC 61508-2:2010, section 7.4.4. (See example below). Note: • Independent of hardware architecture and systematic capability considerations, the hardware probability of failure for the entire safety function needs to be calculated for the application to ensure the required PFH (for a high or continuous demand safety function) or PFDAVG (for a low demand safety function) for the SIL is met. 4.4 Example of use in a safety function In this example, the application context is assumed to be: • the safety function is to repeat current within ±2% • the logic solver will diagnose currents above 21mA and below 3.6mA as faults and take appropriate action The failure modes shown above can then be defined as: Failure mode Category Output current >21mA (upscale) Dangerous detected, dd Output current 2% in error Dangerous undetected, du Output current correct within ±2% No effect, ne* The failure rates of the MTL4541A and MTL5541A for these categories are then (FITs): Model sd su dd du ne* MTL4541A or MTL5541A 0 0 227 42 73 In this example, the safe failure fraction (SFF) is 84.4%. * ne is not used in the calculation of SFF. Defining the “output current correct within ±2%” failure mode as ne represents a conservative approach to the calculation of SFF. Interpreting this failure mode as su (safe, undetected) may also be considered and yields an SFF value of 87.7%. Accordingly, the SFF of all module types described in this manual, when used in the same application, are as follows: Model sd su dd du ne SFF MTL4541A, MTL5541A, MTL4541AS, MTL5541AS 0 0 227 42 73 84.4% MTL4544A, MTL5544A 0 0 267 49 80 84.5% MTL5544AS, MTL5544AS 0 0 267 49 81 84.5% 8SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 4.5 EMC The MTL4500 and MTL5500 modules are designed for operation in normal industrial electromagnetic environ- ment but, to support good practice, modules should be mounted without being subjected to undue conducted or radiated interference, see Appendix A for applicable standards and levels. 4.6 Environmental The MTL4500 and MTL5500 modules operate over the temperature range from -20°C to +60°C, and at up to 95% non-condensing relative humidity. The modules are intended to be mounted in a normal industrial environment without excessive vibration, as specified for the MTL4500 & MTL5500 product ranges. See Appendix A for applicable standards and levels. Continued reliable operation will be assured if the exposure to temperature and vibration are within the values given in the specification. 5 Installation There are two particular aspects of safety that must be considered when installing the MTL4500 or MTL5500 modules and these are: • Functional safety • Intrinsic safety Reference must be made to the relevant sections within the instruction manual for MTL4500 range (INM4500) or MTL5500 range (INM5500) which contain basic guides for the installation of the interface equipment to meet the requirements of intrinsic safety. In many countries there are specific codes of practice, together with industry guidelines, which must also be adhered to. Provided that these installation requirements are followed then there are no additional factors to meet the needs of applying the products for functional safety use. To guard against the effects of dust and water the modules should be mounted in an enclosure providing at least IP54 protection degree, or the location of mounting should provide equivalent protection such as inside an equipment cabinet. In applications using MTL4500 range, where the environment has a high humidity, the mounting backplanes should be specified to include conformal coating. 9SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 6 Maintenance To follow the guidelines pertaining to operation and maintenance of intrinsically safe equipment in a hazardous area, yearly periodic audits of the installation are required by the various codes of practice. In addition, proof- testing of the loop operation to conform with functional safety requirements should be carried out at the intervals determined by safety case assessment. Proof testing must be carried out according to the application requirements, but it is recommended that this be carried out at least once every three years. Refer to Appendix B for the proof testing procedure of the MTLx541A/AS and MTLx544A/AS modules. Note that there may also be specific requirements laid down in the E/E/PE operational maintenance procedure for the complete installation. If an MTLx541A/AS and MTLx544A/AS module is found to be faulty during commissioning or during the normal lifetime of the product, then such failures should be reported to the local MTL office. When appropriate, a Cus- tomer Incident Report (CIR) will be notified by Eaton to enable the return of the unit to the factory for analysis. If the unit is within the warranty period then a replacement unit will be sent. Consideration should be given to the service lifetime for a device of this type, which is in the region of ten years. Operating an MTLx541A/AS and MTLx544A/AS module for longer than this period could invalidate the functional safety analysis, meaning that the overall safety function no longer meets its target SIL. If high failure rates of the MTL modules are detected, indicating that they have entered the ‘end of life phase’ of their service life, then they should be replaced promptly. 7 Appendices 7.1 Appendix A: Summary of applicable standards This annex lists all standards referred to in the previous sections of this document: IEC 61508:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems. Parts 1 and 2 as relevant EN 61131-2:2003 Programmable controllers – Part 2: Equipment requirement and tests (EMC requirements) EN 61326-1:2013 Electrical equipment for measurement, control and laboratory use – EMC requirements. (Criterion A) IEC 61326-3-1:2017 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for equipment performing or intended to perform safety related functions (functional safety) – General industrial applications. (Criterion FS) NE21:2007 Electromagnetic Compatibility of Industrial Process and Laboratory Control Equipment. (Criterion A) Lloyds Register Type Approval System: 2015, Test Specification Number 1. Specifically vibration: 1.0mm displacement @ 5 to 13.2Hz and EN 60068-2-27 Environmental testing. Test Ea and guidance. Shock. (Criterion FS) 10SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 7.2 Appendix B: Proof Test Procedure, MTLx541A/AS, MTLx544A/AS Modules Confirmation, through testing, that a safety function will operate as designed, is a necessary periodic activity to ensure that the probability of failure upon demand (PFDavg) is maintained. In some applications, the user may prefer to conduct a proof test on the overall safety instrumented function without dismantling or disconnecting the individual instrumentation components, in order to avoid disturbing the integrity of the installation. However, where it is deemed desirable to perform proof testing on the MTL modules individually, the following procedure may be used. Proof tests of the other components of the loop must then be conducted in accordance with their manufacturers’ instructions, to maintain the integrity of the overall safety function. Alternative proof tests may be devised and applied, provided they give a similar level of test coverage that is appropriate to the safety function. The tests described here - see Figure 7.1 - compare the output current of the MTL isolator with the input current (A1) over the required range of operation, and measure the “error current” i.e. the difference between the two - as indicated on A2. The tests should be employed per channel, as appropriate. Figure 7.1 - Basic test arrangement Ammeter A2 must be capable of measuring currents of either polarity. If it is not an auto-ranging instrument, set it to a high range before switch on, and then adjust sensitivity to obtain the required reading. Proof Test Procedure Test sequence: 1. System - Normal operation test 2. Input /Output characteristic functional safety test 3. System - Normal operation test ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ Modules types MTL4541A, MTL4544A, MTL5541A, MTL5544A Modules types MTL4541AS, MTL4544AS, MTL5541AS, MTL5544AS 11SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 1 System - Normal operation test Make sure that the module to be tested is operating normally in the target system, without errors and in an energised mode. If the module is in a faulty or de-energised loop, restore normal fault-free and energised operation before testing. 2 Input/Output characteristic functional safety test Observe normal anti-static precautions when handling equipment during device testing. Remove the unit from the target system and connect it as shown in Figure 7.2. This figure shows the arrangement for the MTLx541A/ AS single-channel modules; for equivalent connections for the MTLx544A/AS dual-channel modules, refer to the relevant product data sheets. Note that it is acceptable to leave the unit in the target system but only after ensuring that the all the hazardous area input and safe area output terminals have been disconnected from the system and are available for test. Alternatively, for the backplane-mounted MTL4500 range modules, a separate backplane can be used to provide access to the power and output connections. Note that the combination of the 24V power supply and variable resistor RV1 in the hazardous area connection can be provided by a suitable industrial current simulator, which is likely to be more readily available. Also, the 250R resistor does not need to be a precision type; any value in the range 200-300R is acceptable would suffice, such as a standard value of 240R. Where a second power supply is introduced for testing the MTLx541AS or MTLx544AS module variants, note that both power supplies must be floating and not share a common 0V connection. During testing, a 24V nominal system power supply in the range 20.0 to 35.0V should be connected between terminals 13 and 14 (+ve to terminal 14). Figure 7.2 - Connections for testing the MTL5541A/AS and MTL4541A/AS modules 1 2 3 4 5 6 Ch1 i/p Ch2 i/p Ch2 o/p Ch1 o/p MTL5541A 13(–) 14(+) 7 8 9 10 11 12 V VS Power supply + MTL5501-SR 13(-) 14(+) V S +– +– +– +– + – +– V + Ch1 i/p Ch2 i/p Insert 250R and 24V supply for MTLx54xS modules, otherwise use direct link to o/p(+) 14 13 12 11 1 0 9 8 7 MTL4541A 1 2 3 4 5 6 Ch1 i/p Ch2 i/p Ch2 o/p Ch1 o/p + – + – + – + – + – A 1 A1 250RRV 1 + 250R 24V dc 24V dc – – + – + – A1 A 1 250RRV 1 + 250R 24V dc 24V dc – – 12SM4541A/AS, 5541A/AS, 4544A/AS, 5544A/AS rev 2 Channel 1 Channel 2 Measurements Make the following measurements. It is recommended to record the results in a table such as that shown on the next page. 1. Adjust resistor RV1 to vary the loop current (measured by Ammeter A1) through the range 4 to 20mA. (Tests 1 - 5 in table) 2. The measured current imbalance (measured by Ammeter A2) over this range should not exceed ±50µA. 3. Adjust RV1 to vary the current (A1) to 3.5mA and then 21.5mA (tests 6 & 7 in table). 4. The measured current imbalance (A2) at these currents should not exceed ±200µA. 5. Record the supply voltage Vs. If appropriate, repeat these measurements for Channel 2. 3 System - Normal operation test Disconnect the test setup from the unit and reconnect the original system configuration. Make sure that the tested unit operates normally in the target system, as before, without errors and in energised mode. Date: ______/______/__________ Supply voltage Vs: ______________V dc Module type: ________________ Serial No: ____________________________ Test # Description Actual Target 1 Current imbalance (A2) at loop current (A1) = 4mA <±50µA 2 Current imbalance (A2) at loop current (A1) = 8mA <±50µA 3 Current imbalance (A2) at loop current (A1) = 12mA <±50µA 4 Current imbalance (A2) at loop current (A1) = 16mA <±50µA 5 Current imbalance (A2) at loop current (A1) = 20mA <±50µA 6 Current imbalance (A2) at loop current (A1) = 3.5mA <±200µA 7 Current imbalance (A2) at loop current (A1) = 21.5mA <±200µA Test Step# Description Actual Target 1 Current imbalance (A2) at loop current (A1) = 4mA <±50µA 2 Current imbalance (A2) at loop current (A1) = 8mA <±50µA 3 Current imbalance (A2) at loop current (A1) = 12mA <±50µA 4 Current imbalance (A2) at loop current (A1) = 16mA <±50µA 5 Current imbalance (A2) at loop current (A1) = 20mA <±50µA 6 Current imbalance (A2) at loop current (A1) = 3.5mA <±200µA 7 Current imbalance (A2) at loop current (A1) = 21.5mA 17V @ 20mA) is at least 1.5V greater than the total voltage developed across the transmitter and associated field wiring at 20mA. The Analogue Input module must not itself be part of a Safety Instrumented Function. Its non-hazardous 4-20mA output signal may be part of the basic process control system, but must not be used as part of the Safety Instrumented System. Note that HART communications are not supported on the 4-20mA signal. Note: • The MTL5314 is capable of operating in conjunction with MTL Analogue Input modules (such as MTL5541) that provide power for the hazardous area current loop, where the MTL5314 is connected in series with the process transmitter. This configuration also provides a means of transferring the loop current to the non-hazardous area in addition to the trip alarms, and is shown in other MTL documentation such as the MTL5314 product data sheet. However, this configuration is different to that described in 2.1 above, and has not been assessed for Functional Safety applications. SM5314 rev 1 rev 2 DRAFT - 2401207 4 ASSESSMENT OF FUNCTIONAL SAFETY 4.1 Hardware Safety Integrity The hardware safety integrity stated in this manual is drawn from a Failure Modes, Effects and Diagnostic Analysis (FMEDA) for the MTL5314 Trip Amplifier, conducted on behalf of Eaton-MTL by Exida (Exida report no. MTL 05/05-26 R007, version V1, revision R1). Minor amendments have been made in this manual where appropriate, to ensure that the calculation of Safe Failure Fraction (SFF) is in compliance with IEC 61508-2: 2010. The hardware assessment shows that MTL5314 module: • has a hardware fault tolerance (HFT) of 0 • is classified as a Type A device (“non-complex” component with well-defined failure modes) • has no internal diagnostic elements The failure rates derived by the FMEDA for the MTL5314 are stated as FITs (failures per 109 hours, or failures per thousand million hours) in the table below: Model sd su dd du ne* SFF MTL5314, Low Trip 0 156 0 50 165 75.7% MTL5314, High Trip 0 151 0 56 165 72.9% The Safe Failure Fraction (SFF) shown in the table is calculated as (dd + sd + su) / (du + dd + sd + su), and stated as a percentage. For both trip modes, the calculated SFF is between 60 and 90%, and therefore meets the requirements for SIL 2 according to Table 2 of IEC 61508-2: 2010, for a hardware fault tolerance of 0. * Note that “No-effect” failures (ne) are not used in the calculation of SFF. No-effect failures are defined in IEC 61508-4: 2010 as failures of elements (or components) that are part of the safety function but have no effect on the safety function. 4.2 Assumptions The following assumptions have been made during this analysis: • The fail safe state is defined as the alarm relay in the MTL5314 being de-energised. • Only one trip output is used in the Safety Instrumented Function. • A single failure will fail the entire product. • Failure rates are constant; wear-out mechanisms are not considered. • Propagation of failures is not relevant. • All components that are not part of the safety function and cannot influence the safety function are excluded. • The stress levels are typical for an industrial environment and can be compared to the Ground Fixed classification of MIL-HDBK-217F. This is similar to Class C (sheltered location) as defined in IEC 60654-1, with temperature and humidity levels within those stated in the product data sheet and Section 4.6 of this manual, and an average long-term temperature of 40oC. • The module is powered from a nominal 24V dc supply. • Power supply failure rates are not considered. SM45314 rev 1 DRAFT - 2401208 4.3 Systematic Safety Integrity The MTL5314 module has a systematic safety integrity measure of SC 2. This has been established using compliance Route 1S, as described in IEC 61508-2: 2010, section 7.4.2.2 c. 4.4 SIL Capability Considering both the hardware safety integrity and the systematic capability, this allows the module to be used in safety functions up to SIL 2 in a simplex architecture (HFT=0). The hardware safety integrity assessment has been conducted according to compliance Route 1H, as described in IEC 61508-2: 2010, section 7.4.4. Note: • Independent of hardware architecture and systematic capability considerations, the hardware probability of failure for the entire safety function needs to be calculated for the application to ensure the required PFH (for a high or continuous demand safety function) or PFDavg (for a low demand safety function) for the SIL is met. 4.5 EMC The MTL5314 module is designed for operation in normal industrial electromagnetic environment but, to support good practice, the module should be mounted without being subjected to undue conducted or radiated interference. See Appendix A for applicable standards and levels. 4.6 Environmental The MTL5314 module is designed for operation over the temperature range from -20°C to +60°C, and at up to 95% non-condensing relative humidity. The module is intended to be mounted in a normal industrial environment without excessive vibration, as specified for the MTL5500 product range. See Appendix A for applicable standards and levels. Continued reliable operation will be assured if the exposure to temperature and vibration are within the values given in the specification. 5 INSTALLATION There are two aspects of safety that must be considered when installing the MTL5314 module. These are: • Functional safety • Intrinsic safety To comply with intrinsic safety requirements, reference should be made to the relevant sections in the instruction manual INM5500, which is available to download from the Eaton-MTL website. In many countries there are also specific codes of practice and industry guidelines, which must also be adhered to. Provided that these installation requirements are followed then there are no additional environmental factors to meet the needs of applying the products for functional safety use. To guard against the effects of dust and water the modules should be mounted in an enclosure providing at least IP54 protection degree, or the mounting location should provide equivalent protection such as inside an equipment cabinet. SM5314 rev 1 rev 2 DRAFT - 2401209 6 MAINTENANCE To follow the guidelines relating to operation and maintenance of intrinsically safe equipment in a hazardous area, yearly periodic audits of the installation are required by the various codes of practice. In addition, proof- testing of the loop operation to conform with functional safety requirements should be carried out at the intervals determined by safety case assessment. Proof testing must be carried out according to the application requirements, but it is recommended that this be performed at least once every three years. Refer to Appendix B for the proof testing procedure for the MTL5314 module. Note that there may also be specific requirements laid down in the E/E/PE operational maintenance procedure for the complete installation. If an MTL5314 module is found to be faulty during commissioning or during the normal lifetime of the product, then such failures should be reported to the local Eaton-MTL office. Where appropriate, a Customer Incident Report (CIR) will be notified by Eaton to enable the unit to be returned to the factory for analysis. If the unit is within the warranty period and the failure is due to defective components or manufacture, then a replacement unit will be sent. Consideration should be given to the service lifetime for a device of this type, which is in the region of ten years. Operating an MTL5314 module for longer than this period could invalidate the functional safety analysis, meaning that the overall safety function no longer meets its target SIL. If high failure rates of the module are detected in service, indicating that they have entered the ‘end of life phase’ of their service life, then they should be replaced promptly. SM45314 rev 1 DRAFT - 24012010 7 APPENDICES 7.1 Appendix A: Summary of applicable standards This annex lists all standards referred to in the previous sections of this document: IEC 61508: 2010 Functional safety of electrical/electronic/programmable electronic safety-related systems. Parts 1 and 2 as relevant EN 61131-2: 2003 Programmable controllers – Part 2: Equipment requirement and tests (EMC requirements) EN 61326-1: 2013 Electrical equipment for measurement, control and laboratory use – EMC requirements. (Criterion A) IEC 61326-3-1: 2017 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for equipment performing or intended to perform safety related functions (functional safety) – General industrial applications. (Criterion FS) NE21:2007 Electromagnetic Compatibility of Industrial Process and Laboratory Control Equipment. (Criterion A) Lloyds Register Type Approval System: 2002, Test Specification Number 1. (specifically vibration: 1.0mm displacement @ 5 to 13.2Hz and 0.7G acceleration @13.2Hz to 100Hz per IEC60068-2-6, test Fc) EN 60068-2-27 Environmental testing. Test Ea and guidance. Shock. (Criterion FS) Note that other standards are referenced in Exida report no. MTL 05/05-26 R007, version V1, revision R1, which was used for the derivation of failure rates used in this manual. SM5314 rev 1 rev 2 DRAFT - 24012011 7.2 Appendix B : Proof Test Procedure, MTL5314 Module Confirmation, through testing, that a safety function will operate as designed, is a necessary periodic activity to ensure that the probability of failure upon demand (PFDavg) is maintained. In some applications, the user may prefer to conduct a proof test on the overall safety instrumented function without dismantling or disconnecting the individual instrumentation components, in order to avoid disturbing the integrity of the installation. However, where it is deemed desirable to perform proof testing on the MTL modules individually, the following procedure may be used. Proof tests of the other components of the loop must then be conducted in accordance with their manufacturers’ instructions, to maintain the integrity of the overall safety function. Alternative proof tests may be devised and applied, provided they give a similar level of test coverage that is appropriate to the safety function. Observe normal anti-static precautions when handling equipment during device testing. Remove the MTL5314 from the target system and observe the following test sequence: 1. Select a variable current source or sink, according to which is most representative of the actual field device in the Safety Instrumented Function. A current sink is representative of typical 2 or 3-wire field transmitters, whereas a current source is representative of the 4-20mA output from 4-wire transmitters. The current source or sink should have a traceable calibration history. 2. Set the current source or sink to 12.0mA, and connect it to the appropriate input terminals on the MTL5314 module as shown in Figure 7.2. 3. Adjust the trip potentiometers on the top of the MTL5314 module for Alarms A and B in turn, until the associated LEDs just extinguish. 4. Set the current source or sink to 11.5mA 5. Using the switches on top of the module, set both Alarms to ‘Low Alarm’. 6. Confirm that the LEDs and alarm relays comply with the status shown in ‘Low Alarm’ column of the table below. A multi-meter set to a low ohms range can be used to check that the relays are open or closed. 7. Set both Alarms to ‘High Alarm’, and confirm that the LEDs and alarm relays comply with the status shown in the ‘High Alarm’ column of the table. 8. Set the current source or sink to 12.5mA and repeat steps 5 to 7. Current High Alarm Low Alarm LEDs Alarm A LEDs Alarm A Terminals 11 - 12 Terminals 10 - 11 Terminals 11 - 12 Terminals 10 - 11 Alarm B Alarm B Terminals 8 - 9 Terminals 7 - 8 Terminals 8 - 9 Terminals 7 - 8 11.5mA on closed open off open closed 12.5mA off open closed on closed open continued SM45314 rev 1 DRAFT - 24012012 Figure 7.2 - Connections for testing MTL5314 module Source or sink 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Trip B Trip A Vs Vs 20 to 35V dc SM5314 rev 1 rev 2 DRAFT - 24012013 THIS PAGE IS LEFT INTENTIONALLY BLANK SM45314 rev 1 DRAFT - 24012014 THIS PAGE IS LEFT INTENTIONALLY BLANK SM5314 rev 1 rev 2 DRAFT - 24012015 THIS PAGE IS LEFT INTENTIONALLY BLANK DRAFT - 20 November 2014 EUROPE (EMEA): +44 (0)1582 723633 mtlenquiry@eaton.com THE AMERICAS: +1 800 835 7075 mtl-us-info@eaton.com ASIA-PACIFIC: +65 6 645 9888 sales.mtlsing@eaton.com The given data is only intended as a product description and should not be regarded as a legal warranty of properties or guarantee. In the interest of further technical developments, we reserve the right to make design changes. Eaton Electric Limited, Great Marlings, Butterfield, Luton Beds, LU2 8DL, UK. Tel: + 44 (0)1582 723633 Fax: + 44 (0)1582 422283 E-mail: mtlenquiry@eaton.com www.mtl-inst.com © 2020 Eaton All Rights Reserved Publication No. SM5314 rev 1 240120 January 2020 DRAFT - 240120 The safety you rely on. See the complete MTL product portfolio at www.mtl-inst.com For more information: If further assistance is required, please contact an authorised MTL Distributor, Sales Office, or Customer Service Department Connect with Eaton, MTL: AUSTRALIA Eaton Electrical (Australia) Pty Ltd, 10 Kent Road, Mascot, New South Wales, 2020, Australia Tel: +61 1300 308 374 Fax: +61 1300 308 463 E-mail: mtlsalesanz@eaton.com BeNeLux MTL Instruments BV Ambacht 6, 5301 KW Zaltbommel The Netherlands Tel: +31 (0)418 570290 Fax: +31 (0)418 541044 E-mail: mtl.benelux@eaton.com CHINA Cooper Electric (Shanghai) Co. 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Suite 200, Houston TX 77086, USA Tel: +1 281-571-8065 Fax: +1 281-571-8069 E-mail: mtl-us-info@eaton.com www.eaton.eu Application Note 11/2017 AP040017EN PowerXL™ DE1 Variable Speed Starters Motor Data – Motor Protection – V/f curves – Slip Compensation Level 2 1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 2 Contents Disclaimer

2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 3 Danger! - Dangerous electrical voltage! · Disconnect the power supply of the device. · Ensure that devices cannot be accidentally restarted. · Verify isolation from the supply. · Cover or enclose any adjacent live components. · Follow the engineering instructions (AWA/IL) for the device concerned. · Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system. · Before installation and before touching the device ensure that you are free of electrostatic charge. · The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection. · Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions. · Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states. · Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specification, otherwise this may cause malfunction and/or dangerous operation. · Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatch- ing of the emergency-stop devices must not cause a restart. · Devices that are designed for mounting in housings or control cabinets must only be operated and con- trolled after they have been properly installed and with the housing closed. · Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, me- chanical interlocks etc.). · Variable speed starters may have hot surfaces during and immediately after operation. · Removal of the required covers, improper installation or incorrect operation of motor or variable speed starter may destroy the device and may lead to serious injury or damage. · The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live variable speed starters. · The electrical installation must be carried out in accordance with the relevant electrical regulations (e. g. with regard to cable cross sections, fuses, PE). · Transport, installation, commissioning and maintenance work must be carried out only by qualified per- sonnel (IEC 60364, HD 384 and national occupational safety regulations). · Installations containing variable speed starters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the variable speed starters using the operating software are permitted. · All covers and doors must be kept closed during operation. · To reduce the hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the variable speed starter (increased motor speed or sudden standstill of motor). These measures include: • Other independent devices for monitoring safety related variables (speed, travel, end positions etc.). • Electrical or non-electrical system-wide measures (electrical or mechanical interlocks). • Never touch live parts or cable connections of the variable speed starter after it has been discon- nected from the power supply. Due to the charge in the capacitors, these parts may still be alive after disconnection. Consider appropriate warning signs. 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 4 Disclaimer The information, recommendations, descriptions, and safety notations in this document are based on Eaton’s experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the purchaser. THERE ARE NO UNDERSTAND- INGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLI- GATION OF EATON. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BETWEEN THE PARTIES. As far as applicable mandatory law allows so, in no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, or otherwise for any special, indirect, incidental, or consequential damage or loss whatsoev- er, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information, recommendations, and descriptions contained herein. The information contained in this manual is subject to change without notice. 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 5 General Devices of the series PowerXL™ DE1 are Variable Speed Starters for the supply of standard asyn- chronous motors. By default they are configured, that motors of the respective power class can be supplied without changing the settings. Many standard cases can be covered. There are some applications, which require an adaptation by changing parameters. In this Applica- tion Note the following aspects are covered: · Adaptation to the connected motor · Slip compensation · Motor protection · Setting the V/f curve · Energy optimization Motor data Condition for a proper operation is the right connection (star / delta) of the motor to the output ter- minals of the device. The rated voltage of the motor windings is decisive. Device Output Voltage Motor Connection DE1-12… 3 x 230 V 230 / 400 V Delta DE1-34… 3 x 400 V 230 / 400 V 400 / 660 V Star Delta DE1-34… 3 x 400 V 230 / 400 V Delta Special case: 87 Hz-curve (see Example 4 below) An adaptation to the connected motor can be done with the following parameters: · P-07 Motor Nom Voltage · P-08 Motor Nom Current · P-09 Motor Nom Frequency · P-10 Motor Nom Speed The respective values can be taken from the name plate of the motor or from the data sheet of the motor manufacturer. They are used for the setting of the motor protection and define the V/f curve. 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 6 Motor Nom Voltage (P-07) Motor rated voltage (name plate) taking the connection (star / delta) into account. This value defines the max. output voltage of the Variable Speed Starter. Is the output frequency higher than the rated frequency of the motor (P-09), the output voltage remains on the value set with P-07. See also chap- ter “V/f curve” below. Devices of the series DE1 have a voltage compensation. That means, that the output voltage is kept constant, even with fluctuation of the mains voltage. In case P-07 = 0 , the voltage compensation is disabled. In this case the maximum output voltage of the device is equal to the mains voltage at the input terminals. In exceptional cases, a different setting of P-07 is necessary. See chapter “87 Hz curve” PNU Parameter Name Range Default 211.0 P-07 Motor Nom Voltage 0 / 50 V … Ue Ue Ue = Rated voltage of the device, e.g. 230 V or 400 V, depending on device type Motor Nom Current (P-08) Rated current of the motor. By default, parameter P-08 „Motor Nom Current“ is set to the rated cur- rent Ie of the Variable Speed Starter. P-08 is also used to set the thermal protection for the motor. See also chapter “Motor Protection”. In case the rated current of the motor is different to the one of the Variable Speed Starter, P-08 has to be set accordingly to provide a thermal motor protection. It must be pointed out, that this current value is set, which is assigned to the type of connection of the motor. In the example above it is 3,2 A at 230 V (Delta) respectively 1,9 A at 400 V (Star). PNU Parameter Name Range Default 210.0 P-08 Motor Nom Current 0.1 · Ie … Ie Ie Ie = Rated current of the device Motor Nom Frequency (P-09) Rated frequency of the motor. By default this parameter is set to the mains frequency (50 Hz in Eu- rope, 60 Hz in USA) and doesn’t need to be changed in the majority of cases. In case, motors with rated frequencies different from the mains frequency (e.g. 200 Hz for fast rotat- ing motors) or if the 87 Hz curve is used, P-09 has to be set accordingly. PNU Parameter Name Range Default 216.0 P-09 Motor Nom Frequency 20 … 300 Hz 50 Hz resp. 60 Hz 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 7 Motor Nom Speed (P-10) (Switching from Hz to rpm, Slip compensation) P-10 = 0: Setting / display of the output frequency in Hz P-10 > 0: all speed related parameters (P-01, P-02, P-20…P-23) are set and displayed in rpm. Fur- thermore the slip compensation is activated, which ensures, that the motor speed is kept constant even with changing loads. In case the value of P-10 corresponds to a synchronous speed (e.g. 3000 rpm for a 2 pole motor at 50 Hz), the speed is set and displayed in rpm, but the slip compensation is not activated. With slip compensation Without slip compensation The slip is the difference between a synchronous speed because of a rotating field and the actual speed of the motor. The name plate in the example on page 5 shows a rated speed of 1410 rpm. It is a 4 pole motor with a synchronous speed of 1500 rpm. Between no load and rated load there is a slip of 90 rpm. Running the motor with a Variable Speed Starter, one wants to prevent the speed vari- ance by compensating the slip. With slip compensation: at load increase j voltage and frequency are increased accordingly k. The speed n1 remains constant. At load decrease voltage and frequency are reduced. Without slip compensation: with load j the speed drops from n1 to n2 k, when unloading the speed increases again. PNU Parameter Name Range Default 217.0 P-10 Motor Nom Speed 0 / 200 … 18000 rpm 0 rpm 2017-11-09 AP040017EN DE1 Motor Data – Motor Protection – V/f Curves – Slip Compensation Page 8 Motor protection The Variable Speed Starters of the series DE1 own an internal motor protection function, which trips the drive after a certain time in case of overload. The display shows the fault message “I.t-trP“. The overload is related to the rated current of the motor, set with P-08. In case the output current of the device exceeds the value set with P-08 „Motor Nom Current“, this status is displayed on the keypad. 7-Segment LED display: dots a…f are flashing

OLED display: text „O-L“ is displayed It has to be considered that, similar to a thermal overload relay, the current is used to estimate the temperature inside the motor. This kind of “indirect temperature measurement” is sufficient in many cases, but doesn’t reflect the real temperature conditions inside the motor. In case of Variable speed it has to be taken into account, that the cooling of the motor is done by an impeller, which is mount- ed on the motor’s shaft. Therefore the cooling is reduced at lower speeds. Experience shows that this is not critical between approx. 40 % and 100 % speed, but below 40 % it can lead to problems, if the application requires full torque also in this range (= full amount of losses). In pump and fan applica- tions where the torque is square with the speed, this effect is uncritical. In case of steady operation with nearly rated load below 40 % rated speed it is recommended to use motors with temperature sensors (thermistors or thermo contacts), which provide information about the real motor temperature. Thermistors as well as temperature contacts can be directly connected to DE1 devices. Example thermistor Example temperature contact Parameter P-15 has to be set in a way, that the function „External Fault“ (EXTFLT) is assigned to ter- minal 3 (DI3). During proper operation, a High-Signal is applied to terminal 3. In case of fault the temperature contact must open respectively the resistance of the thermistor has to increase. DE1 trips at a resistance of > 3.6 kΩ, Reset can be performed at values 100 % of the current set in P-08 for a certain time. · Check if the value of P-08 is equal to the motor rated current · Check motor connection (star / delta) · Flashing dots on the display indicate an operation with overload (> P- 08). Increase ramp time or decrease load in this case. · Check the load mechanically to ensure it is free and no jams, blockages or other mechanical faults exist. „Fault Code“ 5 x flash 2 s OFF O-t Heatsink overtemperature. The drive is too hot. · Check the ambient temperature around the drive is within the speci- fied range (maximum 50 °C / 60 °C, partly with derating) · Ensure sufficient cooling air is free to circulate around the drive (dis- tance to other devices above and below the variable speed starter). · Improve cooling of the control cabinet, when necessary. · The cooling slots may not be closed e.g. by pollution or by devices which are mounted too close „Fault Code“ 6 x flash 2 s OFF Internal fault in power section " Please refer to your next Eaton sales office. „Fault Code“ 7 x flash 2 s OFF SC-trp Loss of the serial communication · Check, if the connection to drives and other devices in the network is correct · Each participant in the network must have its own unique address. Two devices with the same address are not allowed. „Fault Code“ 8 x flash 2 s OFF P-dEf Default parameters have been loaded „Fault Code“ 9 x flash 2 s OFF Distorsion of the d.c. voltage „Fault Code“ 10 x flash 2 s OFF 4-20 F Analog input current out of range · Check settings of P-16 for AI1 · In case of 4-20mA: Check reference signal on wire break 2017-11-13 AP040029EN DE1 Starting, Stopping and Operation Page 19 Message Possible causes and remedy „Fault Code“ 11 x flash 2 s OFF U-t Undertemperature. This message is displayed, when the ambient temperature is below – 10 °C. To start the drive, the temperature must be above this value. „Fault Code“ 12 x flash 2 s OFF Th-flt Thermistor on the heatsink is faulty. Please refer to your next Eaton sales of- fice. „Fault Code“ 13 x flash 2 s OFF dAtA-F Fault in the internal memory. Parameters are not saved and default settings are reloaded. Try to save the (again modified) parameters again. If the message still appears: Please refer to your next Eaton sales office. 2017-11-13 AP040029EN DE1 Starting, Stopping and Operation Page 20 5 Stopping There are multiple possibilities to stop a variable speed drive: Possible with DE1? Accessories required Switch off, drive coasts to standstill YES None Ramp down to standstill YES None Ramp down to standstill with overvoltage control YES None Dynamic braking with brake resistor No - DC braking YES None Feedback energy to the mains NO - Mechanical brake (Variant DE11 only) YES None. Control with DE11 5.1 Ramping down or coasting? Parameter P-05 „Stop Mode“ determines, if the motor coasts or if it ramps down when the enable signal (FWD, REV, STOP) is removed. 5.1.1 Stop Mode (P-05) Coast to stop (P-05 = 0): When the enable signal is removed, the output of the inverter is disabled and the motor coasts to stop. Ramp to stop (P-05 = 1): When the enable signal is removed, the motor ramps to standstill with the ramp set with P-04. ATTENTION: In a drive system the energy always flows from the subsystem with the higher frequency to the one with lower frequency. If the output frequency of the variable speed starter is reduced too fast (deceleration ramp too short) and the motor still turns at a higher speed than the one corre- sponding to the output frequency of the inverter because of its inertia, the motor becomes a genera- tor and feeds back energy into the d.c. link. This leads to an increase of the d.c. link voltage and pos- sibly to a trip with the message O.Volt (Overvoltage). To prevent this, variable speed starters have the function “Overvoltage control”, which is enabled by default. More details see chapter 4.2.1. PNU Parameter Name Range Default 620.1 P-05 Stop Mode 0: coast to stop 1: ramp to stop 0 2017-11-13 AP040029EN DE1 Starting, Stopping and Operation Page 21 5.2 DC braking to standstill A DC current is injected into the motor, which generates a braking torque. The rotating energy of the machine is converted into heat, dissipated by the motor. This means that a DC braking must not be performed quite often, not to overload the motor. A DC braking cannot be used for a speed reduction e.g. from 1000 rpm to 800 rpm, but to a braking to standstill only. The DC braking is also used to stop rotating motors (e.g. fans, which turn because of the chimney effect inside a wind tunnel) before they start. This is to prevent overcurrent trips. See chapter 3.3 “Starting a rotating motor”. 5.2.1 DCBrake (P-25), t-DCBrake@Stop (P-26), DCBrake Voltage (P-27), f- DCBrake@Stop (P-28) Parameter P-25 „DCBrake“ determines, in which situations a DC braking is performed. In case a DC braking is required at stop, P-25 has to be set to 1 or 3. The behavior at removal of the signals FWD / REV / START depends on the stop mode (P-05). P-05 = 0 (coast to stop): The DC braking starts, once the signal FWD / REV / START is removed. P-05 = 1 (ramp to stop) At removal of FWD / REV / START the motor decelerates with the ramp set with “t-dec” (P-04). Once the frequency set with “f-DCBrake@Stop” (P-28) is reached, the DC braking starts. The strength and the duration depend on the settings of P-26 “t-DCBrake@Stop” and P-27 “DCBrake Voltage” (in percent of the motor rated voltage P-07). With P-25 = 3 it has to be noted, that the brak- ing time before a start is the same as after a stop. During a DC braking the LED „Fault code“ on the front of the variable speed starter lights yellow. 2017-11-13 AP040029EN DE1 Starting, Stopping and Operation Page 22 PNU Parameter Name Range Default 2221.0 P-25 DCBrake 0: OFF 1: ON at Stop 2: ON before Start 3: ON before Start and at Stop 0 2222.1 P-26 t-DCBrake@Stop 0.0…10 s 0.0 s 2220.0 P-27 DCBrake Voltage 0.0…100 % 0.0 % 2223.0 P-28 f-DCBrake@Stop 0 … P-01 (f-max) 0.0 Hz 2017-11-13 AP040029EN DE1 Starting, Stopping and Operation Page 23 5.3 Control of a mechanical brake HINT: The information is exclusively valid for the variant DE11! When a mechanical brake is used it should be activated at a certain speed. The relay contact be- tween the terminals 13 and 14 have the possibility to generate a speed dependent signal. The threshold is adjustable. It can be configured, if the relay contact closes above or below the threshold. Die Funktion des Ausgangs ist entsprechend zu konfigurieren. Kind of signal Terminals Function Threshold Normally open contact 13 / 14 P-51 „RO1 Function“ P-52 „RO1 Upper Limit“ 5.3.1 RO1 Funktion (P-51), RO1 obere Grenze (P-52) PNU Parameter Name Wertebereich Werk 451.0 P-51 RO1 Function 0: Drive running 1: Drive healthy 2: Motor at target speed 3: Drive tripped 4: Speed > RO1 Upper Limit (P-19) 5: Motor current > RO1 Upper Limit (P-19) 6: Speed < RO1 Upper Limit (P-19) 7: Motor current 0: all speed related parameters (P-01, P-02, P-20 … P-23) are set and displayed in rpm. PNU Parameter Name Range Default 217.0 P-10 Motor Nom Speed 0 / 200 … 30000 rpm 0 rpm 2017-11-10 AP040042EN DE1 Set Point Setting Page 6 1.2 Upper and lower speed limit The speed range of the connected motor is determined by the parameters “f-min” (P-02) and “f- max” (P-01). The reference is linear between these two values. Please note, that the value of P-01 cannot be exceeded, respectively the value of P-02 cannot be undercut. This is true for both senses of rotation. Frequency respectively speed = P-02 + (set pointactual / set pointmax) · (P-01 – P-02) Example 1: P-10 = 0 (setting / display in Hz) P-01 = 50 Hz P-02 = 0.0 Hz Set point via analog input: 0 … 10 V Set point actually set: 5 V Frequency = 0 Hz + (5 V / 10 V) · (50 Hz – 0 Hz) = 0 Hz + 0.5 · 50 Hz = 25 Hz Example 2: P-10 = 1470 rpm (setting / display in rpm) P-01 = 1470 rpm P-02 = 300 rpm Set point via analog input: 0 … 10 V Set point actually set: 5 V Speed = 300 rpm + (5 V / 10 V) · (1470 rpm – 300 rpm) = 300 rpm + 0.5 · 1170 rpm = 885 rpm PNU Parameter Name Range Default 20.1 P-01 f-max P-02 … 5 · P-09 (300 Hz max) 50.0 Hz 20.0 P-02 f-min 0.0 Hz … P-01 0.0 Hz Note: · With values of P-10 > 0 the setting is done in rpm instead of Hz. · The value, which can be set with P-01 „f-max“, is limited to five times „Motor Nom Frequen- cy“ (P-09) with a maximum of 300 Hz. 1.3 Behavior during change over between reference sources During a change over between two reference sources, e.g. from an analog signal to a fixed frequency, the new reference is approached with the actual ramp. The ramp times are determined by “t-acc” (P- 03) for acceleration and “t-dec” (P-04) for deceleration. 2017-11-10 AP040042EN DE1 Set Point Setting Page 7 1.4 Skip frequencies to avoid resonances In some applications an operation of the motor in a certain frequency band leads to mechanical res- onances, which can end up in a destruction of machine parts. The devices of the series PowerXLTM DE1… have the possibility to skip this frequency band for steady operation to avoid this effect. Fading out frequencies is possible with all kind of reference sig- nals, not depending on where they come from, e.g. analog input, fixed frequency, digital reference … , whatever is selected. The band width is determined by P-42 “f-SkipBand1”, while the center point is defined by P-43 “f-Skip1”. The diagram on the left hand side shows the behavior. Setting P-26 to zero, deactivates the function. REF = Reference Example: A motor runs up to 50 Hz. In the range between 15 Hz and 25 Hz mechanical resonances can occur. Therefore the motor may not run inside this range steadily. Band width: P-42 = 25 Hz – 15 Hz = 10 Hz Center point: P-43 = 15 Hz + 25 Hz 2 = 20 Hz How it works: The reference is below the disabled range. " Drive runs with the set frequency. " Increase of refer- ence into the disabled range " Motor accelerates and remains at the lower limit (in this example: 15 Hz). " Increase of reference above the disabled range " Motor accelerates with the ramp, set with P-03 “t-acc” to the new speed. " Motor operates above the disabled range according to the refer- ence. " Reduction of reference into the disabled area " Motor decelerates and remains at the up- per limit (in this example: 25 Hz). " Reduction of reference below the disabled area " Motor decel- erates with the ramp, set with P-04 “t-dec” to the new speed. PNU Parameter Name Range Default 22.0 P-42 f-SkipBand1 0…P-01 0 Hz1) 21.0 P-43 f-Skip1 0…P-01 0Hz1) 1) The default setting of P-10 “Motor Nom Speed” = 0. In this case the values for P-42 and P-43 are given in Hz. When P-10 is different from „0“, P-42 and P-43 have to be set in min-1. 2017-11-10 AP040042EN DE1 Set Point Setting Page 8 2 Analog reference Variable speed starters of the series DE1 have one analog input: · Analog input AI1 terminal 4 The configuration of the inputs and outputs is described inside the Application Note „I/O Configura- tion“ (AP040036EN). Beside the setting of the signal format (voltage or current), a scaling factor can be used to adopt the speed to the input signal. 2.1 Selecting the sense of rotation The analog value at terminal 4 determines the amount of speed. The control commands FWD and REV select clockwise or counter clockwise sense of rotation. If a change of sense is required, the actual command (e.g. FWD) has to be removed first, before applying the other one (e.g. REV). Applying FWD and REV simultaneously leads to a coasting of the motor. 2.2 Format of the analog value The speed reference signal can be a voltage signal as well as a current one. It is invertible with Pa- rameter P-18 in a way that a minimum signal leads to the maximum speed and vice versa. Format P-18 counter clockwise rotation clockwise rotation f-min f-max f-min f-max 0 … 10 V (U 0-10) 0 0 V + REV 10 V + REV 0 V + FWD 1 10 V + REV 0 V + REV 10 V + FWD 0 V + FWD 0 … 20 mA (A 0-20) 0 0 mA + REV 20 mA + REV 0 mA + FWD 20 mA + FWD 1 20 mA + REV 0 mA + REV 20 mA + FWD 0 mA + FWD 4 … 20 mA (t 4-20) 0 4 mA + REV 20 mA + REV 4 mA + FWD 20 mA + FWD 1 20 mA + REV 4 mA + REV 20 mA + FWD 4 mA + FWD 4 … 20 mA (r 4-20) 0 4 mA + REV 20 mA + REV 4 mA + FWD 20 mA + FWD 1 20 mA + REV 4 mA + REV 20 mA + FWD 4 mA + FWD Note: In case a terminal configuration without the commands FWD and REV is selected with P-15, the sense of rotation is set with the commands START and DIR. · Clockwise rotation " START · Counter clockwise rotation " START + DIR 2017-11-10 AP040042EN DE1 Set Point Setting Page 9 3 Fixed frequencies Fixed frequencies are references, which are set once, e.g. during commissioning and which can be selected by a digital command when required. The devices of the series DE1 have up to 4 fixed fre- quencies f-Fix1 … f-Fix4, which can be selected independently. 3.1 Setting the frequency value The setting of the fixed frequencies is done with P-20 up to P-23. Each value can be between zero and the maximum frequency „f-max“ (P-01). It has to be noted, that the minimum frequency “f-min” (P-02) will not be undercut, even when the fixed frequency is set to a lower value than P-02. Example: P-02 (f-min) = 10 Hz P-20 (f-Fix1) = 5 Hz When f-Fix1 is selected, the drive runs with 10 Hz! PNU Parameter Name Range Default 5.1 P-20 f-Fix1 0 … f-max (P-01) 20.0 Hz 5.2 P-21 f-Fix2 0 … f-max (P-01) 30.0 Hz 5.3 P-22 f-Fix3 0 … f-max (P-01) 40.0 Hz 5.4 P-23 f-Fix4 0 … f-max (P-01) 50.0 Hz 3.2 Selecting the sense of rotation When using a fixed frequency the sense of rotation is determined by the commands FWD (clockwise) and REV (counter clockwise) respectively DIR. 3.3 Selecting the fixed frequency The fixed frequencies can be activated via commands at the control terminals or via a field bus. The selection is binary coded " for 4 fixed frequencies 2 Bits (FF20 and FF21) are required. The predefined terminal configurations selected with P-15 enable access to the fixed frequencies. 3.3.1 Selection with predefined terminal configurations (P-15) 2017-11-10 AP040042EN DE1 Set Point Setting Page 10 Inside the Application Note „I/O Configuration“ (AP040036EN) the configuration of the control ter- minals is described. The following commands are important for the selection of fixed frequencies: Abbreviation Function FF1 Selection between the analog speed reference at analog input AI1 (ter- minal 6) and the fixed frequency 1 (f-Fix1), set with P-20. Low = analog reference, High = f-Fix1. FF20 / FF21 Selection of the digital frequencies f-Fix1 … f-Fix4 with digital commands FF20 FF21 f-Fix1 (P-20) L L f-Fix2 (P-21) H L f-Fix3 (P-22) L H f-Fix4 (P-23) H H 3.3.2 Use of fixed frequencies in device functions In certain situations, fixed frequencies are selected by a device function. Please take care, that there is no collision because of user specific settings. Fixed frequency Function f-Fix1 When P-16 = 4 (analog inputs with a signal 4 … 20 mA) the drive ramps to f-Fix1, in case of wire break in the reference circuit. 2017-11-10 AP040042EN DE1 Set Point Setting Page 11 4 Digital reference The speed reference of the variable speed starters DE1 can also be given via digital commands. The command UP (faster) increases the content of the reference counter, while DOWN (slower) reduces it. The use of a digital reference has the advantage, that the reference can be set from different loca- tions by paralleling push buttons, which is required in cases of large machines. The setting occurs between the minimum speed / frequency (f-min, P-02) and the maximum fre- quency / speed (f-max, P-01) with the actual ramp. The setting can be done with the keypad as well as via terminals. Example: · When an enabled drive gets the “UP” command, the motor accelerates according to the ac- tual ramp according to “t-acc” (P-03) · When the „UP“ command is removed, the speed remains constant. Applying “UP” again leads to a further acceleration. The maximum frequency / speed is defined with “f-max” (P- 01). · Consequently, applying „DOWN“ leads to a speed reduction. · When starting, the drive ramps to the speed determined by P-24 without an “UP” command. 2017-11-10 AP040042EN DE1 Set Point Setting Page 12 4.1 Configuration 4.1.1 Terminals / Keypad With the settings P-15 = 4, 5 or 6 UP and DOWN commands via terminals are possible. In case a key- pad DEX-KEY-LED is used, the reference value can be modified by using the arrow keys in addition. With P-12 = 1 or 2 the variable speed starter can be started and stopped with the keys on the key- pad. The behavior depends on the setting of P-24 “Digital Reference Reset Mode” (see 4.1.2) 4.1.2 Reference at start and at changeover between speed sources When starting a drive with a digital reference and when changing over from another speed source, e.g. a fixed frequency, to a digital reference the reference value to be ramped to is determined by the setting of P-24 “Digital Reference Reset Mode”: · P-24 = 0 or 2 o Minimum speed o Example 1: Behavior at start § Drive runs with digital reference " switch OFF " restart " drive ramps to the minimum speed, set with P-02 „f-min“. 2017-11-10 AP040042EN DE1 Set Point Setting Page 13 o Example 2: Behavior at changeover between speed sources § Drive runs with digital reference " Changeover to another speed source by applying a signal to the terminal " drive ramps to the speed required by the other speed source " Select “Digital reference” by removing the signal from the terminal " drive remains at the speed of the other speed source. The speed can now be changed with the keys on the keypad or with the signals UP and DOWN at the control terminals. · P-24 = 1 or 3 o Start with the latest speed before switching OFF or changing over to another speed source, set with the keypad or with the commands UP and DOWN at the terminals. This also applies to cases where another speed source was active at the time of switching OFF, but which is not selected at restart. o Example 1: The digital reference was set with the keypad to 1000 rpm. The speed source was changed from “Digital reference” to „Fixed Frequency 1“ by means of a command at the control terminals. The drive is switched OFF when “Fixed Frequen- cy1” is active. § Select „Digital reference“ at the terminals " drive ramps to the 1000 rpm set with the keypad § „Fixed Frequency 1“ was selected at the terminal when restarting " Drive ramps to Fixed Frequency 1 § Changeover to “Digital reference” with the signal at the terminals " drive ramps to 1000 rpm o Example 2: Switching OFF when the drive runs with another speed source than the digital reference § Selection of the other speed source is still active at restart " drive ramps to the speed of the other speed source. § Selection of the other speed source is not active at restart " drive ramps to the latest digital reference. P-24 „Digital Reference Reset Mode“ also determines, how the drive can be started when P-12 = 1 or 2: · P-24 = 0…1 o Starting of the drive by pushing the green START button on the keypad. § To start, an additional signal at the terminals is necessary (START / FWD / REV) · P-24 = 2…3 o The start of the drive is carried out via the terminals (see also 4.1.1). A start with the button on the keypad is not possible. o Note: With P-12 = 2 it is still possible to reverse the drive by pushing the green but- ton on the keypad. 2017-11-10 AP040042EN DE1 Set Point Setting Page 14 PNU Parameter Name Range Default 620.3 P-24 Digital Reference Reset Mode 0 / 1: START via keypad 0: Minimum speed (P-02) 1: Previous speed from Keypad / terminals (UP/DOWN) 2 / 3: START via terminals 2: Minimum speed (P-02) 3: Previous speed from Keypad / terminals (UP/DOWN) 1 4.2 Bedienung 4.2.1 Starting / Stopping Drives, which operate with a digital reference, can be started via terminals as well as via keypad. The possibilities depend on the setting of the parameters P-12 “Local ProcessData Source”, P-15 “DI Con- fig Select” and P-24 “Digital Reference Reset Mode”. Note: It can also be selected, that a signal from the terminal as well as one from the keypad must be ap- plied to start the drive. In this case the signal at the terminal must be present before the button on the keypad is pushed. P-12 P-24 P-15 Starting via terminal only Starting via keypad only Starting via terminal AND keypad P-12 = 0 P-24 = 0…3 P-15 = 4 / 5 / 6 YES NO NO P-12 = 1 / 2 P-24 = 0 / 1 P-15 = 0 … 9 NO NO YES P-24 = 2 / 3 P-15 = 0 … 9 YES* NO NO *In this case the keypad cannot be used to start the drive, but with P1-12 = 2 the green button can still be used to reverse it (see 4.2.3) 4.2.2 Increase / reduce speed When using a digital reference the speed is changed via the commands UP and DOWN. For the dura- tion of the commands the speed is increased respectively reduced. The commands are given via the keypad or via terminals. The behavior of the drive is depending on keypad or terminal adjustment. While a command via ter- minals modifies the speed with the actual ramp directly, an adjustment with the keypad has a slope and works more smoothly. This results in a delay of about 1.5 s for every actuation. With the setting of P-12 = 1 or 2 a speed adjustment via keypad is always possible, an adjustment via terminals only with the settings P-12 = 1 or 2 AND P-15 = 4 / 5 / 6. 2017-11-10 AP040042EN DE1 Set Point Setting Page 15 Note: · Simultaneous use of UP and DOWN (both via terminals or both via keypad) reduces the speed. · The terminal command dominates the one from the keypad. This also means: DOWN via keypad and UP via terminal " the speed increases. · A speed adjustment via keypad is also possible in cases where starting and stopping via key- pad is disabled. 4.2.3 Change sense of rotation The sense of rotation at start with a digital reference is basically determined by the terminal com- mands. With P12 = 2 one has the possibility to reverse the motor by pressing the green Start button on the keypad. Behavior at start: see column “Sense of rotation at START” in the table below. P-12 P-24 P-15 Sense of rotation via terminal Sense of rotation via keypad Sense of rotation at START P-12 = 0 P-24 = 0 … 3 P-15 = 4 / 5 NO NO No change of sense of rotation possible P-15 = 6 YES Sense of rotation as selected via terminals P-12 = 1 P-24 = 0 … 3 P-15 = 3 / 4 / 5 / 7 NO NO No change of sense of rotation possible P-15 = 8 / 9 YES (DIR) Sense of rotation as selected via terminals P-24 = 2 / 3 P-15 = 0 / 1 / 2 / 6 YES (FWD / REV) P-12 = 2 P-24 = 0 … 3 P-15 = 3 / 4 / 5 / 7 NO YES (INV) Sense of rotation as selected via termi- nals, taking into ac- count a possible in- version at the time of stopping the drive (Start button on the keypad). P-15 = 8 / 9 YES (DIR) P-24 = 2 / 3 P-15 = 0 / 1 / 2 / 6 YES (FWD / REV) Note: · P-15 = 0 / 1 / 2 / 6: o Applying the FWD and REV commands simultaneously leads to a coasting of the motor o In applications with reversion, the Stop Mode should be set in a way, that the ramp is active (P1-5 = 1). If this is not the case a changeover between the com- mands FWD and REV is detected as stop command and the drive behaves ac- cording the setting with P-05. After this, it restarts into the opposite direction. Starting a motor, which is still turning can lead to an overcurrent trip. · P-12 = 2 o A possible inversion with the Start button on the keypad is stored at stop. The drive restarts with the same sense of rotation he had before stopping. Please note, that in this case the sense of rotation at restart cannot be clearly defined by the terminal commands.. www.eaton.eu Application Note 11/2017 AP040036EN PowerXL™ DE1 Variable Speed Starter I/O Configuration Level 2 1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended 2017-11-13 AP040036EN DE1 I/O Configuration Page 2 Contents 1 General ....5 2 Hardware..6 2.1 Designation of the control terminals and technical data...6 2.2 Wiring examples ....6 2.2.1 Example 1: Application motor starter ....6 2.2.2 Example 2: Application with variable speed...7 2.2.3 Example 3: Control voltage from an external voltage source ....7 2.2.4 Example 4: external reference value ....8 2.2.5 Example 5: control by a PLC ....8 2.3 Relay output...9 3 Configuration .... 10 3.1 Inputs .... 10 3.1.1 Terminal configuration.. 10 3.1.2 Displaying input signals .... 15 3.1.3 Configuration of digital input DI3.. 16 3.1.4 Configuration of analog input AI1 .... 16 3.2 Relay output... 17 3.2.1 Selecting the function of RO1 (DE11 only) .... 18 2017-11-13 AP040036EN DE1 I/O Configuration Page 3 Danger! - Dangerous electrical voltage! • Disconnect the power supply of the device. • Ensure that devices cannot be accidentally restarted. • Verify isolation from the supply. • Cover or enclose any adjacent live components. • Follow the engineering instructions (AWA/IL) for the device concerned. • Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system. • Before installation and before touching the device ensure that you are free of electrostatic charge. • The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection. • Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions. • Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states. • Deviations of the mains voltage from the rated value must not exceed the toleranc e limits give n in the specification, otherwise this may cause malfunction and/or dangerous operation. • Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatch- ing of the emergency-stop devices must not cause a restart. • Devices that are designed for mounting in housings or control cabinets must only be oper ated and c on- trolled after they have been properly installed and with the housing closed. • Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, me - chanical interlocks etc.). • Variable speed starters may have hot surfaces during and immediately after operation. • Removal of the required covers, improper installation or incorrect operation of motor or var iable spe ed starter may destroy the device and may lead to serious injury or damage. • The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live variable speed starters. • The electrical installation must be carried out in accordance with the relevant electrical regulations (e . g. with regard to cable cross sections, fuses, PE). • Transport, installation, commissioning and maintenance work must be carried out only by qualified per - sonnel (IEC 60364, HD 384 and national occupational safety regulations). • Installations containing variable speed starters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the variable speed star te rs using the operating software are permitted. • All covers and doors must be kept closed during operation. • To reduce the hazards for people or equipment, the user must include in the machine design me asure s that restrict the consequences of a malfunction or failure of the variable speed starter (incre ased motor speed or sudden standstill of motor). These measures include: • Other independent devices for monitoring safety related variables (speed, travel, e nd positions etc.). • Electrical or non-electrical system-wide measures (electrical or mechanical interlocks). • Never touch live parts or cable connections of the variable speed starter after it has been disc on- nected from the power supply. Due to the charge in the capacitors, these parts may still be alive after disconnection. Consider appropriate warning signs. 2017-11-13 AP040036EN DE1 I/O Configuration Page 4 Disclaimer The information, recommendations, descriptions, and safety notations in this document are based on Eaton’s experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the pur- chaser. THERE ARE NO UNDERSTANDINGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IM- PLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTA- BILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF EATON. THE CON- TENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BE- TWEEN THE PARTIES. As far as applicable mandatory law alLows so, in no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, or otherwise for any special, indirect, incidental, or consequential damage or loss whatsoev- er, including but not limited to damage or loss of use of equipment, plant or power sy stem, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the infor- mation, recommendations, and descriptions contained herein. The information contained in this manual is subject to change without notice. 2017-11-13 AP040036EN DE1 I/O Configuration Page 5 1 General The variable speed starters of the series PowerXLTM DE1 are configured for many applications by default. In addition there is the possibility to adopt the devices to the application. Not only internal variables like ramp times or speed are changed, but also different functions can be assigned to the terminals. This possibility is universal inside the DE1 series and does not depend on the power rating. This Application Note describes • the existing input and output terminals • the technical data • the assignment of functions to terminals • the configuration of the I/Os Wiring diagram of a variable speed starter DE1 with default settings 2017-11-13 AP040036EN DE1 I/O Configuration Page 6 2 Hardware All signals at the input terminal have the same signal common (0 V). Terminal 4 can be used as digital input as well as analog input. The respective function depends on the configuration (see chapter 3ff). 2.1 Designation of the control terminals and technical data Designation Function Default 0 V Signal common for all inputs (terminals. 1 … 4) - + 10 V Control voltage and reference voltage 20 mA max. Signal common: 0 V - 1 (DI1) Digital input 1 HIGH: 9 … 30 V 10 V: 1,15 mA / 24 V: 3 mA FWD 2 (DI2) Digital input 2 HIGH: 9 … 30 V 10 V: 1,15 mA / 24 V: 3 mA REV 3 (DI3) Digital input 3 HIGH: 9 … 30 V 10 V: 0,12 mA / 24 V: 0,3 mA FF1 4 (AI1 / DI4) Analog input 1 or digital input 4 analog: 0 … 10 V; 0,12 mA 0/4 … 20 mA, RB = 500 Ω digital: HIGH: 9 … 30 V 10 V: 0,12 mA / 24 V: 0,3 mA REF (analog, 0 … 10 V) 13 Relay RO1 (NO) 250 V, 6 A AC / 30 V, 5 A DC RUN, device enabled14 2.2 Wiring examples The control terminals of the devices DE1 are fixed. On the variant DE11, the terminal block for the control signals is pluggable. To apply control signals to the terminals, the internal 10 V as well as ex- ternal voltages, e.g. 24 V from a PLC, can be used. 2.2.1 Example 1: Application motor starter 2017-11-13 AP040036EN DE1 I/O Configuration Page 7 2.2.2 Example 2: Application with variable speed 2.2.3 Example 3: Control voltage from an external voltage source 2017-11-13 AP040036EN DE1 I/O Configuration Page 8 2.2.4 Example 4: external reference value 2.2.5 Example 5: control by a PLC 2017-11-13 AP040036EN DE1 I/O Configuration Page 9 2.3 Relay output Depending on the kind of load, we recommend the use of protection circuitry for the relay outputs. 2017-11-13 AP040036EN DE1 I/O Configuration Page 10 3 Configuration The table gives an overview, how to determine the function of the single I/Os. Designation Selection / setting of Function Format (signal range) Scaling (Gain) Inversion Hysteresis Offset 0 V fixed - - - - - +10 V fixed - - - - - 1 (DI1) P-12 / P-15 - - - - - 2 (DI2) - - - - - 3 (DI3) - - P-19 - - 4 (AI1 / DI4) P-16 P-17 P-18 - P-44 DE1: 13 fixed - - - - - DE1: 14 - DE11: 13 P-51 - - - P-52 / P-53 / P-54 - DE11: 14 3.1 Inputs The function of the inputs can be configured in different ways: • using the default settings. • configuration with the configuration module DXE-EXT-SET. The numbers at the selector switch correspond to the settings of P-15 in terminal mode (P-12 = 0) • via the optional keypad DX-KEY-LED • via the parameter software DrivesConnect The available terminal combinations depend on the selection of the “Local ProcessData Source” (P- 12). Default: P-15 = 0, P-12 = 0. 3.1.1 Terminal configuration PNU Parameter Name Range Default 423.0 P-15 DI Config Select 0 … 9 0 2017-11-13 AP040036EN DE1 I/O Configuration Page 11 2017-11-13 AP040036EN DE1 I/O Configuration Page 12 2017-11-13 AP040036EN DE1 I/O Configuration Page 13 2017-11-13 AP040036EN DE1 I/O Configuration Page 14 For the terminal functions the following abbreviations are used: Abbreviation Function DIR Used for the selection of the sense of rotation in connection with the START command. Low = cw (FWD) High = ccw (REV) ATTENTION: in case of a wire break the drive reverses in case REV is selected! Alternative: use configuration with FWD/REV. DOWN “Reduce speed” command, when a digital reference is selected. Used in combination with the command UP. In case UP and DOWN are ap- plied simultaneously. The motor reduces its speed for the duration of the simultaneous signals with the deceleration ramp set with “t-dec” (P-04). ENA Enable variable frequency drive. To start the drive an additional start signal (START, FWD, REV) is necessary. When removing ENA, the mo- tor coasts to stop. ENAINV In case ENAINV is used instead of ENA, the sense of rotation is invert- ed, compared to the one determined by a keypad or a fieldbus. Example: ENA + FWD = FWD, ENAINV + FWD = REV ENAREF Enable signal for the speed reference. This signal is necessary to oper- ate the variable speed starter in addition to START respectively FWD/REV. At disconnection of ENAREF the variable speed starter ramps to stand still, but the variable speed starter will not be disa- bled. EXTFLT External fault. Enables the inclusion of an external signal into the fault messages of the variable speed starter. P-19 = 0: During operation a High signal must be applied to the termi- nal. A Low signal leads to a trip with the message “E-trip”. P-19 = 1: During operation a Low signal must be applied to the termi- nal. A High signal leads to a trip with the message “E-trip”. FF1 Selection between the analog speed reference at analog input AI1 (terminal 4) and the fixed frequency 1 (f-Fix1), set with P-20. Low = analog reference, High = f-Fix1 FF20 / FF21 Selection of the fixed frequency with digital commands. The fixed frequencies f-Fix1 … f-Fix4 are defined with P-20 … P-23. FF20 FF21 f-Fix1 (P-20) L L f-Fix2 (P-21) H L f-Fix3 (P-22) L H f-Fix4 (P-23) H H FWD START with a clockwise rotating field (FWD = Forward). When applying a High signal to the respective terminal, the motor accelerates with the predefined ramp. Removing the signal leads to a stop. The stop behavior depends on the setting of P-05 “Stop Mode”. At standstill the variable speed starter is disabled. In applications with two direc- tions, counter clockwise rotation is selected with REV. FWD and REV are logically connected (XOR). Applying both signals at the same time leads to a trip of the variable speed starter. 2017-11-13 AP040036EN DE1 I/O Configuration Page 15 Abbreviation Function REF Analog input AI1 (terminal 4) is used as speed reference input. P-16: Format (voltage input / current input …) P-17: Scaling P-18: Inversion REV START with a counter clockwise rotating field (REV = Reverse). When applying a High signal to the respective terminal, the motor acceler- ates with the predefined ramp. Removing the signal leads to a stop. The stop behavior depends on the setting of P-05 “Stop Mode”. At standstill the variable speed starter is disabled. In applications with two directions, clockwise rotation is selected with FWD. FWD and REV are logically connected (XOR). Applying both signals at the same time leads to a trip of the variable speed starter. START Starts and stops the motor. When applying a High signal to the re- spective terminal, the motor accelerates with the predefined ramp. Removing the signal leads to a stop. The stop behavior depends on the setting of P-05 “Stop Mode”. At standstill the variable speed start- er is disabled. In applications with two directions, the sense of rota- tion is selected with DIR or INV.In applications with Smartwire DT this signal is necessary in addition to the start command coming via bus. UP “Increase speed” command, when a digital reference is selected. Used in combination with the command DOWN. In case UP and DOWN are applied simultaneously. The motor reduces its speed for the duration of the simultaneous signals with the deceleration ramp set with “t- dec” (P-04). 3.1.2 Displaying input signals The status of the inputs can be displayed by selecting the respective parameters. PNU Parameter Name Range Default 560.0 P00-01 Analog input1 0.0 … 100 % input signal - 550.0 … 550.3 P00-04 DI1 Status 0 / 1 - The value, displayed with P00-01, takes also a potential scaling factor (P-17) into account. Example: P00-01 = Signal at AI1 [%] · P-17 The display on the keypad can be used to see the status of the digital inputs DI1 … DI4. It starts with DI1 on the left hand side of the display. 0 = Low signal, 1 = High signal at the respective input termi- nal. Voltages between 9 and 30 V are identified as High signal. If an input is configured as analog input, its status is displayed in P00-04 with 0 with voltage levels up to 9 V, above this with 1. 2017-11-13 AP040036EN DE1 I/O Configuration Page 16 3.1.3 Configuration of digital input DI3 Digital input 3 (Terminal 3) can be used to include an external signal into the fault messages. Parame- ter P-19 (DI3 Logic) determines, if a HIGH or a LOW signal is necessary at terminal 3 to indicate a proper status. PNU Parameter Name Range Default 650.2 P-19 DI3 Logic 0 " HIGH = OK, LOW = fault 1 " LOW = OK, HIGH = fault 0 DI3 can be configured in a way, that a thermistor can be used to protect the connected motor. In this case P-19 must be set to 0. Parameter P-15 has to be set in a way, that the function „External Fault“ (EXTFLT) is assigned to terminal 3 (DI3). During proper opera- tion, a High-Signal is applied to terminal 3. In case of fault the tem- perature contact must open respectively the resistance of the ther- mistor has to increase. DE1 trips at a resistance of > 3.6 kΩ, Reset can be performed at values “RO1 Upper Limit” , output will be logic 0 if value “RO1 Upper Limit” , output will be logic 1 if value RO1 Upper Limit (P-52) 5: Motor current > RO1 Upper Limit (P-52) 6: Speed < RO1 Upper Limit (P-52) 7: Motor current 3.6 kΩ, Reset can be performed at values “RO1 Upper Limit” , output will be logic 0 if value “RO1 Upper Limit” , output will be logic 1 if value RO1 Upper Limit (P-52) 5: Motor current > RO1 Upper Limit (P-52) 6: Speed < RO1 Upper Limit (P-52) 7: Motor current < RO1 Upper Limit (P-52) 8: DE1 not enabled 9: Speed not at speed reference value 0 452.0 P-52 RO1 Upper Limit 0.0 … 200.0 % 100.0 % 454.0 P-53 RO1 Hysteresis 0.0 … 100.0 % 0.0 % 457.0 P-54 RO1 Switch-On Delay 0.0 … 250.0 s 0.0 s Application Note 07/2022 AP040184EN PowerXL DG1 – Firmware Update Level 3 1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended 2 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com All proprietary names and product designations are brand names or trademarks registered to the relevant title holders. Services For service and support, please contact your local sales organisation. Contact details: Eaton.com/contacts Service page: Eaton.com/aftersales Original Application Note Original document is the German version of this document. Translation All non-German language versions of this document are translations of the original application note. 1. Edition 2022, publication date 07/2022 © 2021 by Eaton Industries GmbH, 53115 Bonn All rights reserved, also for the translation. No part of this document may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, micro-filming, recording or otherwise, without the prior written permission of Eaton Industries GmbH, Bonn. Subject to alteration. Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 3 DANGER! DANGEROUS ELECTRICAL VOLTAGE! • Disconnect the power supply of the device. • Ensure that devices cannot be accidentally restarted. • Verify isolation from the supply. • Ground and short-circuit. • Cover or enclose any adjacent live components. • Follow the engineering instructions (AWA/IL) for the device concerned. • Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system. • Before installation and before touching the device ensure that you are free of electrostatic charge. • The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection. • Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions. • Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states. • Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specification, otherwise this may cause malfunction and/or dangerous operation. • Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatching of the emergency-stop devices must not cause a restart. • Devices that are designed for mounting in housings or control cabinets must only be operated and controlled after they have been properly installed and with the housing closed. • Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, mechanical interlocks etc.). • The used device may have hot surfaces during and immediately after operation. • Removal of the required covers, improper installation or incorrect operation of motor or device may destroy the device and may lead to serious injury or damage. • The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live device. • The electrical installation must be carried out in accordance with the relevant electrical regulations (e. g. with regard to cable cross sections, fuses, PE). • Transport, installation, commissioning and maintenance work must be carried out only by qualified personnel (IEC 60364, HD 384 and national occupational safety regulations). • Installations containing device must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. 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Consider appropriate warning signs. 4 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com Disclaimer The information, recommendations, descriptions, and safety notations in this document are based on Eaton’s experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the purchaser. THERE ARE NO UNDERSTANDINGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF EATON. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BETWEEN THE PARTIES. 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Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 5 Content General .... 6 Connecting the Drive to a PC.. 6 Apply main voltage .... 6 Firmware Upgrade.. 7 Resetting to default settings .... 11 Firmware Upgrade for optional cards .... 12 6 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com General The device software of the DG1 can be updated to a newer version or downgraded to an old one. Both is done via the so-called firmware update tool. Connecting the Drive to a PC 1. Remove the front cover. 2. Connect the programming cable to terminals 25 and 26. Abbildung 1: Connecting the programming cable Apply main voltage Start the drive by applying the main voltage. Depending on frame size: 230V AC à single phase: L1(L)/L3(N) 400V AC à three phase: L1/L2/L3 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 7 Firmware Upgrade 1. First download the desired firmware package from the Eaton website and unzip the file. Abbildung 2: Firmware package 2. Open the Firmware Upgrade Tool. Abbildung 3: Firmware Upgrade Tool 3. Select the previously downloaded firmware package from your directory by clicking "Browse". Abbildung 4: Power Xpert inControl Software 4. Select the file “DG1_C0033“. Abbildung 5: DG1_C0033 5. Check the cable connection and the COM port in the Windows Device Manager. 8 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com Abbildung 6: Device Manager 6. Enter "1" for "Slave Address" and select the COM port. Abbildung 7: Settings 7. Establish the connection via "Connect". Abbildung 8: Establish connection 8. After the firmware has been detected, a dialog for confirming the firmware package is displayed. The tool automatically sets check marks once the version differences have been detected. Abbildung 9: Update process 9. Choose „Block 0“ for german and „Block 1“ for english. Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 9 Abbildung 10: Update process 10. Confirm the selection with „Program“. Abbildung 11: Confirming 11. Verify that the update has been completed correctly. ("Programming Success - Verification OK"). If "Verification OK" appears, select "Disconnect". If "Failed" appears, repeat the update process or contact After Sales Service. 10 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com Abbildung 12: Update completed Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 11 Resetting to default settings Reset all parameter to the factory settings by proceeding as follows: Parameters à Basic Settings à System à Parameter Sets (P21.1.3) Then select “Reload defaults“. Abbildung 13: Parameter reset Now the firmware update is completed. You can disconnect the programming cable, remove the power connector and reattach the front cover. 12 Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com Firmware Upgrade for optional cards 1. Connect the optional module to one of the expansion slots. Abbildung 14: Installating expansions 2. Follow the steps 2.1 to 4.8. 3. Confirm the selection with „Program“. Abbildung 15: Confirming the selection 4. Check the update version of the board. If "Code is same" appears, no update needs to be performed here. Application Note Firmware Update DG1 07/2022 AP040184EN Eaton.com 13 Abbildung 16: Check the version 5. Click „Disconnect“ to disconnect the communication again. If the drive now remains in "Loader Mode", a connection should be established again via "Connect" and then disconnected again via "Disconnect". If the drive is still in "Booth Loader Mode" and the "Startup Wizard" does not appear, please contact After Sales Service. Eaton Industries GmbH Hein-Moeller-Str. 7- 11 D-53115 Bonn ® 2020 Eaton Corporation . Alle Rechte vorbehalten 07/2022 AP040184EN Eaton is dedicated to ensuring that reliable, efficient and safe power supply is available when it is needed most. With vast of energy management across different industries, experts at Eaton deliver customized, integrated solutions to solve our customer’ most critical challenges. Our focus is on delivering the right solution for the Application. But decision makers demand more than just Innovative products. They turn to Eaton for an unwavering Commitment to personal support that makes customer Success a top priority. For more information, visit Eaton.com Eaton addresses worldwide: Eaton.com/contacts www.eaton.eu Application Note 04/2017 AP040168EN PowerXL™ DG1 Variable Frequency Drives Load balancing in multi motor applications Level 1 1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 2 Contents 1 General .... 5 2 Load balancing via slip .... 6 3 Load balancing via drooping... 7 3.1 Application example .... 8 4 Adjustable load balancing via torque control .... 9 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 3 Danger! - Dangerous electrical voltage! · Disconnect the power supply of the device. · Ensure that devices cannot be accidentally restarted. · Verify isolation from the supply. · Cover or enclose any adjacent live components. · Follow the engineering instructions (AWA/IL) for the device concerned. · Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system. · Before installation and before touching the device ensure that you are free of electrostatic charge. · The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. 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Consider appropriate warning signs. 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 4 Disclaimer The information, recommendations, descriptions, and safety notations in this document are based on Eaton’s experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the purchaser. THERE ARE NO UNDERSTAND- INGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLI- GATION OF EATON. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BETWEEN THE PARTIES. 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Already small differences in the mechanical structure of the drives inside the system or manufacturing tolerances can lead to an unbalanced load sharing. Beside an oversizing other measures exist to balance the load to ensure a reliable operation of the applica- tion and to prevent overload situations for single motors. Like in many other cases, multiple solutions exist, differing in complexity and costs. There is a funda- mental interest to choose the variant with the best value for money. In the end the application de- termines, which kind of solution can be chosen. This application note describes three of the possible solutions in connection with variable frequency drives and provides an indication of the right solu- tion. The following chapters describe, how the different solutions work. The table below gives an overview about the substantial features and differences. Control via slip Droop function Torque control Control mode Speed control Speed control 1 motor with speed control, the other ones with torque control Number of variable frequency drives 1 variable frequency drive per motor; con- necting multiple mo- tors in parallel to the output of one device is possible. 1 variable frequency drive per motor 1 variable frequency drive per motor Load balancing via Slip Load dependent corrective value Torque control Accuracy of balancing + ++ +++ Motors (power, manufacturer) Equal motors necessary Different motors possible Different motors possible Mechanical coupling between the motors Preferably coupled via friction; fixed mechan- ical coupling possible in some applications. Preferably coupled via friction; fixed mechan- ical coupling possible in some applications. Fixed coupling and coupling via friction possible. In case of coupling via friction a speed limitation is recommended. 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 6 2 Load balancing via slip The speed of a three phase induction motor depends on the load. When it is supplied with the voltage and frequency ac- cording to its name plate, an unloaded motor turns with near- ly synchronous speed, while the speed at rated load corre- sponds to the rated speed. In case of a 50 Hz mains supply and a four pole motor this means, that the unloaded motor turns with approximately 1500 rpm and at rated load e.g. with 1470 rpm. The difference between synchronous speed and the speed of the motor axis is called slip. In the example on the left the motor is loaded with torque M1 and it turns with the speed n1. The load is increased up to M2 j ¨ The speed drops down to n2 k. This behavior is utilized in a slip dependent load balancing. This simplest kind of “automatic” load sharing presumes, that the mechanics as well as the motors of all parts of the system are identical. In theory all motors have to carry the same load per definition, but tolerances, temperature dependen- cy and small mechanical differences let the loads drift apart, even when the motors were equally loaded at the point of start. But how does load balancing work? The motor with the highest load drops in speed and in this case the other one(s) have to carry more load than before. The load is now more or less balanced. There is no possibility for load adjustment and the sharing is defined by the system. Therefore it makes sense to add some margin when calculating the motor powers. The variable frequency drive DG1 has to work in the motor control mode “Freq Control” (P8.1 = 0). In case each motor has its own variable frequency drive, they must have identical parameter settings. Parameter Name Range Default P8.1 Motor Control Mode Freq Control (0) Speed Control (1) Open Loop Speed Control (5) Open Loop Torque Control (6) Freq Control (0) It is also possible to connect multiple motors in parallel to one variable frequency drive. It has to be noted, that each motor must have its own motor protection, because the total current is “known” by the variable frequency drive, but not how it is shared between the single motors. 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 7 3 Load balancing via drooping In case speed controlled drive systems are mechanically connected through form fit or friction, the fastest drive takes the load and pulls the other ones, which are less, or in extreme cases, not loaded. To counteract this effect, the speed reference will be corrected, depending on the load. At load in- crease, the droop function reduces the resulting speed reference (set reference – speed reduction), the motor falls back a little bit in its speed and the other motors inside the system take more load automatically. Application experience shows, that it is of advantage in many cases to have one motor inside the system, where the droop function is disabled (P8.13 “Load Drooping” = 0.00 %), while it is enabled (P8.13 “Load Drooping” different from 0.0 %) for all other motors inside the system. The set value of P8.13 is the percentage of speed by which the speed drops in case the motor is loaded with rated torque. With reduced load, the speed reduction will be reduced accordingly. In exceptional cases it can also be advantageous to enable the droop function for all motors. The variable frequency drive DG1 has to work in the motor control mode “Open Loop Speed Control” (P8.1 = 5) to achieve the best result. Parameter Name Range Default P8.1 Motor Control Mode Freq Control (0) Speed Control (1) Open Loop Speed Control (5) Open Loop Torque Control (6) Freq Control (0) P8.13 Load Drooping 0.00 % … 100.00 % 0.00 % 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 8 3.1 Application example Material is transported through the machine by means of two conveyor belts. Each belt is driven by its own motor. Because of the contact pressure, the two belts are connected mechanically. In case one of the two mo- tors tries to run a little bit faster than the other one, it leads to an unequal load sharing. Without an enabled droop function, motor 1 takes 80 % of its rated load, motor 2 85 %. Because of the higher load, motor 2 becomes warmer than motor 1, possibly one can also see the difference in speed on the material which is transported between the belts. Now the droop function will be enabled with P8.13. The system will change to equal load sharing iteratively. Values at the beginning (we are looking to the system at an output frequency of 40 Hz, P1.9 = 50 Hz, P8.13 = 10.00 %): Resulting speed of motor 1: 40 Hz – ((10 % · 50 Hz) · 80 %) = 36 Hz Resulting speed of motor 2: 40 Hz – ((10 % · 50 Hz) · 85 %) = 35,75 Hz Motor 2 now runs slower than motor 1 " The load of motor 1 increases " Therefore the load of motor 2 is reduced ……. . This is a repetitive process until an equal sharing of the load is achieved. Remaining differences in load can be adjusted with 8.13. 2017-04-25 AP040168EN DG1 Load balancing in multi motor applications Page 9 4 Adjustable load balancing via torque control Inside this system, one motor is speed controlled and the other one(s) torque controlled. The speed controlled motor determines the speed of the system, while the torque is the control variable for the other motors. Here it is possible to use motors of different ratings and it is also possible to set indi- vidual shares of the load. A torque control is much more complex than the principles described in chapters 2 and 3. On the other hand you have much more possibilities to adopt the control to the application, which results in a higher accuracy. Nevertheless the other principles are useful in simple applications because of their simplicity and value for money. Torque control is extensively described inside the application Note „AP040167EN Torque Control“. Please refer to this document. One important aspect must be mentioned here: A torque controlled motor always tries to bring the required torque (or tension in case of linear movements) to the load. When this is not possible, the torque is used for acceleration to the maximum possible speed. This is not critical as long as the mo- tors are connected together mechanically, e.g. when all pinions work on the same geared ring. In cases where the speeds of the motors involved are not synchronized mechanically and a slip in speed is possible, it is strongly recommended to limit the speed of the torque controlled motor. The neces- sary aspects and settings are comprehensively described in the application note AP040167EN men- tioned above. www.eaton.eu Application Note 01/2018 AP040177EN DE PowerXL™ DG1 Variable Frequency Drives Motor data and V/f curves Level 2 1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 2 Contents 1 General .... 5 2 Motor data .... 5 2.1 Motor Nom Current .... 6 2.2 Motor Nom Speed .... 6 2.3 Motor PF .... 6 2.4 Motor Nom Voltage .... 6 2.5 Motor Nom Frequency .... 7 2.6 Motor Identification .... 7 3 Motor Control Mode .... 9 3.1 Frequency Control (V/f).. 9 3.2 Speed Control .... 9 3.3 Open Loop Speed Control .... 10 4 V/f curve .... 11 4.1 Optimizing the V/f curve at Frequency Control and Speed Control .... 12 4.1.1 Improving the torque behavior .... 13 4.1.2 Increasing energy efficiency .... 15 4.2 87 Hz curve .... 15 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 3 Danger! - Dangerous electrical voltage! · Disconnect the power supply of the device. · Ensure that devices cannot be accidentally restarted. · Verify isolation from the supply. · Cover or enclose any adjacent live components. · Follow the engineering instructions (AWA/IL) for the device concerned. · Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system. · Before installation and before touching the device ensure that you are free of electrostatic charge. · The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. 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Consider appropriate warning signs. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 4 Disclaimer The information, recommendations, descriptions, and safety notations in this document are based on Eaton’s experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the pur- chaser. THERE ARE NO UNDERSTANDINGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IM- PLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTA- BILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF EATON. THE CON- TENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BE- TWEEN THE PARTIES. As far as applicable mandatory law allows so, in no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, or otherwise for any special, indirect, incidental, or consequential damage or loss whatsoev- er, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the infor- mation, recommendations, and descriptions contained herein. The information contained in this manual is subject to change without notice. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 5 1 General Devices of the series PowerXL™ DG1 are variable frequency drives for the supply of three phase in- duction motors. By default they are configured, that motors of the respective power class can be supplied without changing the settings. Many standard cases can be covered. There are some applications, which require an adaptation by changing parameters. In this Applica- tion Note the following aspects are covered: · Selection of the motor control mode · Adaptation to the connected motor · Slip compensation · Setting the V/f curve 2 Motor data Condition for a proper operation is the right connection (star / delta) of the motor to the output ter- minals of the device. The rated voltage of the motor windings is decisive. Device Output Voltage Motor Connection DG1-32… 3 x 230 V 230 / 400 V Delta DG1-34… 3 x 400 V 230 / 400 V 400 / 660 V Star Delta DG1-34… 3 x 400 V 230 / 400 V Delta Special case: 87 Hz-curve (see section 4.2) An adaptation to the connected motor can be done with the following parameters: · P1.6 Motor Nom Speed · P1.7 Motor PF · P1.8 Motor Nom Voltage · P1.9 Motor Nom Frequency The respective values can be taken from the name plate of the motor or from the data sheet of the motor manufacturer. They are used for the setting of the motor protection and define the V/f curve. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 6 2.1 Motor Nom Current Parameter P1.5 „Motor Nom Current“ is set to the rated current Ie of the variable frequency drive by default. At the same time it is the set value for the thermal protection of the motor. In case the mo- tor has a nominal current different to the one of the VFD, P1.5 must be set accordingly to ensure motor protection. It must be pointed out, that this current value is set, which is assigned to the type of connection of the motor. In the example above it is 3,2 A at 230 V (Delta) respectively 1,9 A at 400 V (Star). Parameter Name Range Default P1.5 Motor Nom Current 0,1 · Ie … 2 · Ie Ie Ie = Rated current of the variable frequency drive All measures to protect the connected motor are described in the Application Note AP040176EN “Starting, stopping and operation”. 2.2 Motor Nom Speed The setting of P1.6 „Motor Nom Speed“ is necessary for three reasons: · to display the right speed value in all modes of operation · for calculation of the slip compensation in operation mode “Speed Control” (P8.1 = 1) · for calculations inside the motor model when operating in vector mode (P8.1 = 5 „Open Loop Speed Control“ Please use the name plate value for setting P1.6. Parameter Name Range Default P1.6 Motor Nom Speed 300 … 20000 rpm 1750 rpm 2.3 Motor PF In vector mode (P8.1 = 5 „Open Loop Speed Control“) the power factor (cos ϕ), which is specified on the motor’s name plate, must be set. Parameter Name Range Default P1.7 Motor PF 0.3 … 1 0.85 2.4 Motor Nom Voltage Motor rated voltage (name plate) taking the connection (star / delta) into account. In exceptional cases, a different setting of P1-07 is necessary. See section 4.2 “87 Hz curve” Parameter Name Range Default P1.8 Motor Nom Voltage 180 … 690 V Ue Ue = Rated voltage of the variable frequency drive, e.g. 230 V or 400 V depending on the device type 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 7 2.5 Motor Nom Frequency Rated frequency of the motor. By default this parameter is set to the mains frequency (50 Hz in Eu- rope, 60 Hz in USA) and doesn’t need to be changed in the majority of cases. In case, motors with rated frequencies different from the mains frequency (e.g. 200 Hz for fast rotat- ing motors) or if the 87 Hz curve is used (see section 4.2), P1.9 has to be set accordingly. When changing the value of P1.9 the setting of P8.5 “Field Weakening Point” is set to the same value. If the application requires different values for P1.9 and P8.5, Motor Nom Frequency must be set first, before adopting the value for the field weakening point Parameter Name Range Default P1.9 Motor Nom Frequency 0.00 … 400.00 Hz 50 Hz 2.6 Motor Identification The motor identification MUST be performed in vector mode (P8.1 = 5 or 6) to gain the required pa- rameter values for an optimal performance of the motor. ATTENTION: The motor data (e.g. the resistance) change with the temperature. Therefore the motor identification run shall be performed with a warm motor. The kind of motor identification run is determined by the setting of P8.14 „Identification“. The fol- lowing motor data are identified: · Motor Stator Resistance R1 (P8.50) · Motor Rotor Resistance R2 (P8.51) · Motor Leak Inductance X1 (P8.52) · Motor Mutual Inductance Xh (P8.53) · Motor Excitation Current (P8.54) P8.14 = 0: No Action No identification of the motor data will be performed. This is the setting during normal operation of the drive. P8.14 = 1: Identification Only Stator Resistor During the identification run only the stator resistance is identified. The other values remain un- changed. P8.14 = 2: Identification with Run The values for the parameters P8.50 ip to P8.54 are identified. The measurement is done with a run- ning motor. The motor must be unloaded (load decoupled, no gearbox …). P8.14 = 3: Identification No Run The values for the parameters P8.50 ip to P8.54 are identified. During the measurement the motor is standing still. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 8 How to perform a motor identification run: · Before starting a motor identification run, the motor data (parameters P1.5 up to P1.9) must be set. · Select the motor control mode P8.1 = “3: Open Loop Speed Control”. · Select in P8.14 „Identification“, which kind of identification shall be performed (P8.14 = 1…3). · Remove any connection between the drive and a PC during identification run. · Apply START command · The identification of the motor data takes place automatically and is active for about 30 s re- spectively until the START signal will be removed. · On the keypad „Motor Identification“ is shown. · The motor data are identified and assigned to the respective parameters. · In case an identification is not possible, the fault message “Motor ID Fault” (#57) is displayed. One reason could be that the rated power of the connected motor deviates too much from the one of the variable frequency drive. Alternatively the motor data can be set manually on the basis of technical information supplied by the motor manufacturer. · After a motor identification run, the START signal must be reapplied to start the motor. The motor doesn’t start automatically, even when the START signal is still applied to the respec- tive terminal. · Parameter P8.14 “Identification” is reset to “0: No action” automatically as soon as the iden- tification run is finished. Parameter Name Range Default P8.14 Identification 0: No Action 1: Identification Only Stator Resistor 2: Identification with Run 3: Identification No Run 0: No Action P8.50 Stator Resistor 0.001 … 65535 W 0.033 W P8.51 Rotor Resistor 0.001 … 65535 W 0.034 W P8.52 Leak Inductance 0.01 … 655.35 mH 0.12 mH P8.53 Mutual Inductance 0.1 … 6553.5 mH 3.4 mH P8.54 Excitation Current 0.1 … 7.4 A 0.1 A 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 9 3 Motor Control Mode Parameter P8.1 „Motor Control Mode“ determines the way, how the motor is controlled (e.g. fre- quency or vector control). The information given inside the Application Note refer to the settings P8.1 = 0, 1 or 5. By default the variable frequency drive is configured for Frequency Control (P8.1 = 0), which is mainly used in simple applications. With speed control (P8.1 = 1 or 5) an improved speed accuracy and a better torque performance can be achieved. In this case the motor data must be set and with Open Loop Speed Control (P8.1 = 5) a motor identification run (P8.14, see section 2.6) is necessary. Parameter Name Range Default P8.1 Motor Control Mode 0: Frequency Control 1: Speed Control 5: Open Loop Speed Control 6: Open Loop Torque Control 0 3.1 Frequency Control (V/f) P8.1 = 0 The output frequency of the variable frequency drive is proportional to the reference, which is for example applied to an analog input. The ratio between the output voltage and the frequency is kept constant. This leads to a speed change when the load is changing, like with a single speed motor connected DOL to the mains. This control mode is preferred, when multiple motors are connected in parallel at the output of one single variable frequency drive respectively in simple applications, where no special requirements concerning speed accuracy at variable load exist. 3.2 Speed Control P8.1 = 1 In principle the Speed Control works like the Frequency Control described in section 3.1. At Speed Control the slip compensation is activated in addition, which takes care, that the motor speed is kept approximately constant even in case of load changes. In this motor control mode the motor data must be set (P1.5 up to P1.9) The slip is the difference between a synchronous speed because of a rotating field and the actual speed of the motor. The name plate in section 2 shows a rated speed of 1410 rpm. It is a 4 pole mo- tor with a synchronous speed of 1500 rpm. Between no load and rated load there is a slip of 90 rpm. Running the motor with a variable frequency drive, one wants to prevent the speed variance by compensating the slip. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 10 with slip compensation without slip compensation With slip compensation: at load increase j voltage and frequency are increased accordingly k. The speed n1 remains constant. At load decrease voltage and frequency are reduced. Without slip compensation: with load j the speed drops from n1 to n2 k, when unloading the speed increases again. 3.3 Open Loop Speed Control P8.1 = 5 Open loop means, that a feedback of the motor speed to the variable frequency drive, e.g. by using an encoder, is not required. The speed information used in the control algorithm is the result of a calculation by the motor model. To ensure an optimal performance, the motor data (parameters P1.5 up to P1.9) must be set and a motor identification run must be performed (see section 2.6). Speed accuracy and torque performance are improved compared to the motor control mode “Speed Con- trol” described in section 3.2. Note: When multiple motors are connected in parallel to one single variable frequency drive, this motor control mode may not be used! 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 11 4 V/f curve The V/f curve determines the magnetization of the motor and therefore the torque behavior signifi- cantly. In addition the energy efficiency of the complete system can be impacted. As described in section 3, multiple motor control modes exist. Common to all of them is, that the field weakening point (FWP) and the maximum frequency must be defined. In case of open loop speed control (P8.1 = 5), the variable frequency drive calculates the necessary settings on the basis of this information and the determined motor data. In case of frequency control (P8.1 = 0) or speed control with slip compensation (P8.1 = 1) it is possible to modify the V/f curve to improve the torque behavior (see section 4.1). · P1.2 „Max Frequency“ maximum frequency for the application. This frequency may be above the „Motor Nom Fre- quency“ (P1.9). · P8.5 „Field Weakening Point“ This parameter defines the frequency, at which the maximum output voltage, defined with P8.6, is reached. · P8.6 „Voltage at FWP“ Maximum voltage of the variable frequency drive in percent of the Motor Nom Voltage (P1.8). This voltage is reached at the field weakening point (FWP) defined with P8.5. Note: At a change of parameter P1.9 „Motor Nom Frequency“ P8.5 is automatically set to the same frequency value. In applications, where the frequency at FWP is different to the Motor Nom Fre- quency, P1.9 must be set first, before setting P8.5. The same is true for the voltage. Here P1.8 “Mo- tor Nom Voltage” must be set before P8.6 “Voltage at FWP”. Parameter Name Range Default P1.2 Max Frequency P1.1 … 400 Hz 50.0 Hz P8.5 Field Weakening Point 8.0 Hz … P1.2 P1.9 P8.6 Voltage at FWP 10 … 200 % – P1.8 P1.8 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 12 4.1 Optimizing the V/f curve at Frequency Control and Speed Control The V/f curve shown in section 4 is idealized (P8.4 = 0 “Linear”) and sufficient for many applications. There are two cases, where the shape of the V/f curve should be adopted: · where a higher starting torque is required, respectively where the motor has to run at lower speed stationary · in pump and fan applications, where the motor losses shall be reduced by field weakening under part load conditions. The different shapes of the V/f curve can be selected with P8.4 “V/Hz Ratio”. · P8.4 = 0 „Linear“ Voltage and frequency change linearly from zero up to the field weakening point (FWP) · P8.4 = 1 „Squared“ Voltage and frequency change squared from zero up to the field weakening point (FWP). See also section 4.1.2. · P8.4 = 2 „Programmable“ The shape of the curve can be configured, see also section 4.1.1- · P8.4 = 3 „Linear + Flux Optimization“ The shape of the V/f curve is adopted to the load conditions automatically, see also section 4.1.2. Parameter Name Range Default P8.4 V/Hz Ratio 0: Linear 1: Squared 2: Programmable 3: Linear + Flux Optimization 0: Linear 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 13 4.1.1 Improving the torque behavior When operating with lower speeds, the voltage drop inside the motor becomes particularly noticea- ble, which leads to a reduced speed, unbalanced run and in extreme cases to a standstill of the motor with current flow at the same time. This effect can be reduced by increasing the output voltage in the lower speed range. P8.3 “V/Hz Optimization” determines, in which way this will be achieved: · P8.3 = 1 „Enabled“ The voltage is increased automatically. The value depends on the motor rating and the values are based on experience. Setting: o Set motor data in parameter group 1 (P1.5 up to P1.9) o P8.3 = 1: Enabled · P8.3 = 0 „Disabled“ The shape of the V/f curve can be configured manually. In this case P8.4 „V/Hz Ratio“ has to be set to „2: Programmable“. · P8.7 „V/Hz Mid Frequency“ · P8.8 „V/Hz Mid Voltage“ · P8.9 „Zero Frequency Voltage“ The V/f curve is divided into two sections. It starts at zero frequency with a voltage defined with P8.9 „Zero Frequency Voltage“, proceeding linearly to a point defined by P8.7 “V/Hz Mid Frequency” for the frequency and by P8.8 “V/Hz Mid Voltage” for the voltage, and from there to the field weakening point (FWP). With this measure it is possible to increase the voltage in the lower range above aver- age to compensate the voltage drop inside the motor and to improve the torque behavior. Beside other cases this measure is used, when a drive is operated in the lower speed range station- ary. It has to be noted, that the cooling of the motor is usually realized by a fan, which is mounted on the motor’s shaft and whose cooling effect is reduced correspondingly. When a certain torque is required in this range, it must be ensured, that the motor will not be overheated. Eventually a sepa- rately driven fan must be used. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 14 When setting the parameters, the motor must initially be operated unloaded with linear V/f curve. It is presumed, that the motor data (P1.5 up to P1.9) are set already and that the general settings for the V/f curve (see section 4) are completed. · P8.4 „V/Hz Ratio“ = 0: Linear · Run the motor with 2/3 of its rated speed. · Read the motor current on the keypad or in the configuration software inControl (M4). Be- cause of the unloaded motor the actual current corresponds approximately to the excitation current. · Remove START signal · Set P8.54 „Excitation Current“ to the value measured before. It is required for internal calcu- lations. · P8.4 „V/Hz Ratio“ = 2: Programmable · During the following settings P1.1 “Min Frequency” must be set to zero, even when the ap- plication requires higher values for the minimal frequency during normal operation. When the V/f settings are completed, P1.1 can be set back to the value, which is required by the application. · Frequency reference = 0, start variable frequency drive · Increase the value of P8.9 “Zero Frequency Voltage”, until the current is as high as measured before. · Stop drive · Set P8.7 and P8.8 to the required values. The setting is application dependent. Additional to the settings here it is possible to set the motor control mode (P8.1) to “1: Speed Control” and/or to enable the “V/Hz Optimization” with P8.3. In general good results can be achieved by using the following rule of thumb: o P8.8 = 1,4 – P8.9 o P8.7 = P8,5 – (P8.8 : P8.6) Parameter Name Range Default P8.3 V/Hz Optimization 0: Disabled 1: Enabled 0: Disabled P8.7 V/Hz Mid Frequency 0 Hz … P8.5 0 Hz P8.8 V/Hz Mid Voltage P8.9 … P8.6 P8.9 Zero Frequency Voltage 0 % … 40 % P8.6 0 % P8.54 Excitation current Depends on drive rating 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 15 4.1.2 Increasing energy efficiency Objective is to reduce the losses inside the motor to increase the overall system efficiency. Because of the voltage reduction the field of the motor is weakened, which leads to a reduction of the reac- tive current, while the active one is increasing at the same time, but not as much as the reactive cur- rent decreases. This leads to a decrease of the overall motor current. This principle is only applicable, when the application doesn’t require full torque in the complete speed range. The device series DG1 has two possibilities to achieve this: · P8.4 „V/Hz Ratio“ = 1: Squared with this setting the voltage increases squared with the frequency, until it reaches it maxi- mum at the FWP, see also drawing in section 4.1.1 · P8.4 „V/Hz Ratio“ = 3: Linear + Flux Optimization In principle the V/Hz curve is linear. When the drive operates under part load conditions for a certain time (approximately 1 minute), the voltage is automatically decreased by some Volts. The procedure is repeated until the current is at its minimum. This leads to less losses inside the motor and to a noise reduction. In case a higher torque is required the drive returns to its linear V/f curve and the process starts again. This kind of energy optimization makes sense, when different torque can be required at the same speed. This principle is only applicable to drives without short term speed changes, but with constant speed for a certain time. 4.2 87 Hz curve In the majority of cases standard asynchronous motors are used up to their rated frequency. The maximum output frequency of the variable frequency drive is 50 Hz. The power of the motor can be increased by √3, by increasing the frequency from 50 Hz to 87 Hz (50 Hz · √3), keeping the flux (mag- netizing current) constant at the same time. Conditions at a 400 V mains · The motor is wounded for 230/400 V (not 400/690 V) · The windings are connected in delta. · The variable frequency drive has a maximum output voltage of 400 V and a maximum frequency of 87 Hz. This results in 50 Hz at 230 V. · The variable frequency drive is selected for a current which is the rated current of the motor at 230 V. Parameters · P1.8 = 400 V · P1.9 = 87 Hz (with 50 Hz on the name plate) ATTENTION: When using a 50 Hz motor at 87 Hz, possible imbalances of the rotor can cause mechan- ical damages. It is recommended to contact the motor manufacturer before using this motor at speeds above rated speed. 2018-01-15 AP040177EN DG1 Motor data and V/f curves Page 16 Example for selection: Motor data · 230 / 400 V · 3,2 / 1,9 A · 0, 75 kW · 1410 min-1 · 50 Hz Selection · Device rated for 400 V, but for the current which is assigned to 230 V (here: 3,2 A) à DG1-343D3FB-C21C. · The power of the motor results in 0,75 kW · √3 = 1,3 kW (rated torque at √3 times rated speed). · The synchronous speed of the motor is 1500 rpm · √3 = 2598 rpm · The expected speed at rated load is 2598 rpm – 90 rpm = 2508 rpm Remark: 90 rpm corresponds to the slip speed (1500 min-1 – 1410 min-1) MTL5500 range Isolating interface units June 2024 INM 5500 Rev 18 Instruction manual MTL intrinsic safety solutions INM 5500 Rev 18ii DECLARATION OF CONFORMITY A printed version of the Declaration of Conformity has been provided separately within the original shipment of goods. However, you can find a copy of the latest version at: http://www.mtl-inst.com/certificates INM 5500 Rev 18iii CONTENTS DECLARATION OF CONFORMITY ii IMPORTANT NOTE v ATEX/UKCA/IECEX SAFETY INSTRUCTIONS vi/vii 1 INTRODUCTION 1 2 DESCRIPTION 1 3 INSTALLATION 2 3 1 Modules – pre-installation 3 3 2 Installing columns of isolators 4 4 ACCESSORIES 6 4 1 MTL5500 power bus - Installation and use 6 4 2 MPA5500 AC power adaptor 7 4 3 Earth rail and tagging accessories 8 5 DX ENCLOSURES 12 5 1 Environmental conditions 12 5 2 Mounting 16 5 3 Accessories in enclosures 17 5 4 IS warning label 17 6 UNIT DESCRIPTIONS, SETTING-UP AND CONNECTIONS 18 6 1 Digital Input modules 19 6.1.1 Phase reversal . . . . 19 6.1.2 Line-Fault Detection (LFD) . . . . 19 6.1.3 MTL5501-SR - Fail-safe Switch/Proximity detector interface . . . . .20 6.1.4 MTL5510 & MTL5510B - Switch/Proximity detector interface . . . . .21 6.1.5 MTL5511 - Switch/Proximity detector interface . . . . .25 6.1.6 MTL5513 - Switch/Proximity detector interface . . . . .26 6.1.7 MTL5514/ MTL5514D/MTL5514-T - Switch/Proximity detector interface . . . . .27 6.1.8 MTL5516C - Switch/Proximity detector interface . . . . .28 6.1.9 MTL5517 - Switch/Proximity detector interface . . . . .29 6 2 Digital Output modules 30 6.2.1 MTL5521/MTL5521-T - Solenoid Alarm driver . . . . .30 6.2.2 MTL5522 - Solenoid Alarm driver . . . . .31 6.2.3 MTL5523 - Solenoid Alarm driver . . . . .32 6.2.4 MTL5523V/MTL5523VL - Solenoid Alarm driver . . . . .33 6.2.5 MTL5524 - Solenoid Alarm driver . . . . .34 6.2.6 MTL5525 - Solenoid Alarm driver . . . . .35 6.2.7 MTL5526 - Switch Operated Relay . . . . .36 6 3 Pulse, Vibration and Foundation Fieldbus modules 37 6.3.1 MTL5531 - Vibration Transducer Interface . . . . .37 6.3.2 MTL5532 - Pulse Isolator . . . . .38 6.3.3 MTL5533 - Vibration Transducer Interface . . . . .40 6.3.4 MTL5553- Isolator/power supply for 31.25kbits/s fieldbuses . . . . .41 6 4 Analogue Input modules 42 6.4.1 MTL5541/MTL5541S/MTL5541S-T - Repeater Power Supply . . . . .42 6.4.2 MTL5541A/MTL5541AS - Repeater Power Supply . . . . .43 6.4.3 MTL5544/MTL5544S - Repeater Power Supply . . . . .44 6.4.4 MTL5544A/MTL5544AS - Current Repeater . . . . .45 6.4.5 MTL5544D - Repeater Power Supply . . . . .46 (continued on next page) INM 5500 Rev 18iv 6 5 Analogue Output modules 47 6.5.1 MTL5546/MTL5546Y/MTL5546Y-T - Isolating Driver . . . . .47 6.5.2 MTL5549/ MTL5549Y - Isolating Driver . . . . .48 6 6 Fire and Smoke Interface modules 49 6.6.1 MTL5561 - Fire and Smoke Detector Interface . . . . .49 6 7 Temperature Input module 50 6.7.1 MTL5573 - Temperature Converter . . . . .51 6.7.2 MTL5575 - Temperature Converter . . . . .52 6.7.3 MTL5576-RTD - Temperature Converter . . . . .53 6.7.4 MTL5576-THC - Temperature Converter . . . . .54 6.7.5 MTL5581 - mV/Thermocouple Isolator . . . . .55 6.7.6 MTL5582/MTL5582B - mV/Resistance Isolator . . . . .56 6 8 General modules 57 6.8.1 MTL5599 - Dummy Isolator . . . . .57 6.8.2 PSG60E24RM Power Supply . . . . .58 6 9 PCS45/PCL45USB configurator for MTL temperature converters 59 7 FAULT FINDING AND ROUTINE MAINTENANCE 59 7 1 Maintenance precautions 59 7 2 Fault finding 59 7 3 Routine maintenance 59 8 BENCH TESTING MODULES 60 8 1 Digital Input (DI) modules 60 8 2 Digital Output (DO) modules 61 8 3 Analogue Input (AI) Modules 62 8 4 Analogue Output (AO) Modules 65 8 5 Testing the functioning of other modules 65 9 APPLICATIONS INVOLVING ZONE 2 AND/OR ZONE 22 HAZARDOUS AREAS 66 9 1 Enclosure 67 10 APPENDIX 1 68 10 1 MTL5000 68 10 2 MTL5018AC - Switch/proximity detector 69 10 3 MTL5051 serial data comms isolator 71 10 4 MTL5314 trip amplifier for 2– or 3– wire transmitters 74 11 APPENDIX 2 77 11 1 Table A - Safety descriptions 77 11 2 Table B - Maximum cable parameters - IIC gas group 78 © 2022 Eaton Electric Limited. All rights reserved. INM 5500 Rev 18v IMPORTANT NOTE WARNING This manual has content describing the use and installation of safety equipment This equipment must be installed, operated and maintained only by trained competent personnel and in accordance with all appropriate international, national and local standard codes of practice and site regulations for intrinsically safe apparatus and in accordance with the instructions contained here WARNING This equipment must be used in accordance with the instructions in this manual otherwise the protection provided by the equipment may be impaired ATEX If the country of installation is governed by the Essential Health and Safety Requirements (Annex II) of the EU Directive 2014/34/EU [the ATEX Directive - safety of apparatus] then consult the ATEX safety instructions for safe use in this manual before installation. Note: Refer to the website for multiple language safety instructions. ELECTRICAL PARAMETERS Refer to the certification documentation for the electrical rating of these products. CERTIFICATION DOCUMENTATION Our website http://www.mtl-inst.com contains product documentation regarding intrinsic safety certification for many locations around the world. Consult this data for information relevant to your local certifying authority. FUNCTIONAL SAFETY If the MTL5500 range of products are to be used in functional safety applications check that each module has been assessed for that service and refer to the Safety Manual for details. REPAIR MTL5500 range of products MUST NOT be repaired. Faulty or damaged products must be replaced with an equivalent certified product. Symbols used on the product and in this manual CAUTION - Read the instructions CAUTION - Hot surface INM 5500 Rev 18vi ATEX/UKCA/IECEx SAFETY INSTRUCTIONS The following information is in accordance with the Essential Health and Safety Requirements (Annex II) of the EU Directive 2014/34/EU [the ATEX Directive - safety of apparatus), and Schedule 1 of the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (UK S.I. 2016/1107) and is provided for those locations where the ATEX Directive or UKCA regulations are applicable. General a) This equipment must only be installed, operated and maintained by competent personnel. Such personnel shall have undergone training, which included instruction on the various types of protection and installation practices, the relevant rules and regulations, and on the general principles of area classification. Appropriate refresher training shall be given on a regular basis. [See clause 4.2 of IEC/EN 60079-17]. b) This equipment has been designed to provide protection against all the relevant additional hazards referred to in Annex II of the ATEX directive (such as clause 1.2.7) or Schedule 1 of the UK regulation (such as clause 13). c) This equipment has been designed to meet the requirements of IEC/EN 60079-0, IEC/EN 60079-7, IEC/EN 60079-11 and IEC/EN 60079-15. Installation a) The installation must comply with the appropriate European, national and local regulations, which may include reference to the IEC code of practice IEC/EN 60079-14. In addition, particular industries or end users may have specific requirements relating to the safety of their installations and these requirements should also be met. For the EU, Directive 1999/92/EC [the ATEX Directive - safety of installations} is also applicable. For the UK, the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) is also applicable. b) This apparatus is an associated electrical apparatus and is normally mounted in a non- hazardous [safe] area. The equipment may be installed in a Zone 2 location providing that equipment is covered by a suitable certificate and the relevant installation conditions are met. Refer to “Special Conditions for Safe Use – Zone 2 mounting” below. c) Unless already protected by design, this equipment must be protected by a suitable enclosure against: i) mechanical and thermal stresses in excess of those noted in the certification documentation and the product specification ii) aggressive substances, excessive dust, moisture and other contaminants. Read also the Special Conditions for Safe Use (below) for any additional or more specific information. Special Conditions of Safe Use for Zone 2 applications a) When used in Zone 2, the equipment must be installed in an area of Pollution Degree 2 or better, as defined in IEC 60664-1, and in an enclosure or an environment that provides a degree of protection of at least IP54 and meets the relevant material and environmental requirements of IEC/EN 60079- 0, and IEC/EN 60079-7 or IEC/EN 60079-15 as appropriate. b) The equipment must not be inserted or removed unless either: i) the area in which the equipment is installed is known to be non-hazardous or ii) the circuit to which it is connected has been de-energised. c) The 24V supply for this equipment must be derived from a regulated power supply complying with the requirements of European Community Directives. d) For MTL5511, MTL5514, MTL5514D, MTL5516C, MTL5517, MTL5526 & MTL5532 only: Relay contacts may switch up to 35V, 2A and 100VA. For MTL5575: Relay contacts may switch up to 35V, 250mA. e) For MTL5573: Maximum Input/Output parameters – see certificate f) For MTL5553: The ambient temperature stated on the certificate refers to the temperature within the enclosure into which it must be installed in accordance with condition number 1). It is the responsibility of the installer to ensure that there is adequate isolation between the MTL 5553 Isolator and the frame of the supplementary enclosure. The equipment must be capable of withstanding the 500V dielectric strength test in accordance with clause 6.1 of IEC 60079-7 between the equipment and the supplementary enclosure. This must be taken into account during installation. The maximum values for the intrinsically safe circuits have to be taken from the IECEx Certificate of Conformity IECEx BAS 18.0060. g) Special Conditions will vary on individual certificates. INM 5500 Rev 18vii Inspection and maintenance a) Inspection and maintenance should be carried out in accordance with European, national and local regulations which may refer to the standard IEC/EN 60079-17. In addition specific industries or end users may have specific requirements which should also be met. b) Access to the internal circuitry must not be made during operation. Repair a) This product cannot be repaired by the user and must be replaced with an equivalent certified product. Marking Each device is marked in compliance with the EU Directive and UK regulation, and CE and UKCA marked accordingly. Example label showing markings: INM 5500 Rev 18viii This page is left intentionally blank INM 5500 Rev 181 1 INTRODUCTION This instruction manual describes the procedures for installing, connecting, checking and maintaining MTL5500 range of isolating interfaces and accessories. The MTL5500 products provide a DIN-rail mounted, intrinsically safe interface to hazardous areas of a process plant. The individual sections of this manual cover the following topics • Section 2 describes the range • Section 3 specifies precautions both before and during installation • Section 4 describes mounting accessories and the power adaptor • Section 5 discusses the DX range of enclosures • Section 6 provides relevant technical data • Section 7 outlines fault-finding and maintenance procedures • Section 8 describes bench test procedure • Section 9 provides hazardous-area application information • Section 10 provides MTL5000 products information • Section 11 provides safety parameter information 2 DESCRIPTION MTL5500 range of isolators provide intrinsically safe (IS) communication and signal conditioning for a wide range of hazardous-area devices. Total AC and DC isolation exists between input, output and power supply on separately powered units, and between input and output on loop-powered units. No IS earth is required. DIN-rail mounting and plug-in signal and power connectors simplify installation and maintenance. Units are powered from a 20 to 35V DC supply, or, in some cases, from the signal itself. Our latest generation of IS interfaces utilises an innovative “One-Core” technology to ensure the highest quality and availability while maintaining maximum flexibility at lowest cost. Incorporating advanced circuit design, a common set of components and innovative isolating transformer construction, they achieve a significant reduction in power consumption while increasing channel packing densities. The compact, 16mm wide design reduces weight and gives exceptionally high packing density. They build on the proven success of the MTL2000, 3000, 4000 and 5000 ranges to bring the benefits of new developments in galvanic isolation without compromising the reliability of the designs from which they have evolved. The backplane mounting MTL4500 range is designed with system vendors in mind for “project- focussed” applications such as Distributed Control System (DCS), Emergency Shutdown Systems (ESD) and Fire and Gas monitoring (F&G). The DIN-rail mounting MTL5500 range meets the needs of the IS interface market for “application focussed” projects, ranging from single instrument loops, through to fully equipped cabinets, across all industries where hazardous areas exist. Both new ranges have been designed for compatibility with earlier models. The MTL4500 range provides plug-replacements for earlier MTL4000 range of units, while the MTL5500 models can easily replace MTL5000 range of units. Each offer the latest in modern technology and efficiency without compromise. In addition to their use in IS circuits, specific models within the MTL4500 and MTL5500 ranges have been assessed and approved for use in Functional Safety applications. These have been verified under the certified Functional Safety Management (FSM) programme implemented by us. INM 5500 Rev 182 The table below lists the modules in the MTL5500 range. Refer also to the individual MTL5500 range of data sheets. Digital Input Channels Function MTL5501-SR 1 fail-safe, solid-state output + LFD alarm MTL5510 4 switch/prox input, solid-state output MTL5510B 4 multi-function, switch/prox input, solid-state output MTL5511 1 switch/prox input, c/o relay output MTL5513 2 switch/prox input, solid-state output MTL5514/5514-T 1 switch/prox input, relay + LFD MTL5514D 1 switch/prox input, dual relay output MTL5516C 2 switch/prox input, relay + LFD outputs MTL5517 2 switch/prox input, c/o relay + LFD outputs Digital Output MTL5521/5521-T 1 loop-powered solenoid driver MTL5522 1 loop-powered solenoid driver, IIB MTL5523 1 solenoid driver with LFD MTL5523V 1 solenoid driver with LFD + voltage control, IIC MTL5523VL 1 solenoid driver with LFD + voltage control, IIC MTL5524 1 switch operated solenoid driver MTL5525 1 switch operated solenoid driver, low power MTL5526 2 switch operated relay Pulse, Vibration and Foundation Fieldbus modules MTL5531 1 vibration probe interface MTL5532 1 pulse isolator, digital or analogue output MTL5533 2 vibration probe interface MTL5553 1 isolator/power supply for 31.25kbits/s fieldbuses Analogue Input MTL5541/MTL5541-T 1 2/3 wire transmitter repeater MTL5541A 1 transmitter repeater, passive input MTL5541AS 1 transmitter repeater, passive input, current sink MTL5541S/5541S-T 1 2/3 wire transmitter repeater, current sink MTL5544 2 2/3 wire transmitter repeater MTL5544A 2 transmitter repeater, passive input MTL5544AS 2 transmitter repeater, passive input, current sink MTL5544S 2 2/3 wire transmitter repeater, current sink MTL5544D 1 2/3 wire transmitter repeater, dual output Analogue Output MTL5546 1 4-20mA smart isolating driver + LFD MTL5546Y/5546Y-T 1 4-20mA smart isolating driver + oc LFD MTL5549 2 4-20mA smart isolating driver + LFD MTL5549Y 2 4-20mA smart isolating driver + oc LFD Fire and Smoke MTL5561 2 loop-powered for fire & smoke detectors Temperature Input MTL5573 1 temperature converter, THC or RTD MTL5575 1 temperature converter, THC or RTD MTL5576-RTD 2 temperature converter, RTD MTL5576-THC 2 temperature converter, THC MTL5581 1 mV/thermocouple isolator for low level signals MTL5582/5582B 1 mV/ resistance isolator to repeat RTD signals General MTL5599 1 dummy module INM 5500 Rev 183 3 INSTALLATION Important • Make sure that all installation work is carried out in accordance with all relevant local standards, codes of practice and site regulations. • When planning the installation of MTL5500 range of isolators it is essential to make sure that intrinsically safe and non-intrinsically safe wiring is segregated, and that units are installed as required by a nationally accepted authority or as described in EN 60079-14, ISA RP 12.6 or DIN VDE-165. • External power supply shall contain double isolation from hazardous voltages or that unit shall be supplied by Limited Power Circuit per UL/IEC 60950 or Limited Energy Circuit per UL/IEC 61010 or Class ll Power Supply per NEC. • Environmental conditions: indoor use, altitude (up to 2000m) and humidity less than 95% non condensing. • Check that the hazardous-area equipment complies with the descriptive system document. • If in doubt, refer to the certificate/catalogue for clarification of any aspects of intrinsic safety or contact Eaton’s MTL product line or your local representative for assistance. • Make sure the correct hazardous-area connector (field-wiring plug) is plugged into the corresponding isolator. It is recommended that the connector is identified by the same tag number as the matching isolator. Figure 3 1: Dimensions of MTL5500 package Mount all MTL5500 range of isolators on low-profile (7mm) or high-profile (15mm) type T35 (top-hat) DIN-rail to EN50022, BS5584, DIN46277. This is available from Eaton, in 1 metre lengths (THR2 - DIN rail). Install isolators within the safe area unless they are enclosed in approved flameproof, pressurised or purged enclosures and ensure that the local environment is clean and free of dirt and dust. Note the ambient temperature considerations of section 3.1.4. It is recommended that, in normal practice, the DIN rail should be earthed/grounded to ensure the safety of personnel in the event of a.c. mains (line) power being applied accidentally to the rail. SAFEHAZ 104.8 109.8 123.6 118.8 Top of DIN rail PWR OPB OP A OPD OPC FLT Optional TH5000 tag holder for individual isolator identification. Accepts tag label 25 x 12.5 ±0.5mm, 0.2mm thick 15.8 +/– 0.2 INM 5500 Rev 184 3 1 Modules – pre-installation 3 1 1 Switch settings for operating conditions Some modules have operating conditions, such as Line-Fault Detection (LFD), Phase Reversal, etc., that can be established by the setting of switches on the unit. The subminiature switches are accessible through an aperture on the side of the module (see Figure 3.2) and can be set in the required positions with, for example, the blade of a small screwdriver. The switch setting options are always indicated on the side label of the module, but the user may also consult the individual module information in Section 6 of this manual for details. Figure 3 2: Location of switches 3 1 2 Relay outputs Reactive loads on all units with relays should be adequately suppressed. To achieve maximum contact life on all mechanical output relays, the load should not be less than 50mW, e.g. 10mA at ≥ 5V DC. 3 1 3 Ambient temperature considerations Ambient temperature limits for unenclosed MTL5500 range of isolators are from –20°C to +60°C with units close-packed and modules with the -T suffix have an extended temperature rating of +65°C, unless otherwise specified. 3 2 Installing columns of isolators On new installations, if isolators are mounted in several rows or columns, mount alternate rows or columns so that units face in opposite directions. This allows safe- and hazardous-area wiring looms to be shared. See Figure 3.1 for isolator dimensions. 3 2 1 Mounting isolators on DIN rail Figure 3 3: DIN rail mounting and removal of isolators Clip an isolator onto the DIN rail as shown in Figure 3.3, with the blue signal plugs facing towards the hazardous-area. To remove an isolator from the rail, insert a screwdriver blade (2.5 - 5.0mm diam.) into the clip as shown. This will release the clip so that the isolator may be pivoted off the rail - there is no need to lever the clip. Allow a maximum mounting pitch of 16.2mm for each unit. OFF position ON position 1 2 3 4 Mounting Removal INM 5500 Rev 185 3 2 2 Wiring up isolators Each unit is supplied with the appropriate number and type of safe- and hazardous-area connectors (see Figure 3.4), as dictated by the terminals used and the type of power supply. Figure 3 4: Removable power and signal plugs Note: Earth Leakage Detection requires the use of hazardous area connector type HAZ1-3, which may need to be ordered separately. See datasheet for ordering information. Loop-powered devices do not require power connectors. Depending on the installation, it may be easier to wire up isolators with power and signal plugs either in place or removed. Either way, allow sufficient free cable to permit plugs to be removed easily for future maintenance and/or replacement purposes. See Section 6 for instructions on wiring individual modules. 3 2 2 1 Signal and power conductors Removable signal and power plugs are fitted with screw clamp terminals. Note that the conductors should be between 14 and 24 AWG (1.6 and 0.5mm diam.) in size. Signal plugs, located on top of the modules, are mechanically keyed to fit in only one position. They are coloured grey, for safe-area connections, and blue, for hazardous-area connections. For externally powered units, a power plug slots into the socket at terminals 13 and 14 on the safe-area side of each module. The socket is coloured black if the unit is dc powered. Power plugs are coloured grey, for plugging into the black sockets of dc powered units. 3 2 2 2 Making connections a) Trim back the insulation of conductors by 12mm. b) Check the terminal assignments shown in section 6 or on the side label of the unit. c) Insert conductors according to the terminal assignments and tighten screws. If the wires are to be fitted with crimp ferrules, the following is a list of those recommended with required trim lengths for each: Plug type Entry Wire size (mm2) Metal tube length (mm) Trim length Recommended ferrules Signal Single 0.75 12 14 Weidmuller 902591 Signal Single 1.0 12 14 Cembre PKC112 Signal Single 1.0 12 14 Phoenix Contact AI 1-12 RD (3200674) Signal Single 1.5 12 14 Cembre PKE1518† Signal Single 2.5 12 14 Cembre PKE2518† Power Twin 2x0.75 10 12 Cembre PKET7510 Power Twin 2x0.75 10 12 AMP (non-preferred) 966144-5 Power Twin 2x1.0 10 12 Phoenix Contact AI-TWIN 2X 1-10 RD Power Single 0.75 10 12 AMP 966067-0 Power Single 1.0 10 12 Phoenix Contact AI 1-10 RD TABLE 3 1: Crimp Ferule Options † These ferrules with 18mm length metal tubes should be cut to 12mm after crimping Note: Smaller section wire than that stated can often be successfully used if the crimping is good. Crimp tool: Phoenix Contact Crimpfox UD6 part number 1204436 Power Plugs Grey: dc supplies (PWR5000) Signal Plugs Grey: safe-area side Blue: hazardous-area side 12mm trim length with ferrule see table below INM 5500 Rev 186 3 2 2 3 Finishing Wire up individual isolators in accordance with wiring schedules. Daisy-chain power supply connections between individual power plugs or use the power bus (see section 4.1). Segregate hazardous- and safe-area wiring into separate trunking or looms wherever possible to avoid errors and maintain a tidy installation. Use an MTL5599 dummy isolator to provide termination and earthing for unused cores from the hazardous area. 4 ACCESSORIES 4 1 MTL5500 power bus - Installation and use 4 1 1 MTL5500 range power bus A power bus kit enables power supply terminals (13 and 14) of up to 32 installed MTL5500 range of units to be linked to a standard 24V power supply. The bus consists of a chain of power plugs and different lengths are available to suit various numbers of modules as follows. Number of modules Kit ID code (contains grey power plugs for 24V dc supply) 1 to 8 PB-8T 9 to 16 PB-16T 17 to 24 PB-24T 25 to 32 PB-32T Table 4 1: Power bus kit options 4 1 2 Installation 1. Check to make sure the bus length is correct for the number of modules involved. 2. If the number of modules is less than the maximum number the chain will support, cut off the surplus power plugs at the tail end of the chain - leaving sufficient cable to attach further power plugs if it becomes necessary later. 3. Insert power plugs into the power terminals on the safe- area side of each module in sequence. 4. Connect the power supply source to the tail end of the chain (using the insulation displacement connectors [Scotchloks] provided if required). Notes: 1. To avoid excessive voltage drop or over-current, DO NOT connect power buses in . 2. Surplus sections can be used (and, if required) connected together provided the cut ends are safely terminated and/or connected together. Use single ferrules with a crimp tool or insulation displacement connectors (Scotchloks). Suitable ferrules and connectors are provided with the kits. Figure 4 1: Power bus wiring, joining and terminating – + Optional insulation displacement connectors x2 INM 5500 Rev 187 4 2 MPA5500 AC power adaptor When only one or two MTL5500 modules are required for a particular application, it may be desirable to power the units from the AC mains supply directly, rather than use a separate DC supply unit. The MPA5500 is an adaptor that plugs into the DC power socket on the side edge of an MTL5500 module and clips securely onto the module housing. Its 25V DC power output is sufficient to supply a single module and can be connected to any normal ac power source. Figure 4 2: MPA5500 AC power adaptor To fit the adaptor, locate the tongue of the adaptor into the top slot on the side of the MTL5500 module and press the adaptor until it fits closely to the body of the module, as shown. Use double-insulated AC power cable with conductor parameters of 0.2–1.5mm2, or 0.25– 1.5mm2 if using ferrules. Strip the outer insulation by no more than 30mm, then strip the inner conductors by 8mm. Insert the cables appropriately in the cage-clamp connectors marked ‘L’ and ‘N’. The incoming AC power must have some form of power disconnection device, such as a switch or circuit breaker; a coupler that can be disconnected without the use of a tool; or a separable plug, without a locking device, to mate with an adjacent socket outlet. In addition, some form of cable anchorage must be used to relieve the cable conductors from strain, including twisting, where they connect to the adaptor, and which will also protect the insulation of the cable from abrasion. WARNING This adaptor is not suitable for use with MTL5000 range of modules. Direction of removal of MPA5500 Area required for removal of MPA5500 11 20 15.8 118.8 133 AC inputs Top of DIN rail INM 5500 Rev 188 4 3 Earth rail and tagging accessories This section explains how to specify and assemble earth rail and tagging strip accessories for the MTL5500 range. The accessories consist of mounting brackets, earth rails, tagging strips and associated parts. They provide facilities for earthing, terminating cable screens and tagging (identifying) the positions of individual units. 4 3 1 Parts list IMB57 Insulating mounting block (Figures 4 3, 4 4 & 4 5) One required at each end of a tagging strip/earth rail. Suitable for low-profile (7.5mm) and high- profile (15mm) symmetrical DIN rail. ERB57S Earth-rail bracket, straight (figure 4 3, 4 4 & 4 9) Nickel-plated bus bar; supplied with two push fasteners, one earth-rail clamp (14mm, 35mm2) and one earth cable clamp (10mm, 16mm2). Note: ERB57S is the preferred choice of earth-rail bracket. It is usually fitted in the upper slot on insulating mounting block IMB57. Where the earth rail is required to be positioned at a lower height and to allow access to the IMB57 mounting screws, the straight earth-rail bracket ERB57S can be inserted in the lower slot, but only after insulating mounting blocks IMB57 are clamped to the DIN rail. This may not be possible if, for example, trunking is fitted. In this case, fit offset earth-rail bracket ERB570 (see figure 4.4 & 4.10) in the upper slot: the mounting blocks can then be fitted in a restricted space with this bracket already fitted. ERB570 Earth-rail bracket, offset (figure 4 9) Nickel-plated bus bar; supplied with two push fasteners, one earth-rail clamp (14mm, 35mm2) and one earth cable clamp (10mm, 16mm2). ERL7 Earth rail, 1m length (figure 4 9) Nickel-plated bus bar; may be cut to length. TAG57 Tagging strip, 1m length (figure 4 3, 4 4 & 4 6) Cut to size. Supplied with tagging strip label. TGL57 Tagging strip labels, set of 10 x 0 5m (figure 4 3 & 4 4) Spares replacement, for use with TAG57 tagging strip. MS010 DIN rail module spacer, 10mm, pack of 5 (figure 4 7) Grey spacer; Used to provide 10mm air-circulation space between modules, if necessary. ETM7 Earth terminal, bag of 50 (figure 4 8) For terminating cable screens and 0V returns on the ERL7 earth rail. For cables ≥ 4mm2. TH5000 Tag holder Spares replacement. Connectors (Figure 4 5) Spares replacement: HAZ1-3, HAZ4-6, HAZ-CJC, PWR5000, SAF7-9, SAF10-12 (SAF1-3 and SAF4-6 grey connectors, also available for use in safe-area applications). 4 3 2 Assembly 4 3 2 1 Fitting earth rails a) In upper position Before fitting insulating mounting blocks IMB57, check that the swing nuts in the base of each unit are turned back into the moulding. Locate the mounting blocks on the DIN rail in the chosen position and tighten the screws (see figure 4.10). Check that the swing nuts rotate correctly to locate underneath the flanges of the DIN rail. INM 5500 Rev 189 ¬ ¬ TGL57 TAG57 ERB57 ERB570 ETM7 Snap off extension when using IMB57 as central support 10mm Earth clamp ERB57S in upper position ERB57S in lower position IMB57 Push fastener 14mm Earth-rail clamp ERL7 THR2 IMB57 ERL7 HAZ1-3 HAZ4-6 TH5000 TAG57 TGL57 SAF7-9 SAF10-12 ERB57S ETM7 PWR5000 Figure 4 3: Assembly drawing showing part numbers Figure 4 4: Mounting details Figure 4 5: IMB57 Insulating mounting block¬ Figure 4 6: TAG57 Tagging strip, 1m length ¬ Figure 4 7: MS010 DIN rail module spacers ¬ ¬ ¬ ¬ Figure 4 8: ETM7 Earth terminals ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ Figure 4 9: Earth rails and clamps INM 5500 Rev 1810 Figure 4 10: Fitting IMB57 Slide a straight earth-rail bracket ERB57S into the upper slot in each mounting block. Push two plastic push fasteners into each bracket to locate the brackets in the mounting blocks. Cut earth rail ERL7 to the length needed. Slide the required number of ETM7 earth terminals (5mm or 7mm wide) onto the rail. Clamp each end of the earth rail to earth-rail brackets ERB57S using the terminal clamps (14mm, 35mm2) supplied. Fit an earth clamp (10mm, 16mm2) to the free end of each earth-rail bracket. Note: For lengths of earth-rail greater than 500mm, provide additional support by installing a third IMB57 mounting block and earth-rail bracket, mid-way between the end mounting blocks. Snap out the perforated extension between the lugs on this mounting block if a continuous tagging strip is to be fitted (see figure 4.6). b) In lower position, where at least 150mm clearance exists on one side, measured from the edge of the mounting block. As for a), but slide earth-rail brackets ERB57S into the lower slots in each mounting block. c) In lower position, where there is insufficient clearance to fit earth-rail brackets ERB57S. As for a), but slide offset earth-rail brackets ERB57O into the upper slot in each mounting block before assembling the mounting blocks to the DIN rail. ERB57S brackets cannot be used because they obscure the fixing screws on the mounting blocks. 4 3 2 2 Fitting tagging strips Assemble mounting blocks IMB57 to the DIN rail as above. Cut TAG57 tagging strip and label to the length needed, and insert label so that the appropriate side is visible. Clip the strip onto the lugs on the mounting blocks. Hinge up the strip to provide access to the tops of the isolators. Note: If necessary, provide additional support for long lengths of tagging strip by installing an extra IMB57 mounting block mid-way between the end mounting blocks. Snap out the perforated extension between the lugs on this mounting block. 4 3 3 Completed assemblies Figure 4.11 illustrates a complete assembly of MTL5500 isolators using the accessories mentioned above. The broken-line boxes either side of the assembly represent cable trunking, and the accompanying dimensions represent the recommended minimum spacing between the trunking and the module assemblies. INM 5500 Rev 1811 ¬¬ ¬¬ Colour Module no Function Yellow MTL5501-SR Digital Inputs White MTL551x Red MTL552x Digital Outputs Blue MTL5531/33 Vibration Purple MTL5532 Pulse Blue MTL5541x MTL5544x Analogue Inputs Green MTL5546x MTL5549x Analogue Outputs Blue MTL556x Fire & Smoke Orange MTL557x MTL558x Temperature inputs Grey MTL5599 Dummy isolator Table 4 2: MTL5500 front label colour coding Figure 4 11: MTL5500 complete assembly INM 5500 Rev 1812 5 DX ENCLOSURES Enclosures are usually selected on the basis of the number of units they will accommodate and Table 5.1 shows the capacity of each of the enclosures. Figure 5.2 shows each type of enclosure containing MTL5500 modules. Table 5 1: DX range of enclosures - module capacities Enclosure Number of MTL5500 isolators 16mm mounting pitch DX070 4 (2*) DX170 10 (8*) (DX430) 26 (24*) no longer available * Use these figures when two IMB57 mounting brackets for tagging/earth-rail accessories are included. Note: The user should be aware that some workshop preparation may be required for the cable gland plates before the enclosure is ready for on-site installation. 5 1 Environmental conditions Environmental conditions that should be taken into account when installing DX enclosures include:- See section Maximum ambient temperature limits 5.1.1 Storage temperatures 5.1.2 Humidity 5.1.3 Corrosion resistance 5.1.4 Flammability 5.1.5 Impact resistance 5.1.6 Chemical resistance 5.1.7 5 1 1 Maximum outside enclosure temperature limits Figure 5 1: Graph depicting outside enclosure temperature limits for DX enclosures used with MTL5500 isolators The maximum outside enclosure temperature depends upon the total power dissipated by the installed modules which, in turn, depends upon their number and type. It can also be influenced by the Authority whose standards may need to be applied to the system, e.g. Baseefa, Factory Mutual Research Corporation, Canadian Standards Association. Figure 5.1 shows, in graphical form, the maximum outside enclosure temperatures (TMO) for given levels of power dissipation. The graph was derived from the following equation and should be used to calculate accurately the suitability of any particular mix of modules. TMO = 60°C - ∂T where ∂T = k1 x P P = total power (watts) dissipated by modules in an enclosure k1 = is a dissipation constant for a given enclosure and module . Select the relevant value from Table 5.2. (60°C is the temperature inside the enclosure) 60 40 20 10 30 50 0 10 20 30 40 Power dissipation (watts) Max. outside enclosure temperature (°C) Enclosures DX070 DX170 DX430 INM 5500 Rev 1813 Figure 5 3: Optimum orientation for wall mounted enclosure DX070 DX170 MTL5500 4.03 1.88 Table 5 2: Dissipation constant k1 for enclosures (°C/watt) Orientation of the enclosures is also important - the optimum position being on a vertical surface with the internal DIN-rail horizontal as shown in Figure 5.3. Any other position can reduce the maximum allowable ambient temperature by up to 5°C. Examples Tables 5.3 and 5.4 list likely combinations of MTL5500 modules in the three enclosure types and indicate the acceptable maximum permitted outside enclosure temperature for these based on the graph in Figure 5.1. See the specifications included in the datasheets for the power dissipation figures of individual MTL5500 modules. Table 5 3: Typical mix of MTL5500 modules Enclosure Modules installed Power dissipation of modules in watts (P) Maximum outside enclosure temp (TMO)°C DX070 2 x MTL5511 + 2 x MTL5544 (2 x 0.72) + (2 x 1.4) = 4.24 42.9 DX170 5 x MTL5511 + 5 x MTL5544 (5 x 0.72) + (5 x 1.4) = 10.6 40.1 Table 5 4: Power versus maximum outside enclosure temperature Enclosure Number of installed modules k °C/watt Power dissipation of modules in watts (P) Maximum outside enclosure temp (TMO) °C DX070 4 4.03 4.0 43.9 4 4.03 6.0 35.8 DX170 10 1.88 10.0 41.2 10 1.88 15.0 31.8 5 1 2 Storage temperatures Storage temperatures are safe within the range -40°C to +80°C. 5 1 3 Humidity limits Safe humidity limits are within the range 5 to 95% RH. 5 1 4 Extended ambient temperature modules Modules with the -T suffix are rated for use in an ambient temperature up to 65°C if suitably certifed. INM 5500 Rev 1814 Figure 5 2: DX range of enclosures 150 DX070 130 113.5 153.5 70 180 163.5 203.5 Ø 5.2 184 147 (inside) Top of DIN rail 270 8080 540 430 520 576 249 305 Ø 7.2 DX430 184 147 (inside) Top of DIN rail 170 249 305 102 102 360 339 395 270 Ø 7.2 DX170 131 (inside) n b DX430 no longer available INM 5500 Rev 1815 5 1 5 Corrosion resistance The effect of corrosion on DX enclosures is negligible. 5 1 6 Flammability rating The flammable properties of the materials used in the construction of the enclosures are well understood by manufacturers and ratings have been established to a number of standards. One of the better known standards is the Underwriter's Laboratory standard UL 94 and the ratings for the enclosure materials are given as: Materials UL94 rating Polycarbonate (all lids) V2/V0 Polycarbonate with glass reinforcement (DX070 base) V1/V0 Polyester with glass reinforcement (DX170 & DX430 bases) V0 Items made from similar materials are well established as suitable for use in process I/O marshalling areas. 5 1 7 Impact resistance The enclosure designs have been tested to an impact resistance of greater than 2 Joules which exceeds the BS EN 61010-1 requirements of 0.5 Joules. 5 1 8 Chemical resistance The overall chemical resistance of the enclosures is limited by the resistance of the transparent polycarbonate lid. The glass-reinforced polycarbonate/polyester (GRP) bases have a higher resistance than plain polycarbonate. Table 5.5 lists qualitative evaluations of resistance to a variety of chemical agents. Table 5 5: Qualitative evaluations of resistance to various chemical agents Chemical agents Qualitative evaluation of resistance Salt water; neutral salts; acids (low concentrations); hydraulic oil Excellent Alcohols Very good Acids (high concentrations); alkalis (low concentrations); petrol; cooling fluids Good Alkalis (high concentrations); solvents. Poor 5 2 Mounting 5 2 1 General These instructions are concerned solely with mounting the DX enclosures. Instructions for wiring and testing individual modules within the enclosures are provided in Section 6. Sufficient space is provided within the enclosures to accommodate tagging and earth-rail accessories but this is at the expense of a reduction in the number of modules that can be fitted. 5 2 2 Location and orientation 5 2 2 1 Location The DX enclosures are intended for safe (non-hazardous) area use. The enclosures are rated NEMA 4X; consequently, in N. America or Canada, assuming the modules have the required approvals, they can be used in Class 1, Division 2 (gases) location, but check with local requirements and ensure all cable entries also conform. In this case, an additional warning label will be required on or near the enclosure warning that the MTL5500 interfaces must not be removed unless the area is known to be non-hazardous. The enclosures are NOT suitable for Class II or III, Division 2 hazardous locations. INM 5500 Rev 1816 5 2 2 2 Orientation As noted earlier (see section 5.1.1), for optimum temperature performance the enclosures should be mounted on a vertical surface with the internal DIN rail horizontal. 5 2 3 Mounting details See Figure 5.2 for the dimensions and mounting hole distances, etc., of the three DX enclosures. The recommended method of mounting-described here-uses the four wall-mounting lugs supplied with each enclosure. An alternative method of mounting is by direct attachment to the mounting surface through the corner holes. Note: When the wall-mounting lugs are used to attach the enclosures, the overall depth of the enclosure is increased by an additional 3.3 mm (DX070) or 7 mm (DX170 and DX430). a) At each of the four corner fixing holes, insert one of the screws provided and use it to attach a fixing lug to the base of the enclosure. b) Each lug can be used in one of two positions as shown in Figure 5.2. c) Attach the lugs to the mounting surface with suitable fasteners. d) Diameters of fixing holes in lugs are 5.5mm (DX070) and 7.0mm (DX170 and DX430) e) Appropriate fixing hole distances are shown in Figures 5.2. 5 2 4 Cable glanding All cables into the enclosures must be glanded to IP65 standards to maintain this rating for the enclosure as a whole. Cable glands and gland plates are not supplied. Glanding requirements vary for each enclosure as follows: DX070 On the DX070, 'knockout' holes are provided, in two different sizes (15.5 mm and 21 mm), on the side faces of the base. See Table 5.7 for recommended cable glands. DX170 The DX170 can accommodate one gland plate on each side - see figure 5.2 for details. Table 5.6 lists suppliers of suitable gland plate kits and Table 5.7 lists recommended glands. Table 5 6: Recommended gland plate kits for the DX170 and DX430 enclosures. Manufacturer/agent Manufacturer's part number Enclosure DX170 Hellermann Tyton TL-27/360 Sarel 21128 Table 5 7: Recommended cable glands for use with DX enclosures. Gland thread size Cable sizes (mm) Gland plate hole size (mm) Weidmuller part nos Sarel part nos Gland Locknut Gland Locknut PG9 5 to 8 15.2 951891 952216 08871 08881 PG13,5 8 to 13 20.4 951893 952218 08873 08883 Weidmuller (UK) http://www.weidmuller.co.uk Sarel (UK) http://www.sarel.co.uk Hellermann Tyton (UK) http://www.hellermantyton.co.uk INM 5500 Rev 1817 5 3 Accessories in enclosures Apart from mounting, there are some other installation details which should be considered before adding the appropriate interface modules and making the necessary cabling connections. A range of accessories is available to accompany the MTL5500 units (see section 4) and the following points should be observed. 5 3 1 Insulating mounting block (IMB57) A pair of these can be attached to the DIN rail, at either end of the modules, to provide a mounting for earth rails. Use of mounting blocks will reduce the space available for isolator modules. 5 3 2 Earth rails (ERL7) Earth rail is produced in 1 metre lengths and will require cutting to length before mounting. ERL7 earth rails can be mounted either side of the modules but are typically mounted on the hazardous side of the DIN rail. 5 3 3 Tagging strip (TAG57 and TGL57) Tagging strip is produced in 1 metre lengths and will require cutting to length before mounting. Similarly, the labels will require cutting to fit the tagging strip. 5 4 IS warning label A 'Take Care' IS warning label is provided inside each enclosure. This should be attached to the inside of the transparent lid when its orientation has been established. INM 5500 Rev 1818 6 UNIT DESCRIPTIONS, SETTING-UP AND CONNECTIONS This section describes the function (briefly), the setting-up procedure and the wiring connections for each MTL5500 unit. For a fuller functional description and a detailed technical specification, refer to the individual datasheets, which can be found on our website at www.eaton.com or in the current MTL IS catalogue. If a fault is suspected, first check that the power LED is lit (not applicable to loop-powered devices). If necessary, check that all signal and power plugs are properly inserted, that no wires are loose and that the unit is mounted correctly. If operation is still suspect, the unit should be replaced with a serviceable unit. There are no replaceable parts inside MTL5500 units, so any that appear to be inoperative should be returned to the manufacturer/supplier for repair or replacement. WARNING When disconnecting units for maintenance purposes, take care to segregate hazardous and safe-area cables. • Short circuit hazardous-area cable cores to an IS earth or insulate and secure the ends. • Insulate and secure safe-area cables. If testing a unit 'in situ' note that the test equipment used MUST be intrinsically safe. The rest of this section is divided into sub-sections based upon the type of module, as follows. 6 1 Digital Input modules MTL5501-SR, MTL5510, MTL5510B, MTL5511, MTL5513, MTL5514, MTL5514-T, MTL5514D, MTL5516C, MTL5517 6 2 Digital Output modules MTL5521, MTL5521 -T, MTL5522, MTL5523, MTL5523V, MTL5523VL, MTL5524, MTL5525, MTL5526 6-3 Vibration, Pulse and Foundation Fieldbus modules MTL5531, MTL5532, MTL5533, MTL5553 6 4 Analogue Input modules MTL5541, MTL5541-T, MTL5541A, MTL5541AS, MTL5541S, MTL5541S-T, MTL5544, MTL5544A, MTL5544AS, MTL5544D, MTL5544S 6 5 Analogue Output modules MTL5546, MTL5546Y, MTL5546Y-T, MTL5549, MTL5549Y 6 5 Fire and Smoke interface modules MTL5561 6 7 Temperature Input modules MTL5573, MTL5575, MTL5576-RTD, MTL5576-THC, MTL5581, MTL5582, MTL5582B 6 8 General modules MTL5599, MTL5991 6 9 PCS45/PCL45USB configurator for MTL temperature converters Note: Any LED indicator provided on the modules will display in the following colours: LED label LED colour PWR (power) Green STS (status) Yellow LFD (line fault) Red FLT (fault) Red OPx (o/p status) Yellow INM 5500 Rev 1819 6 1 Digital Input modules The Digital Input (DI) module range offers solid state or relay output switches in a safe area that respond to input switches located in a hazardous area. Single or multiple channel (2 or 4) options are available, as well as Line-Fault Detection (LFD). Modules with LFD can recognise open or short circuit conditions on the input wires going to the field sensors, and some DI modules have the facility to reverse the effect of the input on the output i.e. phase reversal. These options are chosen with switches located on the edge of the module on the hazardous area terminal side. In some applications it may be easier to set these switches before fitting the module to the DIN-rail. Figure 6 1: Switches to set LFD and phase reversal 6 1 1 Phase reversal Set the PR switch ON or OFF for the appropriate channel(s). 6 1 2 Line-Fault Detection (LFD) Where fitted, set the LF switch ON or OFF for the appropriate channel(s). Note: LFD is permanently active on the MTL5501-SR. For all DI modules with LFD except for the MTL5501-SR; when using the LFD facility with a contact input, resistors must be used. Fit 500Ω to 1kΩ (preferred value 680Ω) in with the switch and 20kΩ to 25kΩ (preferred value 22kΩ) in parallel with the switch. For modes of operation of the MTL5510 & MTL5510B that include LFD, resistors should be fitted as described above. For MTL5501-SR use 1k4Ω in and 10kΩ in parallel with switch contact inputs. For hazardous-area inputs conforming to EN 60947-5-6:2001 (NAMUR), a line fault is judged by the following rules: • Open circuit condition if hazardous-area current 250μA • Short circuit condition if hazardous-area load 360Ω Note: the open circuit window (between 250μA and 50μA), and the short circuit window (between 100Ω and 360Ω), is not hysteresis. All MTL5500 modules, with inputs conforming to EN 60947-5-6:2001 (NAMUR), will switch between open and complete circuit conditions within these limits. The MTL5501-SR LFD relay de-energises when a fault condition is detected. The MTL5514 and the MTL5517 energise the LFD relay to indicate a fault condition. INM 5500 Rev 1820 6 1 3 MTL5501-SR - Fail-safe Switch/Proximity detector interface Single channel, fail-safe module with line-fault detection The MTL5501-SR enables a fail-safe switch/proximity detector located in the hazardous area to control an isolated fail-safe electronic output. It provides line-fault detection (LFD) alarm contacts and is designed for use with approved fail-safe sensors in loops that require operation up to SIL3 according to the functional safety standard IEC 61508. Note: For reliable, long-term operation the load on the LFD switching relay should not be less than 50mW, e.g. 10mA at 5V DC. Hazardous area Safe area Vs– Vs+ 20 to 35V dc 10kΩ 1k4Ω + – LFD Failsafe output + –Resistors must always be fitted for switch inputs 6 5 4 3 2 1 7 8 9 10 11 12 13 14 ¬ Terminal Function 1 Input –ve 2 Input +ve 7 Output –ve 8 Output +ve 10 LFD 11 LFD 13 Supply –ve 14 Supply +ve Figure 6 2: Top label for MTL5501-SR Input / output characteristics Input value in sensor circuits Fail–safe output Operation LFD contacts 2.9mA < Is < 3.9mA ON Normal CLOSED Is 5.1mA OFF Normal CLOSED Is < 50μA OFF Broken line OPEN Rs < 100Ω OFF Shorted line OPEN Correct operation of the fail-safe output and LFD is indicated by the LEDs on the front of the unit. The yellow O/P LED is ON when the fail-safe output is energised. The red LFD LED flashes if a line fault is detected. The fail-safe output is de-energised (OFF) if the module detects an incorrect sensor current, an open circuit or a short circuit in the sensor circuit. Input signal sensors may be either suitable proximity sensors or switches. The proximity sensor properties are specified in the standard EN60947-5-6:2001; however, when used with MTL5501-SR modules, additional requirements for the "low-impedance" current of 3.4 ±0.5mA must be met. The list below shows suitable proximity sensors, all manufactured by Pepperl+Fuchs Group, Germany, and specified as usable to SIL3, according to IEC 61508: SJ 2-SN NJ 4-12GK-SN NJ 10-30GK-SN SJ 3,5-SN NJ 5-18GK-SN NJ 15-30GK-SN SJ 3,5-S1N NJ 8-18GK-SN NJ 6S1+U1+N NJ 2-11-SN NJ 6-22-SN NJ 15S+U1+N NJ 2-11-SN-G NJ 6-22-SN-G NJ 20S+U1+N NJ 2-12GK-SN NJ 5-30GK-S1N NJ 40-FP-SN-P1 INM 5500 Rev 1821 6 1 4 MTL5510 & MTL5510B - Switch/Proximity detector interface 4-channel, digital input and multifunction modules These digital modules provide solid state output switches in a safe area that respond to switches (inputs) located in a hazardous area. The way they respond - their "mode" - can be configured using a bank of four DIL selector switches accessible through the side of the module - see Figure 6.4. Model MTL5510 has an one output channel for each input channel and the user can reverse the output phase if necessary to suit the application. Model MTL5510B has more varied modes that can, for example, enable one input to affect multiple outputs or create latched outputs, etc.) The channel output transistors - Ch1/Ch2 and Ch3/Ch4 - share a common terminal and can switch +ve or –ve polarity signals. Note that parallel resistors are required for switch inputs with LFD - see Section 6.1.2 for recommended values. Hazardous area Ch B Vs– Vs+ 20 to 35V dc – + – – + – Ch D Ch C Ch A 1 2 3 4 common common Outputs 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Safe area ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ Terminal Function 1 Input channel A 2 Input channel AB common (+) 3 Input channel B 4 Input channel C 5 Input channel CD common (+) 6 Input channel D 7 Output channel 4 8 Output channel 3/4 common 9 Output channel 3 10 Output channel 2 11 Output channel 1/2 common 12 Output channel 1 13 Supply –ve 14 Supply +ve Figure 6 3: Top labels for MTL5510 & MTL5510B INM 5500 Rev 1822 Figure 6 4: DIL switches for setting mode Tables 6.1 and 6.2 show details of the modes available and the switch settings required to obtain them. For ease of access, it is recommended that switches are set to the required mode before installation. Table 6.1 indicates whether the output follows the input, or the output is the reverse or antiphase of the input. For example, in mode 0, o/p 1 = chA; so, if channel A switch is closed, then output 1 will also be closed or short circuit. However, in mode 1, o/p 1 = chA rev., so if channel A switch is closed, then output 1 will be the reverse, i.e. open-circuit. Table 6.2 shows the MTL5510B modes. The logic tables and timing diagrams on the following pages provide more detailed information on these modes. *Mode of operation changed August 2015 MTL5510 & MTL5510B diagnostics If an internal fault is detected, all outputs and channel LEDs will turn off and the red Fault LED will turn ON. Table 6 2 - MTL5510B mode options Switch settings MODE Function Equivalent 1 2 3 4 OFF OFF OFF OFF 0 4-ch switch input (see MTL5510 mode 0) MTL5510 ON OFF OFF OFF 1 2-ch each channel one input, two outputs OFF ON OFF OFF 2* Same as mode 1 with all outputs phase reversed ON ON OFF OFF 3 2-ch, 2-pole changeover output OFF OFF ON OFF 4 1-ch with line fault output MTL5014 ON OFF ON OFF 5 As mode 4 with changeover outputs OFF ON ON OFF 6 1-ch with start-stop latch MTL2210B ON ON ON OFF 7* As mode 2 with LFD enabled OFF OFF OFF ON 8 4-ch switch input, see MTL5510 mode 8 MTL5510 ON OFF OFF ON 9 2-ch with line fault output MTL5017 OFF ON OFF ON 10 As mode 9 with LFD changeover ON ON OFF ON 11 As mode 10 with channel phase reversed OFF OFF ON ON 12 3-ch with normally-open LFD output ON OFF ON ON 13 3-ch with normally-closed LFD output OFF ON ON ON 14 2-ch monostable, pulse stretcher ON ON ON ON 15 4-ch switch input, see MTL5510 mode 15 MTL5510 Table 6 1 - MTL5510 mode options Switch setting MODE o/p 1 o/p 2 o/p 3 o/p 4 i/p type 1 2 3 4 OFF OFF OFF OFF 0 chA chB chC chD switch / prox. detector ON OFF OFF OFF 1 chA rev. chB chC chD OFF ON OFF OFF 2 chA chB rev. chC chD ON ON OFF OFF 3 chA chB chC rev. chD OFF OFF ON OFF 4 chA chB chC chD rev. ON OFF ON OFF 5 chA rev. chB chC rev. chD OFF ON ON OFF 6 chA chB rev. chC chD rev. ON ON ON OFF 7 chA rev. chB rev. chC rev. chD rev. OFF OFF OFF ON 8 chA chB chC chD Switch/ prox. detector + LFD ON OFF OFF ON 9 chA rev. chB chC chD OFF ON OFF ON 10 chA chB rev. chC chD ON ON OFF ON 11 chA chB chC rev. chD OFF OFF ON ON 12 chA chB chC chD rev. ON OFF ON ON 13 chA rev. chB chC rev. chD OFF ON ON ON 14 chA chB rev. chC chD rev. ON ON ON ON 15 chA rev. chB rev. chC rev. chD rev. ¬ ¬ INM 5500 Rev 1823 MTL5510B modes The following logic and timing diagrams are provided to assist the user in understanding the behaviour of the MTL5510B module when a specific mode is chosen. The open switch ( ) and closed switch ( ) symbols are used to represent both the input conditions of Ch A, Ch B, Ch C or Ch D and then the output conditions of o/p 1, 2, 3 or 4. Note that in certain modes a Line Fault can cause an override of the output. How to use these mode tables - examples The logic tables for Mode 1 represent Ch A controlling outputs 1 & 3, while Ch C controls outputs 2 & 4. Output 1 & 3 are shown following input Ch A (open or closed) while Outputs 2 & 4 follow input Ch C. Mode 2 however shows o/p 1, 2, 3 and 4 being in antiphase to their inputs. Mode 9 operates with both outputs for each channel being in antiphase to their inputs. Mode 3: 2 ch, 2 pole c/o output i/p - Ch A i/p - Ch C o/p 1 - - o/p 2 - - - - o/p 3 - - o/p 4 i/p - Ch A No fault Line fault No fault Line fault o/p 1 Mode 4: 1 ch with line fault output No fault Line fault No fault Line fault o/p 3 i/p - Ch A No fault Line fault No fault Line fault o/p 1 o/p 2 Mode 5: As mode 4 with c/o outputs No fault Line fault No fault Line fault LFD o/p 3 LFD o/p 4 A Start B Stop i/p Ch A i/p Ch B o/p 2&4 o/p 1&3 BRes et * * i/p Ch A can be open or closed when i/p Ch B opens to stop latch Latching Ch C closed * i/p Ch A can be open or closed when i/p Ch B opens to stop latch o/p 2&4 o/p 1&3 (enable) i/p Ch A i/p Ch B Non-latching Ch C open Mode 1: 2 ch, each ch 1 input 2 outputs i/p - Ch A i/p - Ch C o/p 1 - - - - o/p 2 o/p 3 - - - - o/p 4 Mode 2: As mode 1 with all outputs phase reversed i/p - Ch A i/p - Ch C o/p 1 - - - - o/p 2 o/p 3 - - - - o/p 4 Mode 7: As mode 2 with LFD enabled i/p Ch C Non-latching i/p Ch B Enable i/p Ch A o/p 1 o/p 2 o/p 3 o/p 4 Mode 6: 1 ch with start/stop latch OR i/p Ch C Latching i/p Ch A i/p Ch B No effect o/p 1 o/p 2 o/p 3 o/p 4 Start Reset Stop i/p - Ch A No fault Line fault No fault Line fault o/p 1 o/p 3 i/p - Ch C o/p 2 o/p 4 INM 5500 Rev 1824 MTL5510B modes - continued Mode 14 This mode provides a two channel pulse stretcher for in- puts A and C. Outputs 1 and 2 respond to Ch A, while 3 and 4 respond to Ch C. Input B (or D) being open or closed affects the input i/p A (C) o/p 2 (4) o/p 1 (3) Initiate 1sec (min.) Endi/p B (D) 1sec (min.) i/p A (C) o/p 2 (4) o/p 1 (3) i/p B (D) Initiate End transition and the output polarity as shown in the timing diagrams below. When triggered by A (or C) the outputs hold the change of state for a minimum of 1 second or as long as the input (A or C) remains in the same triggered state. Input Ch B (or D) closed Input Ch B (or D) open Mode 9: 2 ch with line fault output i/p - Ch A No fault Line fault No fault Line fault o/p 1 No fault Line fault No fault Line fault LFD o/p 3 i/p - Ch C No fault Line fault No fault Line fault o/p 2 No fault Line fault No fault Line fault LFD o/p 3 LFD o/p 4 Mode 10: As mode 9 with line fault c/o i/p - Ch A No fault Line fault No fault Line fault o/p 1 i/p - Ch C No fault Line fault No fault Line fault o/p 2 No fault Line fault No fault Line fault LFD o/p 3 LFD o/p 4 Mode 11: As mode 10 with ch phase reversed i/p - Ch A No fault Line fault No fault Line fault o/p 1 i/p - Ch C No fault Line fault No fault Line fault o/p 2 No fault Line fault No fault Line fault LFD o/p 4 Mode 12: 3 ch with common LFD output i/p - Ch A No fault Line fault No fault Line fault o/p 1 i/p - Ch B No fault Line fault No fault Line fault o/p 2 i/p - Ch C No fault Line fault No fault Line fault o/p 3 Mode 13: As mode 12 but with LFD o/p 4 reversed No fault Line fault No fault Line fault LFD o/p 4 INM 5500 Rev 1825 6 1 5 MTL5511 - Switch/Proximity detector interface Single channel, with line-fault detection The MTL5511 contains a changeover relay, which enables a safe-area load to be controlled by a switch or proximity detector located in a hazardous-area. When selected, the line-fault detect (LFD) facility detects open or short circuit conditions in the field wiring and also indicates this on the top of the module. Line-Fault Detect and Phase Reversal for the channel are selected by DIL switches on the side of the module and output is provided by the changeover relay contacts. See page 19 for LFD and PR switch details. Channel 1 only switch settings apply. For switch sensor inputs, with LFD selected, make sure resistors (22kΩ and 680Ω) are fitted. Note: For reliable, long-term operation the load on the output switching relay should not be less than 50mW, e.g. 10mA at 5V DC. Vs– Vs+ 20 to 35V dc 22kΩ 680Ω + – Output Switch-type sensors require resistors if LFD is selected 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Hazardous area Safe area ¬ Terminal Function 1 Input –ve 2 Input +ve 10 Output normally-closed contact 11 Output common 12 Output normally-open contact 13 Supply –ve 14 Supply +ve Figure 6 5: Top label for MTL5511 INM 5500 Rev 1826 6 1 6 MTL5513 - Switch/Proximity detector interface Two-channel, with line-fault detection and phase reversal The MTL5513 enables two solid-state outputs in the safe area to be controlled by two switches or proximity detectors located in the hazardous area. The Ch1/Ch2 output transistors share a common terminal and can switch +ve or -ve polarity signals. Line-Fault Detect and Phase Reversal for the channel are selected by DIL switches on the side of the module. LFD indication is provided on the top of the module. See page 19 for LFD and PR switch details. Channel 1 & 2 switch settings apply. For switch sensor inputs, with LFD selected, make sure resistors (22kΩ and 680Ω) are fitted. Vs– Vs+ 20 to 35V dc Ch 1 Ch 2 Outputs + – 22kΩ 680Ω + – Switch-type sensors require resistors if LFD is selected 22kΩ 680Ω 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Hazardous area Safe area ¬ Terminal Function 1 Input –ve (Ch 1) 2 Input +ve (Ch 1) 4 Input –ve (Ch 2) 5 Input +ve (Ch 2) 10 Output (Ch 2) 11 Output (Ch 1/Ch 2) 12 Output (Ch 1) 13 Supply –ve 14 Supply +ve Figure 6 6: Top label for MTL5513 INM 5500 Rev 1827 6 1 7 MTL5514(-T)/MTL5514D - Switch/Proximity detector interface Single channel, with line-fault detection and phase reversal The MTL5514(-T) enables a safe-area load to be controlled, through a relay, by a proximity detector or switch located in a hazardous area. Line faults are signalled through a separate relay and indicated on the top of the module. The MTL5514D provides signal duplication, enabling two safe-area loads to be controlled by a single device in a hazardous area. Both relay outputs reflect the input signal instead of one showing the line fault condition as in the MTL5514. Line- Fault Detect and Phase Reversal for the channel are selected by DIL switches on the side of the module and output is provided by changeover relay contacts. See page 19 for LFD and PR switch details. Channel 1 only switch settings apply. For switch sensor inputs, with LFD selected, make sure resistors (22kΩ and 680Ω) are fitted. Note: For reliable, long-term operation the load on the output switching relays should be not less than 50mW, e.g. 10mA at 5V DC. ¬ Terminal Function MTL5514 (-T) MTL5514D 1 Input –ve (Ch 1) 2 Input +ve (Ch 1) 7 LFD Output contact N.C. Output 2 contact N.C. 8 LFD Output common Output 2 common 9 LFD Output contact N.O. Output 2 contact N.O. 10 Output contact N.C. Output 1 contact N.C. 11 Output common Output 1 common 12 Output contact N.O. Output 1 contact N.O. 13 Supply –ve 14 Supply +ve Figure 6 7: Top label for MTL5514 (-T) & MTL5514D Hazardous area Safe area Vs– Vs+ 20 to 35V dc 22kΩ 680Ω + – O/P LFD Switch-type sensors require resistors if LFD is selected 6 5 4 3 2 1 7 8 9 10 11 12 13 14 LFD O/P1 O/P2 7 8 9 10 11 12 INM 5500 Rev 1828 6 1 8 MTL5516C - Switch/Proximity detector interface Two channel, with line-fault detection The MTL5516C contains two changeover relays, which enable two safe-area loads to be controlled by switches or proximity detectors located in a hazardous-area. When selected, the line-fault detect (LFD) facility detects open or short circuit conditions in the field wiring and also indicates this on the top of the module. Line-Fault Detect and Phase Reversal for the channel are selected by DIL switches on the side of the module and output is provided by the changeover relay contacts. See page 19 for LFD and PR switch details. Channel 1 & 2 switch settings apply. For switch sensor inputs, with LFD selected, make sure resistors (22kΩ and 680Ω) are fitted. Note: For reliable, long-term operation the load on the output switching relays should be not less than 50mW, e.g. 10mA at 5V DC. Vs– Vs+ 20 to 35V dc + – + – Ch 2 Ch 1 22kΩ 680Ω 22kΩ 680Ω Switch-type sensors require resistors if LFD is selected 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Hazardous area Safe area ¬ Terminal Function 1 Input –ve (Ch 1) 2 Input +ve (Ch 1) 4 Input –ve (Ch 2) 5 Input +ve (Ch 2) 7 Normally-closed contact (Ch 2) 8 Common (Ch 2) 9 Normally-open contact (Ch 2) 10 Normally-closed contact (Ch 1) 11 Common (Ch 1) 12 Normally-open contact (Ch 1) 13 Supply –ve 14 Supply +ve Figure 6 8: Top label for MTL5516C INM 5500 Rev 1829 6 1 9 MTL5517 - Switch/Proximity detector interface Two channel, with line-fault detection and phase reversal The MTL5517 enables two safe-area loads to be controlled, through a relay, by switches or proximity detectors located in a hazardous-area. When selected, the line-fault detect (LFD) is signalled through a separate relay and indicated on the top of the module. Line-Fault Detect and Phase Reversal for the channel are selected by DIL switches on the side of the module and output is provided by the relay contacts. See page 19 for LFD and PR switch details. Channel 1 & 2 switch settings apply. For switch sensor inputs, with LFD selected, make sure resistors (22kΩ and 680Ω) are fitted. Note: For reliable, long-term operation the load on the output switching relays should be not less than 50mW, e.g. 10mA at 5V DC. Vs– Vs+ 20 to 35V dc LFD + – + – Switch-type sensors require resistors if LFD is selected Ch 2 Ch 1 LFD 22kΩ 680Ω 22kΩ 680Ω 6 5 4 3 2 1 7 8 9 10 11 12 13 14 LFD Hazardous area Safe area ¬ Terminal Function 1 Input –ve (Ch 1) 2 Input +ve (Ch 1) 4 Input –ve (Ch 2) 5 Input +ve (Ch 2) 7 Line-fault detection 8 Output (Ch 2) 9 Output (Ch 2) 10 Line-fault detection 11 Output (Ch 1) 12 Output (Ch 1) 13 Supply –ve 14 Supply +ve Figure 6 9: Top label for MTL5517 INM 5500 Rev 1830 6 2 Digital Output modules The single channel Digital Output (DO) module range enables on/off devices in a hazardous area to be controlled from the safe area. Some units are loop powered while others enable solid-state switching by providing independent power supplies. 6 2 1 MTL5521(-T) - Solenoid Alarm driver Single channel, loop powered, IIC The MTL5521(-T) is a loop-powered module that enables a device located in the hazardous area (IIC gas group) to be controlled from the safe area. The MTL5521(-T) can drive a certified intrinsically safe low-power load, as well as non-energy-storing simple apparatus such as an LED. 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Solenoid, alarm or other IS device 20 – 35Vdc – + + – To earth leakage detector * Hazardous area Safe area ¬ ¬ Terminal Function 1 Output –ve 2 Output +ve 11 Supply –ve 12 Supply +ve Figure 6 10: Top label for MTL5521(-T) INM 5500 Rev 1831 6 2 2 MTL5522 - Solenoid Alarm driver Single channel, loop powered, IIB The MTL5522 is a loop-powered module which enables a device located in the hazardous area (IIB gas group) to be controlled from the safe area. The MTL5522 can drive a certified intrinsically safe, low-power load as well as non-energy-storing simple apparatus such as an LED. 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Solenoid, alarm or other IS device 20 – 35Vdc – + + – Hazardous area Safe area ¬ ¬ Terminal Function 1 Output –ve 2 Output +ve 11 Supply –ve 12 Supply +ve Figure 6 11: Top label for MTL5522 INM 5500 Rev 1832 Hazardous area Safe area 6 2 3 MTL5523 - Solenoid Alarm driver Single channel, with line-fault detection, IIC The MTL5523 interface controls an on/off device in a hazardous area using a volt-free contact or logic signal in the safe area, and is suitable for driving loads such as solenoids. Line-Fault Detection (LFD) operates independently of the output state and is signalled by a safe-area, solid-state switch output which, when a field line is open or short-circuited, becomes de- energised. Earth-fault detection can be provided by connecting an earth leakage detector to terminal 3. 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Solenoid, alarm or other IS device + – Vs– Vs+ 20 to 35V dc + – LFD + ‡ ‡ link to reverse output phase Control ¬ Terminal Function 1 Output –ve 2 Output +ve 7 Line fault signal -ve 8 Phase reversal link 9 Phase reversal link 10 Line fault signal +ve 11 Control –ve 12 Control +ve 13 Supply –ve 14 Supply +ve Figure 6 12: Top label for MTL5523 INM 5500 Rev 1833 6 2 4 MTL5523V/MTL5523VL - Solenoid Alarm driver Single channel, voltage controlled with line-fault detection, IIC With the MTL5523V or MTL5523VL interface, an on/off device in a hazardous area can be controlled by a voltage signal in the safe area. It is suitable for driving loads such as solenoids. Line fault detection (LFD), which operates irrespective of the output state, is signalled by a safe- area, solid-state switch which energises if a field line is open or short–circuited. The VL version has a lower current capability to suit alternative load requirements - see datasheet. Hazardous area Safe area Terminal Function 1 Output –ve 2 Output +ve 7, 8, 9 Line fault signal –ve 10 Line fault signal +ve 11 Control –ve 12 Control +ve 13 Supply –ve 14 Supply +ve 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Solenoid, alarm or other IS device + – Vs– Vs+ 20 to 35V dc + – LFD + ControlV PWR STS MTL5523V PWR STS MTL5523VL Figure 6 13: Top labels for MTL5523V & MTL5523VL INM 5500 Rev 1834 Hazardous area Safe area 6 2 5 MTL5524 - Solenoid Alarm driver Single channel, powered, logic drive with phase reversal The MTL5524 enables an on/off device in a hazardous area to be controlled by a volt-free contact or logic signal in the safe area. It can drive loads such as solenoids, alarms, LEDs and other low power devices that are certified as intrinsically safe or are classified as non-energy- storing simple apparatus. 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Solenoid, alarm or other IS device + – Vs– Vs+ 20 to 35V dc + – Control ‡ ‡ use link to reverse phase ¬ Terminal Function 1 Output –ve 2 Output +ve 8 Phase reversal link 9 Phase reversal link 11 Control –ve 12 Control +ve 13 Supply –ve 14 Supply +ve Figure 6 14: Top label for MTL5524 INM 5500 Rev 1835 6 2 6 MTL5525 - Solenoid Alarm driver Single channel, low current, loop powered, IIC The MTL5525 enables an on/off device in a hazardous area (IIC gas group) to be controlled by a switch or voltage change in the safe area. It can drive loads such as solenoids, alarms, LEDs and other low power devices that are certified as intrinsically safe or are classified as non-energy-storing simple apparatus. Similar in function to the MTL5521, this module provides lower power output and corresponding reduced safety description. 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Solenoid, alarm or other IS device 20 – 35Vdc – + + – Hazardous area Safe area ¬ ¬ Terminal Function 1 Output –ve 2 Output +ve 11 Supply –ve 12 Supply +ve Figure 6 15: Top label for MTL5525 INM 5500 Rev 1836 6 2 7 MTL5526 - Switch Operated Relay Two channel, output The MTL5526 enables two separate IS circuits in a hazardous area to be relay-contact controlled by two on-off switches or logic signals in a safe area. Applications include the calibration of strain–gauge bridges; changing the polarity (and thereby the tone) of an IS sounder; the testing of IS fire alarms; and the transfer of safe-area signals into an annunciator with IS input terminals not segregated from each other. The output–relay contacts are certified as non–energy–storing apparatus, and can be connected to any IS circuit without further certification, provided that separate IS circuits are such that they would remain safe if connected together. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 IS relay IS relay 1 Vs– Vs+ 20 to 35V dc + – 2 + – Control 20 to 35V dc + – + – Loop powered Contact inputs All contacts shown in normal position (relays de-energised) 1 2 Sw4 Hazardous area Safe area ¬ Terminal Function 1 IS relay output 1 (normally open) 2 IS relay output 1 (normally closed) 3 IS relay output 1 (common) 4 IS relay output 2 (common) 5 IS relay output 2 (normally closed) 6 IS relay output 2 (normally open) 8 Relay 1 control +ve 9 Relay 1 control –ve 10 Relay 2 control +ve 11 Relay 2 control –ve 13 Supply –ve 14 Supply +ve OFF position ON position 1 2 3 4 Table 6 3: Switch settings for modes Mode Function SW1 SW2 SW3 SW4 Contact/Logic Input 2 ch Off On On On 1in2out On On On On Loop Powered 2 ch Off Off Off Off Figure 6 16: Top label for MTL5526 INM 5500 Rev 1837 6 3 Pulse, Vibration and Foundation Fieldbus modules Single and dual channel modules are available to transfer vibration probe signals from a hazardous area to a safe one. Similarly, pulses from a switch, proximity detector, current pulse transmitter or voltage pulse transmitter, located in the hazardous area, can be safely transferred to the safe area. 6 3 1 MTL5531 - Vibration Transducer Interface Single channel The MTL5531 repeats a signal from a vibration sensor in a hazardous area, providing an output for a monitoring system in the safe area. The interface is compatible with 3-wire, eddy-current probes and accelerometers or 2-wire current sensors, and selection of the mode is made with a switch located on the side of the module Hazardous area Safe area 6 5 4 3 2 1 7 8 9 10 11 12 13 14 COM SIG V– Vibration transducer Vibration transducer Vs– Vs+ 20 to 35V dc –ve 0V Monitor 3- wire 2- wire 2 1 3 Terminal Function 1 Transducer power V– 2 Signal 3 Common 11 Signal output –ve 12 Signal output 0V 13 Supply –ve 14 Supply +ve ¬ OFF position ON position 2-/3-wire 2-/3-wire transducer setting switch Mode SW 2-wire (3 3mA)* OFF 3-wire (20mA) ON * Note: When using 2-wire sensors, ensure that terminals 1 and 2 are linked as shown in the wiring diagram above. WARNING - Revision status 05 and below* To enable optimum heat dissipation the recommended orientation for mounting is with the module vertical, i e with the vents in the case at the top and bottom This enables air to flow through the module In any other orientation, i e with the module horizontal, then the maximum ambient temperature is limited to: • Close packed = 45°C • Minimum of 10mm spacing = 55°C Eaton produce the MS010 DIN rail module spacer for this purpose (packs of 5 - see Section 4 3) *Revision status is the 2 digits after the +++ in the barcode number Figure 6 17: Top label for MTL5531 INM 5500 Rev 1838 6 3 2 MTL5532 - Pulse Isolator Pulse & 4/20mA current outputs The MTL5532 isolates pulses from a switch, proximity detector, current pulse transmitter or voltage pulse transmitter located in a hazardous area. It is ideal for applications involving high pulse rates and fast response times, by repeating the pulses into the safe area, and the transistors used on the pulse output will switch +ve or –ve polarity signals. It may be used immediately in simple or legacy mode, or it may be software configured for more specific applications - see next page for either option. With configuration, an analogue output proportional to frequency is available, together with a relay output, which may act as an alarm. Note: For reliable, long-term operation the load on the output switching relay should not be less than 50mW, e.g.10mA at 5VDC. Hazardous area Safe area 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Vs– Vs+ 20 to 35V dc 3-wire current pulse 4/20 mA – + 3-wire voltage pulse 5 4 1 2-wire current pulse Voltage pulse Current pulse 5 1 Inhibit Load Alarm 4/20mA Configuration socket – + 1 4 + Pulse – + Pulse 4 3 V 4/20 mA 3 1 3 4/20 mA Terminal Function 1 Common input –ve 2 Switch/proximity input +ve 3 Current pulse input +ve 4 Transmitter supply +ve 5 Voltage pulse input +ve 6 Inhibit input +ve 7 Alarm output 8 Current output –ve 9 Current output +ve 10 Alarm output 11 Pulse output –ve 12 Pulse output +ve 13 Supply –ve 14 Supply +ve ¬ ¬ Vsp SW1 SW2 3V ON ON 6V ON OFF 12V OFF OFF OFF position ON position 1 2 3 4 SW1 SW2 SW3 SW4 Vsp Vsp LFD Mode LFD SW3 OFF OFF ON ON Switches located on the edge of the module define the mode of operation. Figure 6 18: Top label for MTL5532 INM 5500 Rev 1839 Switch input operation If switch contacts are used for this Pulse Input (terminals 1 & 2), then and parallel resistors must be fitted - see Section 6.1.2 for recommended values. Simple or Legacy mode - SW4 - OFF If simple "pulse-in/pulse-out" operation is required or, if a replacement for the earlier MTL5032 pulse isolator is required, then SW4 should be set to OFF. The input switching point voltage (Vsp) thresholds can then be defined by Switches 1 & 2, and the LFD operation can be set with Switch 3. When Switch 3 is ON, the Alarm output (terminals 11 & 12) become active. Configurable mode - SW4 - ON In this mode, analogue, alarm and pulse outputs are available but the module must be software configured to define its operating mode. In this mode, software controls the LFD function and Switch 3 has no effect. Switches 1 & 2 continue to define the switching point threshold (Vsp). Configuration requires a personal computer, a PCL45USB interface and PCS45 software. See Section 6.9 for details of the configurator. Alarm inhibiting The Inhibit input is provided to inhibit alarm output operation. This facility is useful, for example, during power-up, when pulse rates are below the alarm threshold. When normal operational values are established the inhibit can be disabled. Such a facility is sometimes referred to as a start-up delay. Inhibit is enabled by connecting a switch or proximity detector between terminals 6 and 3. If switch contacts are used for this input, then and parallel resistors must be fitted - see Section 6.1.2 for recommended values. LED indicators Use the following LED information to understand the module status. LED Description PWR Power (green) ON - Power OK OFF - No power or insufficient voltage O/P Output (yellow) The LED will follow the pulse output state. If the output is pulsing then the LED brightness will pulse. If the pulsing is rapid or very short, the LED may dim if it is unable to respond to such changes. If the output is high, the LED will be ON. STS Status (red - flashing) In legacy mode a line fault will cause the LED to turn ON. In mC mode, the LED is programmable to display a line fault or an Alarm trip operation. In the event, it will also indicate a mC fault condition. INM 5500 Rev 1840 6 3 3 MTL5533 - Vibration Transducer Interface (Reference use only: Terminated product, use 2 x MTL5531) Two channel The MTL5533 repeats signals from vibration sensors in a hazardous area, providing outputs for monitoring systems in the safe area. The interface is compatible with 3-wire eddy-current probes and accelerometers or 2-wire current sensors, and selection of the mode for each channel is made with the switches on the side of the module. Hazardous area Safe area Vibration transducer Vibration transducer Vibration transducer Vibration transducer COM SIG V– COM SIG V– Vs– Vs+ 20 to 35V dc –ve 0V Monitor 3- wire 2 1 3- wire 2- wire 5 4 2- wire Monitor –ve 0V 3 6 Ch 1 Ch 2 Ch 1 Ch 2 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Terminal Function 1 Transducer power V– (Ch1) 2 Signal (Ch1) 3 Common (Ch1) 4 Transducer power V– (Ch2) 5 Signal (Ch2) 6 Common (Ch2) 8 Signal output –ve (Ch2) 9 Signal output 0V (Ch2) 11 Signal output –ve (Ch1) 12 Signal output 0V (Ch1) 13 Supply –ve 14 Supply +ve ¬ OFF position ON position Ch 1 Ch 2 2-/3-wire transducer setting switches Mode SW 2-wire (3 3mA) OFF 3-wire (20mA) ON * Note: When using 2-wire sensors, ensure that terminals 1 & 2 and 4 & 5 have wiring links as shown in the wiring diagram above. WARNING! To enable adequate heat dissipation from the MTL5533 modules, they must be installed on the DIN rail with a 10mm space between adjacent units Eaton produce the MS010 DIN rail module spacer for this purpose (packs of 5 - see Section 4 3), and these then enable operation in ambient temperatures of up to 50°C in vertical or horizontal orientation Figure 6 19: Top label for MTL5533 INM 5500 Rev 1841 6 3 4 MTL MTL5553 isolator/power supply for 31 25kbit/s fieldbuses The MTL5553 has been specifically developed to extend 31.25kbit/s (H1) fieldbus networks into hazardous areas. It provides power, communication and IS isolation to devices powered through the signal conductors. The MTL5553 complies with the requirements of Fieldbus Foundation™ specified power supply Type 133 (IS power supply). To comply with fieldbus standards, each bus must be terminated at both ends. MTL's FBT1-IS or FCS-MBT fieldbus terminators (see section 6.33?) can be supplied for this purpose or, for installations in which the safe-area bus length is small, the MTL5553 includes an internal safe-area terminator which is enabled by making a link between terminals 7&8 on the top of the unit. For network and termination criteria, check applicable fieldbus standards and specification IEC 61158-2, ISA-S50.02 for 31.25kbit/s fieldbus systems, Foundation™ Fieldbus 31.25kbit/s Physical LayerProfile Specification FF-816 and MTL's Application Brief AB002.) Hazardous area Safe area 20-35V dc Vs+ Vs- +ve -ve +ve -ve Host (31.25kbit/s) Terminator 1 2 4 5 +ve -ve +ve -ve Field (31.25kbit/s) 6 3 2.6W Max 8 9 T 14 13 11 10 7 12 Link 7- 8 for Terminator Terminal Function 1 Hazardous-area fieldbus device(s) connection –ve 2 Hazardous-area fieldbus device(s) connection +ve 4 Optional HHC connection –ve 5 Optional HHC connection +ve 7 Link to 8 to enable internal terminator 8 & 11 Safe-area fieldbus device(s) connection –ve 9 & 12 Safe-area fieldbus device(s) connection +ve 13 Supply –ve 14 Supply +ve Note: To assist the process of terminating cable screens, screw terminals have been provided in terminals 3, 6, and 10. Please note, however, that there is no internal connection for these terminals so they are not earthed. NOTE To allow adequate heat dissipation under all likely thermal conditions, it is recommended that MTL5553s are installed on a horizontal DIN-rail mounted on a vertical surface* with a 10mm space between adjacent units. MTL MS010 10mm DIN-rail module spacers are available for this purpose. * If an MTL5553 is mounted in a non-optimum orientation, the maximum operating temperature is reduced to 45°C. INM 5500 Rev 1842 6 4 Analogue Input modules The analogue input (AI) modules support 2-wire or 3-wire 4/20mA or HART transmitters located in a hazardous area; repeating the current in other circuits to drive safe-area loads. 6 4 1 MTL5541/MTL5541-T/MTL5541S (-T) - Repeater Power Supply Single channel, for 4/20mA HART® for 2- or 3-wire transmitters The MTL5541 provides a fully-floating dc supply for energising a conventional 2- or 3-wire 4/20mA transmitter which is located in a hazardous area, and repeats the current in another floating circuit to drive a safe-area load. For HART 2-wire transmitters, the unit allows bi- directional communications signals superimposed on the 4/20mA loop current. Alternatively, the MTL5541S (-T) acts as a current sink for a safe-area connection rather than driving a current into the load. Separately powered current sources, such as 4-wire transmitters, can be connected but will not support HART communication. Hazardous area Safe area 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Vs– Vs+ 20 to 35V dc 4/20mA MTL5541 MTL5541S – 4/20mA Load+ Load + — + Com Tx+ Input I I ¬ Terminal Function 1 Current input 2 Transmitter supply +ve 3 Common 10 Output +ve via 220Ω for HART apps. 11 Output –ve (+ve current sink) 12 Output +ve (–ve current sink) 13 Supply –ve 14 Supply +ve Figure 6 20: Top labels for MTL5541 & MTL5541S S INM 5500 Rev 1843 6 4 2 MTL5541A/MTL5541AS - Repeater Power Supply Single channel, for 4/20mA, HART® for 2- or 3-wire transmitters The MTL5541A provides an input for separately powered 4/20mA transmitters and also allows bi–directional transmission of HART communication signals superimposed on the 4/20mA loop current. Alternatively, the MTL5541AS acts as a current sink for a safe-area connection rather than driving a current into the load. Hazardous area Safe area Vs– Vs+ 20 to 35V dc – 4/20mA Load +– + MTL5541A MTL5541AS Load + — + 4/20mA 6 5 4 3 2 1 7 8 9 10 11 12 13 14 I I¬ ¬ Terminal Function 1 Input –ve 2 Input +ve 11 Output –ve (+ve current sink) 12 Output +ve (–ve current sink) 13 Supply –ve 14 Supply +ve Figure 6 21: Top labels for MTL5541A & MTL5541AS INM 5500 Rev 1844 6 4 3 MTL5544/MTL5544S - Repeater Power Supply Two channel, for 4/20mA HART® for 2- or 3-wire transmitters The MTL5544 provides fully-floating dc supplies for energising two conventional 2-wire or 3-wire 4/20mA or HART transmitters located in a hazardous area, and repeats the current in other circuits to drive two safe-area loads. For HART transmitters, the unit allows bi-directional transmission of digital communication signals superimposed on the 4/20mA loop current. Alternatively, the MTL5544S acts as a current sink for a safe-area connection rather than driving a current into the load. Separately powered current sources, such as 4-wire transmitters, can be connected but will not support HART communication. Hazardous area Safe area Vs– Vs+ 20 to 35V dc – 4/20mA Load + – 4/20mA Load + Ch 2 Ch 1 MTL5544 MTL5544S Load + – Load + – 4/20mA 4/20mA Ch 2 Ch 1 Com Tx+ Input Com Tx+ Input 6 5 4 3 2 1 7 8 9 10 11 12 13 14 I I I I ¬ ¬ Terminal Function 1 Ch1 current input 2 Ch1 transmitter supply +ve 3 Ch1 common 4 Ch2 current input 5 Ch2 transmitter supply +ve 6 Ch2 common 7 Ch2 output +ve via 220Ω for HART apps. 8 Ch2 output –ve (+ve current sink) 9 Ch2 output +ve (–ve current sink) 10 Ch1 output +ve via 220Ω for HART apps. 11 Ch1 output –ve (+ve current sink) 12 Ch1 output +ve (–ve current sink) 13 Supply –ve 14 Supply +ve Hazardous area Safe areaThe MTL5544 or MTL5544S can also be used to drive two safe-area loads from a single 2-wire transmitter (i.e. 1 in, 2 out) by interconnecting the input channels as shown in the diagram (right). Note: In this mode the HART data is transferred via channel 1 output only. See also the MTL5544D. Vs– Vs+ 20 to 35V dc – 4/20mA Load + – 4/20mA Load + Ch 2 Ch 1 MTL5544 MTL5544S Load + – Load + – + –4/20mA 6 5 4 3 2 1 7 8 9 10 11 12 13 14 I I I I Figure 6 22: Top labels for MTL5544 & MTL5544S INM 5500 Rev 1845 6 4 4 MTL5544A/MTL5544AS - Current Repeater Two channel, for 4/20mA passive input for HART® transmitters The MTL5544A provides an input for separately powered 4/20mA transmitters and also allows bi–directional transmission of HART communication signals superimposed on the 4/20mA loop current. Alternatively, the MTL5544AS acts as a current sink for a safe-area connection rather than driving a current into the load. Hazardous area Safe area Vs– Vs+ 20 to 35V dc + – Ch 2 Ch 2 Ch 1 + – Ch 1 4/20mA 4/20mA 6 5 4 3 2 1 7 8 9 10 11 12 13 14 I I I I MTL5544A MTL5544AS – 4/20mA Load+ Load + — + – 4/20mA Load+ Load + — + ¬ ¬ Terminal Function 1 Ch1 input –ve 2 Ch1 input +ve 4 Ch2 input –ve 5 Ch2 input +ve 8 Ch2 output –ve (+ve current sink) 9 Ch2 output +ve (–ve current sink) 11 Ch1 output –ve (+ve current sink) 12 Ch1 output +ve (–ve current sink) 13 Supply –ve 14 Supply +ve Figure 6 23: Top labels for MTL5544A & MTL5544AS INM 5500 Rev 1846 6 4 5 MTL5544D - Repeater Power Supply Two channel, for 4/20mA HART® for 2- or 3-wire transmitters, two outputs The MTL5544D provides a fully-floating dc supply for energising a conventional 2- or 3-wire 4/20mA transmitter located in a hazardous area, and repeats the current in other circuits to drive two safe-area loads. For HART 2-wire transmitters, the unit allows bi-directional transmission of digital communication signals superimposed on the 4/20mA loop current via channel 1 only,Separately powered current sources, such as 4-wire transmitters, can be connected but will not support HART communication. Hazardous area Safe area Vs– Vs+ 20 to 35V dc Ch 2 Ch 1 – 4/20mA Load+ – 4/20mA Load+4/20mA 6 5 4 3 2 1 7 8 9 10 11 12 13 14 Com Tx+ Input I I I ¬ Terminal Function 1 Current input 2 Transmitter supply +ve 3 Common 7 Ch2 output +ve via 220Ω HART not supported. 8 Ch2 output –ve 9 Ch2 output +ve 10 Ch1 output +ve via 220Ω for HART apps. 11 Ch1 output –ve 12 Ch1 output +ve 13 Supply –ve 14 Supply +ve NOTE: For correct operation of the module, a suitable load must be present on both output channels. This is of particular importance during testing, commissioning or maintenance activities when the temporary disconnection, or absence, of a load can affect the transfer accuracy of the analogue variable. Figure 6 24: Top label for MTL5544D INM 5500 Rev 1847 6 5 Analogue Output modules The analogue output (AO) modules accept 4/20mA floating signals from safe-area controllers to drive current/pressure converters (or any other load up to 800Ω) in a hazardous area. 6 5 1 MTL5546/MTL5546Y(-T) - Isolating Driver Single channel, for 4/20mA HART® valve positioners with line-fault detection The MTL5546 accepts a 4/20mA floating signal from a safe-area controller to drive a current/ pressure converter (or any other load up to 800Ω) in a hazardous area. For HART valve positioners, the module also permits bi-directional transmission of digital communication signals so that the device can be interrogated either from the operator station or by a hand-held communicator. Process controllers with a readback facility can detect open or short circuits in the field wiring: if these occur, the current taken into the terminals drops to a preset level. The MTL5546Y(-T) is very similar to the MTL5546 except that it provides open circuit detection only (i.e. no short-circuit detection). Hazardous area Safe area ¬ ¬ ¬ ¬ ¬ Terminal Function 1 Output –ve 2 Output +ve 11 Input –ve 12 Input +ve 13 Supply –ve 14 Supply +ve Input characteristics Field wiring state MTL5546 MTL5546Y Normal <6.0V <6.0V Open-circuit <0.9mA <0.5mA Short-circuit <0.9mA N.A. Figure 6 25: Top labels for MTL5546 & MTL5546Y INM 5500 Rev 1848 6 5 2 MTL5549/ MTL5549Y - Isolating Driver Two channel, for 4/20mA HART® valve positioners with line-fault detection The MTL5549 accepts 4/20mA floating signals from safe-area controllers to drive 2 current/ pressure converters (or any other load up to 800Ω) in a hazardous area. For HART valve positioners, the module also permits bi-directional transmission of digital communication signals so that the device can be interrogated either from the operator station or by a hand-held communicator. Process controllers with a readback facility can detect open or short circuits in the field wiring: if these occur, the current taken into the terminals drops to a preset level. The MTL5549Y is very similar to the MTL5549 except that it provides open circuit detection only (i.e. no short-circuit detection). Hazardous area Safe area ¬ ¬ ¬ ¬ ¬ Terminal Function 1 Output –ve (Ch 1) 2 Output +ve (Ch 1) 4 Output –ve (Ch 2) 5 Output +ve (Ch 2) 8 Input –ve (Ch 2) 9 Input +ve (Ch 2) 11 Input –ve (Ch 1) 12 Input +ve (Ch 1) 13 Supply –ve 14 Supply +ve Input characteristics Field wiring state MTL5549 MTL5549Y Normal <6.0V <6.0V Open-circuit <0.9mA <0.5mA Short-circuit +50mV ON – NO Vin* ON – YES 16.5V. 8 3 2 Modules: MTL5541S(-T), MTL5544S & MTL5561 Figure 8 6: AI test circuit #2 "o/p sinking" Output Measurements Note: Do not connect a voltmeter in circuit to measure V1 until requested in Step 4 below, because current measurement A2 could be affected. 1. Adjust RV1 to vary the current (A1) through the range 4 to 20mA. 2. The measured current imbalance (A2) over this range for the MTL5541S and the MTL5544S should not exceed ± 20μA. For the MTL5561 the imbalance should not exceed ± 400μA. 3. Adjust RV1 for a 20mA reading on A1 4. The voltage V1, across the channel input, should typically be >16.5V. ¬ ¬ ¬ ¬ + – + – V1 i/p o/p RV1 10kΩ lin. A1 250Ω 24V + – I oli A2 + – INM 5500 Rev 1863 8 3 3 Modules: MTL5541A & MTL5544A Figure 8 7: AI test circuit #3 "active i/p" Output Measurements 1. Adjust RV1 to vary the current (A1) through the range 4 to 20mA. 2. The measured current imbalance (A2) over this range should not exceed ± 20mA 8 3 4 Modules: MTL5541AS & MTL5544AS Figure 8 8: AI test circuit #4 "active i/p - o/p sinking" Output Measurements 1. Adjust RV1 to vary the current (A1) through the range 4 to 20mA. 2. The measured current imbalance (A2) over this range should not exceed ± 20mA ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ ¬ INM 5500 Rev 1864 8 3 5 Module: MTL5581 Figure 8 9: AI test circuit #5 "mV input" Note: V1 should be capable of measurement to within 1mV. Output Measurements 1. With the LINK connected, vary output V2 between 0 and 50mV using RV1. V1 should show +50mV with the switch set to '+', or 19V. Vary the potentiometer setting and check that the reading on voltmeter V varies by no more than ±100mV. + – + – A2 + – A1 o/p i/p current source +– 470Ω load I oli INM 5500 Rev 1866 8 5 2 Testing MTL5553 - Isolator/power supply for 31 25kbits/s fieldbuses Make the safe and hazardous-area connections shown in figure 10.2 and, substituting appropriate resistors at Rtest, carry out the following checks. Rtest Voltage across terminals 2 and 1 (V1) Open-circuit 17.8 < V1 < 19V 220Ω 11.5V < V1 < 13.5V 10Ω V1 < 5V 20-35V dc Vs- Vs+ -ve +ve -ve Host (31.25kbit/s) Terminator 1 2 4 5 6 3 2.6W Max 8 9 T 14 13 11 10 7 12 Link 7- 8 for Terminator Hazardous Area Safe Area V1 R test + - Top Label, MTL5553 Test circuit for MTL5553 INM 5500 Rev 1867 9 APPLICATIONS INVOLVING ZONE 2 AND/OR ZONE 22 HAZARDOUS AREAS IMPORTANT: See page iv at the front of this manual for important additional information regarding the use of these products in countries governed by the ATEX Directive. The European Community permits Category 3G equipment, such as the MTL5500 , to be installed in, or connected to, Zone 2 flammable atmospheres provided it meets the requirements of the ATEX Directive. MTL5500 Category 3 products have been designed to meet, and carry approval markings for, Ex nC and/or Ex nA. In general, meeting the relevant requirements of the appropriate European (CENELEC) standards is considered the most appropriate method of demonstrating compliance with the ATEX directive. However, Eaton often has its products approved by other national bodies, such as FM and CSA and, because national, European, and international standards are converging, it is generally possible to use other national approvals as supporting evidence for the ATEX Technical File. In the context of this document, Zone 2 (Division 2) and Zone 22 hazardous areas are those that may become potentially explosive through the presence of flammable gases, vapours and dusts for periods of up to 10 hours per year. It is recommended that the current version of the standards is consulted for detailed information on the requirements applicable to the particular installation. As a consequence of their IS approvals, MTL5500 products may also be connected into Zone 22 hazardous areas. Consult individual module approvals for further details. Unless otherwise specified, the following ambient conditions apply: Ambient Temperature range –20°C to +60°C Pollution Degree 2 (See EN 61010-1) Measurement Category II (See EN 61010-1) 9 1 Enclosure EN 60079-15 specifies the minimum required degree of protection to be IP54, but generally this is provided by the external enclosure in which the product is mounted. The user must refer to the specific certificates relating to the products being installed within the hazardous area to check that all special conditions of safe use have been complied with. INM 5500 Rev 1868 10 APPENDIX 1 10 1 MTL5000 Many modules in the MTL5000 Isolating Interface Units range have now been superceded by their equivalent in the MTL5500. For new applications the MTL5500 modules are recommended, these offer all the benefits of greater efficiency, new multichannel modules and new functionality. A number of the products in the MTL5000 will continue to provide key functionality as part of MTL DIN rail isolator range and are described within this Appendix. Important • Make sure that all installation work is carried out in accordance with all relevant local standards, codes of practice and site regulations. • When planning the installation of MTL5000 isolators it is essential to make sure that intrinsically safe and non-intrinsically safe wiring is segregated, and that units are installed as required by a nationally accepted authority or as described in EN 60079-14, ISA RP 12.6 or DIN VDE-165. • Check that the hazardous-area equipment complies with the descriptive system document. • If in doubt, refer to the certificate/catalogue for clarification of any aspects of intrinsic safety or contact Eaton's MTL product line or your local representative for assistance. • Make sure the correct hazardous-area connector (field-wiring plug) is plugged into the corresponding isolator. It is recommended that the connector is identified by the same tag number as the matching isolator. Mount all MTL5000 isolators on low-profile (7mm) or high-profile (15mm) type T35 (top-hat) DIN-rail to EN50022, BS5584, DIN46277. This is available from Eaton, in 1 metre lengths (THR2 - DIN rail). Install isolators within the safe area unless they are enclosed in approved flameproof, pressurised or purged enclosures and ensure that the local environment is clean and free of dirt and dust. Note the ambient temperature considerations of section 3.1.4. It is recommended that, in normal practice, the DIN rail should be earthed/grounded to ensure the safety of personnel in the event of a.c. mains (line) power being applied accidentally to the rail. Power connectors 104 115 110 16 16.2mm PITCH HAZ SAFE Hazardous-area connections Non-hazardous (safe) area connections INM 5500 Rev 1869 10 2 MTL5018AC single-pole, changeover relay, two-channel, switch/proximity detector with line fault detection and phase reversal The MTL5018AC modules enable each of two safe-area loads to be relay-controlled by switches or proximity detectors in a hazardous area. Line fault detection (LFD) and output phase reversal facilities are included (see section 6.1). 10 2 1 Wiring connections See figure 10.1 for wiring connections. Note: Reactive loads must be adequately suppressed. 10 2 2 Line fault detection (See section 6.1 for definition of a line fault) On each channel, input line faults (open- or short-circuit) are indicated by an LED and the de-energising of the output. LFD is enabled/disabled by switches located on the top of the module. Note: that if the LFD facility is enabled for switch inputs, the resistors shown in 10.1 and 10.2 MUST be fitted. Terminal Function 1 Input –ve (Ch 1) 2 Input +ve (Ch 1) 3 4 Input –ve (Ch 2) 5 Input +ve (Ch 2) 6 7 Normally-closed contact (Ch 2) 8 Common (Ch 2) 9 Normally-open contact (Ch 2) 10 Normally-closed contact (Ch 1) 11 Common (Ch 1) 12 Normally-open contact (Ch 1) 13 Supply N 14 Supply L Hazardous area Safe area Figure 10 1: MTL5018AC wiring diagram and connections INM 5500 Rev 1870 10 2 3 Testing Make the safe- and hazardous-area connections shown in figure 10.2, and check the status of the output contacts for each channel in turn (with a 22kΩ resistor connected to the other channel) as shown in the table 10.1. Phase reverse switch Line fault detection Input switch (SW) Output relay (11-12, 8-9) Output relay (10-11, 7-8) Channel status LED (yellow) Line fault LED (red) Normal Off a Closed Open On Off Reverse Off ISC = 7 _ 9mA Open Closed Off Off Reverse Off Open Closed Open Off Off Normal On VOC = 7.5 _ 9.5V Open Closed Off On Normal On a Open Closed Off On Normal On b Open Closed Off Off Normal On c Closed Open On Off Figure 10 2: Test circuit for MTL5018AC Table 10 1 INM 5500 Rev 1871 10 3 MTL5051 serial data comms isolator The MTL5051provides either bi-directional serial data communications from a computer system in a safe area to instrumentation in a hazardous area or data communications across a hazardous area. It is used to provide a fully floating dc supply for, and serial data communications to MTL640 text displays and MTL650 text and graphics terminals or to other IS and non-IS instrumentation and keyboards. 10 3 1 Wiring connections See the figures 10.3 and 10.4 and the terminal specifications in tables 10.2 and 10.3 for wiring connections. Figure 10.3: MTL5051 wiring diagram (to a hazardous area) Hazardous area Safe area Safe areaHazardous area Figure 10.4: MTL5051 wiring diagram (across a hazardous area) INM 5500 Rev 1872 10 3 2 Hazardous-area interfacing Displays/terminals: For details of interfacing with MTL640 and MTL650 displays/terminals (as an alternative to the MTL696 communications interface) see the appropriate product instruction manual. Table 10 2 MTL5051 Terminals MTL640 mode MTL650 mode Comms mode Other IS devices 1 Common Common Common Common 2 V signal 12V - 5V/12V 3 I return Rx Rx - 4 - Tx Tx - 5 - - - Tx 6 - - - Rx Switch 1a On Off Off Off 1b On On On Off/On Table 10 3 Terminals RS232 mode TTL mode RS422 mode 7 - - Rx- 8 - - Rx+ 9 - Tx Tx+ 10 Tx - Tx- 11 Common Common Common 12 Rx Rx - 13 Supply -ve Supply -ve Supply -ve 14 Supply +ve Supply +ve Supply +ve Switch 2a Off On On 2b On Off Off Across hazardous areas: For communication across hazardous areas MTL5051 devices are used in pairs to transfer bi-directional full duplex data across hazardous areas, as shown in figure 10.4. Current switching is used to minimise the bandwidth-limiting effects of long cables. The maximum baud rate in this mode is the lesser of 19.2k baud or the cable-related rate produced by the following formula. Remote signalling baud rate formula, for back-to-back mode across a hazardous area: max baud rate = K/(RxCxL2) where K = 0.25 (constant) R = cable resistance (Ω/m) C = cable capacitance (F/m) L = length (m) For example, with a 2km cable of 100pF/m capacitance and 40mΩ/m resistance, the maximum baud rate = 0.25/(40mΩ x 100pFx 2km2) = 15k baud. This assumes that the cable is 2 cores plus screen, with the screen used for the ‘common’ connection. RS232-level devices: Communication with RS232-level interfaces, such as a suitably certified IS keyboard, mouse, etc, is achieved by using one or more MTL5051 units as required by the IS device.(TTL level interfaces are accommodated by the TTL compatibility of RS232 receivers.) The supply to IS equipment at terminal 2 can be set to either 5V or 12V, by a switch located on top of the unit, as follows: +12V mode 12.0V ±5% (load 23mA to 23mA to <50mA) Note: the normal RS232 limitations of bandwidth versus cable length are applicable. As a rule of thumb, speed (baud) x length (metres) trip setting • open closed H (high) Input trip setting closed open L (low) Input Industry Events & Webinars>Industry Automation Control Blog> mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric mySchneider Sustainability School: Training you for success Everything you need to know to thrive in the New Electric World Turn your climate ambition into action At Schneider Electric, we’re training partners worldwide to enable sustainable practices and decarbonize the economy. Our Sustainability School provides the knowledge and tools you need to differentiate your business and win more projects! Chapter 1 courses – two levels! In our FUNDAMENTAL and ADVANCED Chapter 1 courses, discover why the low-carbon transition is key to reducing and preventing global warming. 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Learn More About the Galaxy VX Here: Go to https://www.se.com/ww/en/product-range/63732 to learn more about this product. 990-5451K-001 3 480 V UPS System 480 V UPS System Table of Contents Important Safety Instructions — SAVE THESE INSTRUCTIONS

6 990-5451K-001 Important Safety Instructions — SAVE THESE INSTRUCTIONS Read these instructions carefully and look at the equipment to become familiar with it before trying to install, operate, service or maintain it. The following safety messages may appear throughout this manual or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure. The addition of this symbol to a “Danger” or “Warning” safety message indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed. This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages with this symbol to avoid possible injury or death. DANGER DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury. Failure to follow these instructions will result in death or serious injury. WARNING WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury. Failure to follow these instructions can result in death, serious injury, or equipment damage. CAUTION CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury. Failure to follow these instructions can result in injury or equipment damage. NOTICE NOTICE is used to address practices not related to physical injury. The safety alert symbol shall not be used with this type of safety message. Failure to follow these instructions can result in equipment damage. Please Note Electrical equipment should only be installed, operated, serviced, and maintained by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material. A qualified person is one who has skills and knowledge related to the construction, installation, and operation of electrical equipment and has received safety training to recognize and avoid the hazards involved. 990-5451K-001 7 Important Safety Instructions — SAVE THESE INSTRUCTIONS 480 V UPS System FCC Statement NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. Any changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment. Safety Precautions DANGER HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH • The product must be installed according to the specifications and requirements as defined by Schneider Electric. It concerns in particular the external and internal protections (upstream circuit breakers, battery circuit breakers, cabling, etc.) and environmental requirements. No responsibility is assumed by Schneider Electric if these requirements are not respected. • After the UPS system has been electrically wired, do not start up the system. Start-up must only be performed by Schneider Electric. Failure to follow these instructions will result in death or serious injury. DANGER HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH The UPS System must be installed according to local and national regulations. Install the UPS according to: • IEC 60364 (including 60364–4–41- protection against electric shock, 60364– 4–42 - protection against thermal effect, and 60364–4–43 - protection against overcurrent), or • NEC NFPA 70 depending on which one of the standards apply in your local area. Failure to follow these instructions will result in death or serious injury. DANGER HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH • Install the UPS system in a temperature controlled area free of conductive contaminants and humidity. • Install the UPS system on a non-inflammable, level, and solid surface (e.g. concrete) that can support the weight of the system. Failure to follow these instructions will result in death or serious injury. 8 990-5451K-001 480 V UPS System Important Safety Instructions — SAVE THESE INSTRUCTIONS DANGER HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH The UPS is not designed for and must therefore not be installed in the following unusual operating environments: • Damaging fumes • Explosive mixtures of dust or gases, corrosive gases, or conductive or radiant heat from other sources • Moisture, abrasive dust, steam or in an excessively damp environment • Fungus, insects, vermin • Salt-laden air or contaminated cooling refrigerant • Pollution degree higher than 2 according to IEC 60664-1 • Exposure to abnormal vibrations, shocks, and tilting • Exposure to direct sunlight, heat sources, or strong electromagnetic fields Failure to follow these instructions will result in death or serious injury. NOTICE RISK OF OVERHEATING Respect the clearance requirements around the UPS system and do not cover the product’s ventilation openings when the UPS system is in operation. Failure to follow these instructions can result in equipment damage. NOTICE RISK OF EQUIPMENT DAMAGE Do not connect the UPS output to regenerative load systems including photovoltaic systems and speed drives. Failure to follow these instructions can result in equipment damage. 990-5451K-001 9 Important Safety Instructions — SAVE THESE INSTRUCTIONS 480 V UPS System Technical Data System Overview Each Galaxy VX UPS consists of the following components: • An I/O cabinet for wield wiring containing the static switch, a backfeed breaker BF21, and the user interface. • A number of 250 kW power cabinets containing the power electronics. UPSs with 1250 kW I/O Cabinet The 1250 kW I/O cabinet is used for UPS systems from a minimum configuration of 500 kW with two power cabinets to a maximum configuration of 1250 kW N+1 with six power cabinets. The I/O cabinet is placed to the left and two to six power cabinets (depending on system size) are placed to the right. The image below shows the maximum configuration. UPSs with 1500 kW I/O Cabinet The 1500 kW I/O cabinet is used for UPS systems from a minimum configuration of 500 kW with two power cabinets to a maximum configuration of 1500 kW N+1 with seven power cabinets. The image below shows the maximum configuration. 10 990-5451K-001 480 V UPS System Technical Data 1. For a 1250 kW I/O cabinet, the BF2 can be installed internal in the UPS or externally in the switchgear. Maintenance Bypass Cabinet for UPSs with a Maximum Rating of 750 kW The maintenance bypass cabinet contains the following breakers to isolate the UPS during maintenance: • Static switch input breaker (SSIB) • Maintenance bypass breaker (MBB) • Unit output breaker (UOB) Maintenance Bypass Cabinet 990-5451K-001 11 Technical Data 480 V UPS System Model List UPSs with 1250 kW I/O Cabinet • Galaxy VX 500 kW, 480 V, start-up 5x8 (GVX500K500NGS) • Galaxy VX 500 kW scalable to 750 kW 480 V, start-up 5x8 (GVX500K750NGS) • Galaxy VX 500 kW scalable to 1000 kW 480 V, start-up 5x8 (GVX500K1000NGS) • Galaxy VX 500 kW scalable to 1250 kW 480 V, start-up 5x8 (GVX500K1250NGS) • Galaxy VX 625 kW, 480 V, start-up 5x8 (GVX625K625NGS) • Galaxy VX 625 kW scalable to 1000 kW 480 V, start-up 5x8 (GVX625K1000NGS) • Galaxy VX 500 kW N+1 redundant UPS 480 V, start-up 5x8 (GVX750K500NGS) • Galaxy VX 750 kW, 480 V, start-up 5x8 (GVX750K750NGS) • Galaxy VX 750 kW scalable to 1000 kW 480 V, start-up 5x8 (GVX750K1000NGS) • Galaxy VX 750 kW scalable to 1250 kW 480 V, start-up 5x8 (GVX750K1250NGS) • Galaxy VX 800 kW, 480 V, start-up 5x8 (GVX800K800NGS) • Galaxy VX 750 kW N+1 redundant UPS 480 V, start-up 5x8 (GVX1000K750NGS) • Galaxy VX 1000 kW, 480 V, start-up 5x8 (GVX1000K1000NGS) • Galaxy VX 1000 kW scalable to 1250 kW 480 V, start-up 5x8 (GVX1000K1250NGS) • Galaxy VX 1100 kW, 480 V, Start-up 5x8 (GVX1100K1100NGS) • Galaxy VX 1000 kW N+1 redundant UPS 480 V, start-up 5x8 (GVX1250K1000NGS) • Galaxy VX 1250 kW, 480 V, start-up 5x8 (GVX1250K1250NGS) • Galaxy VX 1100 kW N+1 Redundant UPS 480 V, Start up 5x8 (GVX1500K1100NGS) • Galaxy VX 1250 kW N+1 Redundant UPS 480 V, start-up 5x8 (GVX1500K1250NGS) • Galaxy VX 1250 kW I/O Cabinet without Backfeed protection on Mains 2 (GVXI1250KDNBF2)2. Requires ordering the 250 kW power cabinets separately. 12 990-5451K-001 480 V UPS System Technical Data 2. Backfeed protection can be installed internally in the 1250 kW I/O cabinet with the optional backfeed kit (GVXOPT001) (ordered separately), or installed externally upstream of the UPS in the switchgear. UPSs with 1500 kW I/O Cabinet • Galaxy VX 500 kW 480 V scalable to 1500 kW, start-up 5x8 (GVX500K1500GS) • Galaxy VX 750 kW 480 V scalable to 1500 kW, start-up 5x8 (GVX750K1500GS) • Galaxy VX 1000 kW scalable to 1500 kW 480 V, start-up 5x8 (GVX1000K1500GS) • Galaxy VX 1250 kW scalable to 1500 kW 480 V, start-up 5x8 (GVX1250K1500GS) • Galaxy VX 1500 kW 480 V, start-up 5x8 (GVX1500K1500GS) • Galaxy VX 1500 kW N+1 Redundant UPS 480 V, start-up 5x8 (GVX1750K1500GS) 990-5451K-001 13 Technical Data 480 V UPS System Overview of Configurations Breakers in the System UIB Unit input breaker SSIB Static switch input breaker BB Battery breaker MBB Maintenance bypass breaker UOB Unit output breaker BF2 Backfeed protection switch Overview of UPSs with 1250 kW I/O Cabinet - Single Utility/Mains NOTE: Depending on your chosen configuration, the backfeed breaker BF2 (marked with * in the illustration) can be preinstalled in the UPS, delivered as an optional backfeed kit GVXOPT001 to be installed in the UPS, or installed upstream of the UPS in the switchgear. The illustration shows a 750 kW UPS. The principle is the same for the other UPSs with the 1250 kW I/O cabinet. 14 990-5451K-001 480 V UPS System Technical Data Overview of UPSs with 1250 kW I/O Cabinet - Dual Utility/Mains NOTE: Depending on your chosen configuration, the backfeed breaker BF2 (marked with * in the illustration) can be preinstalled in the UPS, delivered as an optional backfeed kit GVXOPT001 to be installed in the UPS, or installed upstream of the UPS in the switchgear. The illustration shows a 750 kW UPS. The principle is the same for the other UPSs with the 1250 kW I/O cabinet. Overview of UPSs with 1500 kW I/O Cabinet – Single Utility/Mains The illustration shows a 1500 kW UPS. The principle is the same for the other UPSs with the 1500 kW I/O cabinet. Galaxy VX 1500 kW UPS 990-5451K-001 15 Technical Data 480 V UPS System Overview of UPSs with 1500 kW I/O Cabinet – Dual Utility/Mains The illustration shows a 1500 kW UPS. The principle is the same for the other UPSs with the 1500 kW I/O cabinet. Galaxy VX 1500 kW UPS Parallel System Galaxy VX can support up to 4+0 UPSs in parallel for capacity and up to 4+1 UPSs in parallel for redundancy. NOTE: Note that for systems over 4 MW it can be difficult to find appropriate breakers/switches in the correct size for the switchgear. 16 990-5451K-001 480 V UPS System Technical Data Input Power Factor 500 kW 625 kW 750 kW 800 kW 1000 kW 1100 kW 1250 kW 1500 kW 25% load 0.98 0.98 0.98 0.98 0.98 0.98 0.98 0.98 50% load 0.99 0.99 0.99 0.99 0.99 0.99 0.99 0.99 75% load 0.99 0.99 0.99 0.99 0.99 0.99 0.99 0.99 100% load 0.99 0.99 0.99 0.99 0.99 0.99 0.99 0.99 Input Voltage Window 990-5451K-001 17 Technical Data 480 V UPS System Inverter Short–Circuit Capabilities (Bypass not Available) IK1 – Short-Circuit between a Phase and Neutral 480 V IK1 S [kVA] Ik10ms [A] Normal operation /Battery operation Ik30ms [A] Normal operation /Battery operation Ik100ms [A] Normal operation /Battery operation Ik500ms [A] Normal operation /Battery operation Ik1s [A] Normal operation /Battery operation Ik5s [A] Normal operation /Battery operation I2 t total [A2s] Normal operation /Battery operation 250 – /810 – /810 – /570 – /290 – /290 – /290 – /493600 500 – /1620 – /1620 – /1140 – /580 – /580 – /580 – /1974400 750 – /2430 – /2430 – /1710 – /870 – /870 – /870 – /4442400 1000 – /3240 – /3240 – /2280 – /1160 – /1160 – /1160 – /7897600 1250 – /4050 – /4050 – /2850 – /1450 – /1450 – /1450 – /12340000 1500 – /4860 – /4860 – /3420 – /1740 – /1740 – /1740 – /17769600 18 990-5451K-001 480 V UPS System Technical Data IK2 – Short-Circuit between Two Phases 480 V IK2 S [kVA] Ik10ms [A] Normal operation /Battery operation Ik30ms [A] Normal operation /Battery operation Ik100ms [A] Normal operation /Battery operation Ik500ms [A] Normal operation /Battery operation Ik1s [A] Normal operation /Battery operation Ik5s [A] Normal operation /Battery operation I2 t total [A2s] Normal operation /Battery operation 250 790 /790 770 /770 550 /550 430 /280 430 /280 280 /280 606450 /460820 500 1580 /1580 1540 /1540 1100 /1100 860 /560 860 /560 560 /560 2425800 /1843280 750 2370 /2370 2310 /2310 1650 /1650 1290 /840 1290 /840 840 /840 5458050 /4147380 1000 3160 /3160 3080 /3080 2200 /2200 1720 /1120 1720 /1120 1120 /1120 9703200 /7373120 1250 3950 /3950 3850 /3850 2750 /2750 2150 /1400 2150 /1400 1400 /1400 15161250 /11520500 1500 4740 /4740 4620 /4620 3300 /3300 2580 /1680 2580 /1680 1680 /1680 21832200 /16589520 990-5451K-001 19 Technical Data 480 V UPS System IK3 – Short-Circuit between All Three Phases 480 V IK3 S [kVA] Ik10ms [A] Normal operation /Battery operation Ik30ms [A] Normal operation /Battery operation Ik100ms [A] Normal operation /Battery operation Ik500ms [A] Normal operation /Battery operation Ik1s [A] Normal operation /Battery operation Ik5s [A] Normal operation /Battery operation I2 t total [A2s] Normal operation /Battery operation 250 670 /660 670 /660 610 /610 440 /440 360 /440 300 /300 580600 /589380 500 1340 /1320 1340 /1320 1220 /1220 880 /880 720 /880 600 /600 2322400 /2357520 650 1742 /1716 1742 /1716 1586 /1586 1144 /1144 936 /1144 780 /780 3924856 /3984209 1000 2680 /2640 2680 /2640 2440 /2440 1760 /1760 1440 /1760 1200 /1200 9289600 /9430080 1250 3350 /3300 3350 /3300 3050 /3050 2200 /2200 1800 /2200 1500 /1500 14515000 /14734500 1500 4020 /3960 4020 /3960 3660 /3660 2640 /2640 2160 /2640 1800 /1800 20901600 /21217680 20 990-5451K-001 480 V UPS System Technical Data Efficiency for UPSs with 1250 kW I/O Cabinet Efficiency for a 500 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 94.9% 97.3% 96.9% 96.6% 50% load 95.9% 98.4% 98.2% 96.7% 75% load 96.0% 98.8% 98.7% 96.3% 100% load 95.9% 99.0% 98.9% 95.9% Efficiency for a 625 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 95.0% 97.5% 97.1% 95.8% 50% load 96.2% 98.6% 98.4% 96.2% 75% load 96.3% 98.8% 98.7% 96.3% 100% load 96.2% 99.0% 98.9% 96.2% Efficiency for a 750 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 95.4% 97.9% 97.7% 96.5% 50% load 96.1% 98.6% 98.5% 96.6% 75% load 96.0% 98.8% 98.7% 96.2% 100% load 95.8% 98.9% 98.9% 95.8% Efficiency for an 800 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 95.2% 98.7% 97.4% 96.9% 50% load 96.2% 98.9% 98.5% 96.6% 75% load 96.1% 98.9% 98.8% 96.8% 100% load 96.3% 99.0% 99.1% 96.3% 990-5451K-001 21 Technical Data 480 V UPS System Efficiency for a 1000 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 95.6% 98.1% 97.9% 96.6% 50% load 96.3% 98.8% 98.7% 96.7% 75% load 96.2% 99.0% 98.9% 96.3% 100% load 96.0% 99.1% 99.1% 95.9% Efficiency for a 1100 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 95.8% 98.3% 97.8% 96.3% 50% load 96.4% 98.9% 98.7% 96.5% 75% load 96.3% 99.0% 98.9% 96.4% 100% load 96.1% 99.1% 99.0% 96.1% Efficiency for a 1250 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 95.8% 98.3% 97.9% 96.6% 50% load 96.4% 98.9% 98.7% 96.6% 75% load 96.2% 99.1% 99.0% 96.3% 100% load 96.0% 99.1% 99.1% 96.1% 22 990-5451K-001 480 V UPS System Technical Data Efficiency for UPSs with 1500 kW I/O Cabinet Efficiency for a 500 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 95.8% 98.5% 98.2% 95.9% 50% load 96.4% 99.1% 99.1% 96.4% 75% load 96.2% 99.2% 99.2% 96.0% 100% load 96.1% 99.2% 99.2% 95.6% Efficiency for a 750 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 95.9% 98.5% 98.2% 95.9% 50% load 96.5% 99.1% 99.0% 96.4% 75% load 96.3% 99.2% 99.2% 96.0% 100% load 96.0% 99.2% 99.2% 95.6% Efficiency for a 1000 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 95.9% 98.6% 98.2% 95.9% 50% load 96.5% 99.1% 99.0% 96.4% 75% load 96.4% 99.2% 99.2% 96.0% 100% load 95.9% 99.2% 99.2% 95.6% Efficiency for a 1250 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 96.0% 98.7% 98.3% 95.9% 50% load 96.6% 99.2% 99.1% 96.4% 75% load 96.4% 99.3% 99.3% 96.0% 100% load 96.0% 99.3% 99.3% 95.6% 990-5451K-001 23 Technical Data 480 V UPS System Efficiency for a 1500 kW UPS Normal operation ECO mode eConversion Battery operation Voltage (V) 480 480 480 480 25% load 96.0% 98.7% 98.3% 95.9% 50% load 96.5% 99.1% 99.1% 96.4% 75% load 96.3% 99.3% 99.3% 96.1% 100% load 96.0% 99.3% 99.3% 95.7% 24 990-5451K-001 480 V UPS System Technical Data Derating Due to Load Power Factor 0.7 leading to 0.5 lagging without derating. 990-5451K-001 25 Technical Data 480 V UPS System Batteries (VRLA) End of Discharge Voltage The voltage is 1.6 to 1.75 per cell depending on discharge ratio. Battery Voltage Range (VRLA) 26 990-5451K-001 480 V UPS System Technical Data Compliance Safety UL 1778 5th edition EMC/EMI/RFI IEC 62040-2: 2016, 3rd edition Uninterruptible Power Systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements C2 FCC 15B, class A Performance IEC 62040-3: 2011-03, 2nd edition Uninterruptible Power Systems (UPS) - Part 3: Method of specifying the performance and test requirements Environmental IEC 62040-4: 2013-04, 1st edition Uninterruptible Power Systems (UPS) - Part 4: Environmental aspects – Requirements and reporting Markings UL1778 Listing and CSA C22.2 NO.107.3 Transportation ISTA 2B IEC 60721-4-2 Level 2M2 Seismic OSHPD, IBC2012 and CBC2013 to SDS = 1.83 g Overvoltage category III Earthing system TN, TT, IT Protective class I Pollution degree 2 990-5451K-001 27 Technical Data 480 V UPS System Communication and Management Local Area Network 100 Mbps Extensions Two optional Network Management Cards MODBUS MODBUS TCP/IP Relay outputs 6 configurable Dry contact inputs 5 configurable Standard control panel 7" touch-screen display Audible alarm Yes Emergency Power Off (EPO) Options: • Normally Open (NO) • Normally Closed (NC) • External 24 VDC SELV External switchgear Option containing: • Unit Input Breaker (UIB) • Unit Output Breaker (UOB) • Static Switch Input Breaker (SSIB) • Maintenance Bypass Breaker (MBB) • System Isolation Breaker (SIB) External synchronization Yes Battery monitoring Yes — string level breaker monitoring EPO Connections 28 990-5451K-001 480 V UPS System Technical Data Overview of Input Contacts and Output Relays Input Contacts Do not connect any circuit to the input contacts unless it can be confirmed that the circuit is Class 2/SELV. All circuits connected must have the same 0 V reference. The input contacts support 24 VDC 10 mA. The switch SW5500 on 0P6548 is used to select between internal SELV supply for inputs (standard setting) and external supply3. If external supply is selected, the supply must be connected to J5530. Name Description Location IN 1 (Contact 1) Configurable input contact 0P6548 terminal J55024 IN 2 (Contact 2) Configurable input contact 0P6548 terminal J55034 IN 3 (Contact 3) Configurable input contact 0P6548 terminal J55044 IN 4 (Contact 4) Configurable input contact 0P6548 terminal J55054 IN 5 (Contact 5) Configurable input contact 0P6548 terminal J55104 IN 6 UOB redundant AUX contact 0P6548 terminal J55094 IN 7 Transformer temperature switch 0P6548 terminal J55084 IN 8 External bonding contact 0P6548 terminal J55074 IN 9 Forced external synchronization input 0P6548 terminal J55064 IN 10 External synchronization requested 0P6548 terminal J55114 IN 11 Use static bypass standby 0P6548 terminal J55124 IN 14 MegaTie 0P6552 terminal J90274 Output Relays NOTE: Maximum 250 VAC 5 A must be connected to the output relays. All external circuitry must be fused with maximum 5 A fast acting fuses. 990-5451K-001 29 Technical Data 480 V UPS System 3. An external supply is useful in parallel systems where inputs are connected between different UPSs. This is to have a common reference and to avoid cross currents. 4. Class 2/SELV wiring Name Description Location OUT 1 (Relay 1) Configurable output relay 0P6547 terminal J4939 OUT 2 (Relay 2) Configurable output relay 0P6547 terminal J4940 OUT 3 (Relay 3) Configurable output relay 0P6547 terminal J4941 OUT 4 Forced external synchronization output 0P6548 terminal J55205 OUT 5 MegaTie 0P6548 terminal J55215 OUT 6 External synchronization requested output 0P6548 terminal J55225 OUT 7 UPS in inverter ON 0P6548 terminal J55235 OUT 8 (Relay 4) Configurable output relay 0P6548 terminal J55245 OUT 9 (Relay 5) Configurable output relay 0P6548 terminal J55255 OUT 10 (Relay 6) Configurable output relay 0P6548 terminal J55285 OUT 14 Bonding contactor 0P6552 terminal J90295 NOTE: Refer to the operation manual for configuration options. 30 990-5451K-001 480 V UPS System Technical Data 5. Class 2/SELV wiring Facility Planning Specifications for 500 kW UPS Voltage (V) 380 400 415 440 480 Input Connections IEC: L1, L2, L3, PE 6 UL: L1, L2, L3 + G 7 Input voltage range (V)8 340-456 340-480 353-498 374-528 408-576 Frequency (Hz) 40-70 Nominal input current (A) 816 775 746 699 646 Maximum input current (A)9 921 885 852 798 757 Input current limitation (A) 890 832 760 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 100 kA RMS Total harmonic distortion (THDI) <3% at 100% load, <4% at 50% load, 40% load, 0.98 at >20% load, 0.97 at >10% load Protection Contactors Ramp-in Adaptive 1-300 seconds Bypass Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE 10 UL 1250 kW I/O: L1, L2, L3, G or L1, L2, L3, N, G UL 1500 kW I/O11: L1, L2, L3, G Bypass voltage range (V) 342-418 360-440 374-457 396-484 432-528 Frequency (Hz) 50 or 60 Frequency range (Hz) Programmable: ±0.1, ±3, ±10. Default is ±3 Nominal bypass current (A) 813 773 745 703 642 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 1250 kW I/O: 100 kA Icw 1500 kW I/O: 100 kA RMS (conditioned by an internal molded switch with 90 kA peak magnetic trip) Thyristor I²t (kA*s²) 1250 kW I/O: 9680 1500 kW I/O: 16245 1250 kW I/O: 9165 1500 kW I/O: 16245 BF2 magnetic trip 1250 kW I/O: 39 kA 1500 kW I/O: 39 kA Protection 1250 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 1250 kW I/O with GVXOPT001 installed: Molded switch with trip for backfeed protection 1500 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 990-5451K-001 31 Facility Planning 480 V UPS System 6. TN, TT, and IT power distribution systems are supported. 7. WYE source – solid grounded and high resistance grounded sources are supported. Corner (line) grounding is not permitted. 8. The system can operate at 600 V for 1 minute. 9. At nominal input voltage and full charge. 10. TN, TT, and IT power distribution systems with no earthed line conductors are supported. 11. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. Voltage (V) 380 400 415 440 480 Output Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE UL 1250 kw I/O: L1, L2, L3, G, GEC12 or L1, L2, L3, N, G UL 1500 kW I/O13: L1, L2, L3, G, GEC12 Overload capacity Normal operation: 150% for 1 minute, 125% for 10 minutes Battery operation: 128% for 10 seconds, 115% for 1 minute Bypass operation: 110%14 continuous, 1000% for 60 milliseconds for systems with 1250 kW I/O cabinet, and 1000% for 100 milliseconds for systems with 1500 kW I/O cabinet Output voltage tolerance Balanced load: ±1%, Unbalanced load: ±3% Dynamic load response ±5% after 2 ms, ±1% after 50 ms Output power factor 1 Nominal output current (A) 760 722 696 656 601 Minimum short circuit rating15 Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating16 100 kA RMS Inverter output short circuit capabilities Varies with time. See graph and table values in Inverter Short–Circuit Capabilities (Bypass not Available), page 18. Total harmonic distortion (THDU) <2% at 100% linear load, <3% at 100% non-linear load Output frequency (Hz) 50/60 (synchronized to bypass), 50/60 Hz ±0.1% (free-running) Slew rate (Hz/sec) Programmable: 0.25, 0.5, 1, 2, 4, 6 Output performance classification (according to IEC/ EN62040-3) Double-conversion: VFI-SS-111 Load crest factor Up to 3 (THDU < 5%) Load power factor 0.7 leading to 0.5 lagging without derating Battery (VRLA) Charging power in % of output power 35% at ≤ 80% load, 12% at 100% load 40% at ≤ 80% load, 15% at 100% load Maximum charging power (kW) 60 at 100% load, 175 at <80% load 75 at 100% load, 200 at 80% load Nominal battery voltage (VDC) 480 Nominal float voltage (VDC) 546 End of discharge voltage (full load) (VDC) 384 End of discharge voltage (no load) (VDC) 420 Battery current at full load and nominal battery voltage (A) 1090 Battery current at full load and minimum battery voltage (A) 1362 Maximum short circuit rating 50 kA Maximum battery backup time Unlimited Temperature compensation (per cell) -3.3 mV per °C for T ≥ 25 °C, 0 mV per °C for T < 25 °C Ripple current < 5% C20 (5-minute backup time) Battery test Manual/automatic (selectable) Deep discharge protection Yes Recharge according to battery temperature Yes 32 990-5451K-001 480 V UPS System Facility Planning 12. Per NEC 250.30. 13. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. 14. 125% for 480 V. 15. Minimum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. 16. Maximum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. Specifications for 625 kW UPS Voltage (V) 380 400 415 440 480 Input Connections IEC: L1, L2, L3, PE 17 UL: L1, L2, L3 + G 18 Input voltage range (V)19 340-456 340-480 353-498 374-528 408-576 Frequency (Hz) 40-70 Nominal input current (A) 1021 969 932 870 807 Maximum input current (A)20 1151 1106 1065 994 946 Input current limitation (A) 1113 1040 950 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 100 kA RMS Total harmonic distortion (THDI) <3% at 100% load, <4% at 50% load, 40% load, 0.98 at >20% load, 0.97 at >10% load Protection Contactors Ramp-in Adaptive 1-300 seconds Bypass Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE 21 UL 1250 kW I/O: L1, L2, L3, G or L1, L2, L3, N, G UL 1500 kW I/O22: L1, L2, L3, G Bypass voltage range (V) 342-418 360-440 374-457 396-484 432-528 Frequency (Hz) 50 or 60 Frequency range (Hz) Programmable: ±0.1, ±3, ±10. Default is ±3 Nominal bypass current (A) 1017 966 931 878 802 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 1250 kW I/O: 100 kA Icw 1500 kW I/O: 100 kA RMS (conditioned by an internal molded switch with 90 kA peak magnetic trip) Thyristor I²t (kA*s²) 9680 (1250 kW I/O) 9165 (1250 kW I/O) BF2 magnetic trip 1250 kW I/O: 39 kA 1500 kW I/O: 39 kA Protection 1250 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 1250 kW I/O with GVXOPT001 installed: Molded switch with trip for backfeed protection 1500 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 990-5451K-001 33 Facility Planning 480 V UPS System 17. TN, TT, and IT power distribution systems are supported. 18. WYE source – solid grounded and high resistance grounded sources are supported. Corner (line) grounding is not permitted. 19. The system can operate at 600 V for 1 minute. 20. At nominal input voltage and full charge. 21. TN, TT, and IT power distribution systems with no earthed line conductors are supported. 22. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. Voltage (V) 380 400 415 440 480 Output Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE UL 1250 kw I/O: L1, L2, L3, G, GEC23 or L1, L2, L3, N, G UL 1500 kW I/O24: L1, L2, L3, G, GEC23 Overload capacity Normal operation: 150% for 1 minute, 125% for 10 minutes Battery operation: 128% for 10 seconds, 115% for 1 minute Bypass operation: 110%25 continuous, 1000% for 60 milliseconds for systems with 1250 kW I/O cabinet, and 1000% for 100 milliseconds for systems with 1500 kW I/O cabinet Output voltage tolerance Balanced load: ±1%, Unbalanced load: ±3% Dynamic load response ±5% after 2 ms, ±1% after 50 ms Output power factor 1 Nominal output current (A) 950 902 870 820 752 Minimum short circuit rating26 Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating27 100 kA RMS Inverter output short circuit capabilities Varies with time. See graph and table values in Inverter Short–Circuit Capabilities (Bypass not Available), page 18. Total harmonic distortion (THDU) <2% at 100% linear load, <3% at 100% non-linear load Output frequency (Hz) 50/60 (synchronized to bypass), 50/60 Hz ±0.1% (free-running) Slew rate (Hz/sec) Programmable: 0.25, 0.5, 1, 2, 4, 6 Output performance classification (according to IEC/ EN62040-3) Double-conversion: VFI-SS-111 Load crest factor Up to 3 (THDU < 5%) Load power factor 0.7 leading to 0.5 lagging without derating Battery (VRLA) Charging power in % of output power 35% at ≤ 80% load, 12% at 100% load 40% at ≤ 80% load, 15% at 100% load Maximum charging power (kW) 75 at 100% load, 218.75 at <80% load 93.75 at 100% load, 250 at 80% load Nominal battery voltage (VDC) 480 Nominal float voltage (VDC) 546 End of discharge voltage (full load) (VDC) 384 End of discharge voltage (no load) (VDC) 420 Battery current at full load and nominal battery voltage (A) 1362 Battery current at full load and minimum battery voltage (A) 1703 Maximum short circuit rating 50 kA Maximum battery backup time Unlimited Temperature compensation (per cell) -3.3 mV per °C for T ≥ 25 °C, 0 mV per °C for T < 25 °C Ripple current < 5% C20 (5-minute backup time) Battery test Manual/automatic (selectable) Deep discharge protection Yes Recharge according to battery temperature Yes 34 990-5451K-001 480 V UPS System Facility Planning 23. Per NEC 250.30. 24. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. 25. 125% for 480 V. 26. Minimum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. 27. Maximum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. Specifications for 750 kW UPS Voltage (V) 380 400 415 440 480 Input Connections IEC: L1, L2, L3, PE 28 UL: L1, L2, L3 + G 29 Input voltage range (V)30 340-456 340-480 353-498 374-528 408-576 Frequency (Hz) 40-70 Nominal input current (A) 1225 1162 1119 1050 969 Maximum input current (A)31 1381 1327 1278 1199 1136 Input current limitation (A) 1335 1248 1140 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 100 kA RMS Total harmonic distortion (THDI) <3% at 100% load, <4% at 50% load, 40% load, 0.98 at >20% load, 0.97 at >10% load Protection Contactors Ramp-in Adaptive 1-300 seconds Bypass Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE 32 UL 1250 kW I/O: L1, L2, L3, G or L1, L2, L3, N, G UL 1500 kW I/O33: L1, L2, L3, G Bypass voltage range (V) 342-418 360-440 374-457 396-484 432-528 Frequency (Hz) 50 or 60 Frequency range (Hz) Programmable: ±0.1, ±3, ±10. Default is ±3 Nominal bypass current (A) 1220 1159 1117 1054 964 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 1250 kW I/O: 100 kA Icw 1500 kW I/O: 100 kA RMS (conditioned by an internal molded switch with 90 kA peak magnetic trip) Thyristor I²t (kA*s²) 1250 kW I/O: 9680 1500 kW I/O: 16245 1250 kW I/O: 9165 1500 kW I/O: 16245 BF2 magnetic trip 1250 kW I/O: 39 kA 1500 kW I/O: 39 kA Protection 1250 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 1250 kW I/O with GVXOPT001 installed: Molded switch with trip for backfeed protection 1500 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 990-5451K-001 35 Facility Planning 480 V UPS System 28. TN, TT, and IT power distribution systems are supported. 29. WYE source – solid grounded and high resistance grounded sources are supported. Corner (line) grounding is not permitted. 30. The system can operate at 600 V for 1 minute. 31. At nominal input voltage and full charge. 32. TN, TT, and IT power distribution systems with no earthed line conductors are supported. 33. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. Voltage (V) 380 400 415 440 480 Output Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE UL 1250 kw I/O: L1, L2, L3, G, GEC34 or L1, L2, L3, N, G UL 1500 kW I/O35: L1, L2, L3, G, GEC34 Overload capacity Normal operation: 150% for 1 minute, 125% for 10 minutes Battery operation: 128% for 10 seconds, 115% for 1 minute Bypass operation: 110%36 continuous, 1000% for 60 milliseconds for systems with 1250 kW I/O cabinet, and 1000% for 100 milliseconds for systems with 1500 kW I/O cabinet Output voltage tolerance Balanced load: ±1%, Unbalanced load: ±3% Dynamic load response ±5% after 2 ms, ±1% after 50 ms Output power factor 1 Nominal output current (A) 1140 1083 1043 984 902 Minimum short circuit rating37 Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating38 100 kA RMS Inverter output short circuit capabilities Varies with time. See graph and table values in Inverter Short–Circuit Capabilities (Bypass not Available), page 18. Total harmonic distortion (THDU) <2% at 100% linear load, <3% at 100% non-linear load Output frequency (Hz) 50/60 (synchronized to bypass), 50/60 Hz ±0.1% (free-running) Slew rate (Hz/sec) Programmable: 0.25, 0.5, 1, 2, 4, 6 Output performance classification (according to IEC/ EN62040-3) Double-conversion: VFI-SS-111 Load crest factor Up to 3 (THDU < 5%) Load power factor 0.7 leading to 0.5 lagging without derating Battery (VRLA) Charging power in % of output power 35% at ≤ 80% load, 12% at 100% load 40% at ≤ 80% load, 15% at 100% load Maximum charging power (kW) 90 at 100% load, 262 at <80% load 112.5 at 100% load, 300 at 80% load Nominal battery voltage (VDC) 480 Nominal float voltage (VDC) 546 End of discharge voltage (full load) (VDC) 384 End of discharge voltage (no load) (VDC) 420 Battery current at full load and nominal battery voltage (A) 1634 Battery current at full load and minimum battery voltage (A) 2043 Maximum short circuit rating 50 kA Maximum battery backup time Unlimited Temperature compensation (per cell) -3.3 mV per °C for T ≥ 25 °C, 0 mV per °C for T < 25 °C Ripple current < 5% C20 (5-minute backup time) Battery test Manual/automatic (selectable) Deep discharge protection Yes Recharge according to battery temperature Yes 36 990-5451K-001 480 V UPS System Facility Planning 34. Per NEC 250.30. 35. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. 36. 125% for 480 V. 37. Minimum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. 38. Maximum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. Specifications for 800 kW UPS Voltage (V) 380 400 415 440 480 Input Connections IEC: L1, L2, L3, PE 39 UL: L1, L2, L3 + G 40 Input voltage range (V)41 340-456 340-480 353-498 374-528 408-576 Frequency (Hz) 40-70 Nominal input current (A) 1307 1239 1193 1120 1033 Maximum input current (A)42 1474 1415 1363

1279 1212 Input current limitation (A) 1424 1331 1216 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 100 kA RMS Total harmonic distortion (THDI) <3% at 100% load, <4% at 50% load, 40% load, 0.98 at >20% load, 0.97 at >10% load Protection Contactors Ramp-in Adaptive 1-300 seconds Bypass Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE 43 UL 1250 kW I/O: L1, L2, L3, G or L1, L2, L3, N, G UL 1500 kW I/O44: L1, L2, L3, G Bypass voltage range (V) 342-418 360-440 374-457 396-484 432-528 Frequency (Hz) 50 or 60 Frequency range (Hz) Programmable: ±0.1, ±3, ±10. Default is ±3 Nominal bypass current (A) 1302 1236 1191 1124 1027 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 1250 kW I/O: 100 kA Icw 1500 kW I/O: 100 kA RMS (conditioned by an internal molded switch with 90 kA peak magnetic trip) Thyristor I²t (kA*s²) 9680 (1250 kW I/O) 9165 (1250 kW I/O) BF2 magnetic trip 1250 kW I/O: 39 kA 1500 kW I/O: 39 kA Protection 1250 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 1250 kW I/O with GVXOPT001 installed: Molded switch with trip for backfeed protection 1500 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 990-5451K-001 37 Facility Planning 480 V UPS System 39. TN, TT, and IT power distribution systems are supported. 40. WYE source – solid grounded and high resistance grounded sources are supported. Corner (line) grounding is not permitted. 41. The system can operate at 600 V for 1 minute. 42. At nominal input voltage and full charge. 43. TN, TT, and IT power distribution systems with no earthed line conductors are supported. 44. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. Voltage (V) 380 400 415 440 480 Output Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE UL 1250 kw I/O: L1, L2, L3, G, GEC45 or L1, L2, L3, N, G UL 1500 kW I/O46: L1, L2, L3, G, GEC45 Overload capacity Normal operation: 150% for 1 minute, 125% for 10 minutes Battery operation: 128% for 10 seconds, 115% for 1 minute Bypass operation: 110%47 continuous, 1000% for 60 milliseconds for systems with 1250 kW I/O cabinet, and 1000% for 100 milliseconds for systems with 1500 kW I/O cabinet Output voltage tolerance Balanced load: ±1%, Unbalanced load: ±3% Dynamic load response ±5% after 2 ms, ±1% after 50 ms Output power factor 1 Nominal output current (A) 1216 1155 1113 1050 962 Minimum short circuit rating48 Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating49 100 kA RMS Inverter output short circuit capabilities Varies with time. See graph and table values in Inverter Short–Circuit Capabilities (Bypass not Available), page 18. Total harmonic distortion (THDU) <2% at 100% linear load, <3% at 100% non-linear load Output frequency (Hz) 50/60 (synchronized to bypass), 50/60 Hz ±0.1% (free-running) Slew rate (Hz/sec) Programmable: 0.25, 0.5, 1, 2, 4, 6 Output performance classification (according to IEC/ EN62040-3) Double-conversion: VFI-SS-111 Load crest factor Up to 3 (THDU < 5%) Load power factor 0.7 leading to 0.5 lagging without derating Battery (VRLA) Charging power in % of output power 35% at ≤ 80% load, 12% at 100% load 40% at ≤ 80% load, 15% at 100% load Maximum charging power (kW) 96 at 100% load, 280 at <80% load 120 at 100% load, 320 at 80% load Nominal battery voltage (VDC) 480 Nominal float voltage (VDC) 546 End of discharge voltage (full load) (VDC) 384 End of discharge voltage (no load) (VDC) 420 Battery current at full load and nominal battery voltage (A) 1743 Battery current at full load and minimum battery voltage (A) 2179 Maximum short circuit rating 50 kA Maximum battery backup time Unlimited Temperature compensation (per cell) -3.3 mV per °C for T ≥ 25 °C, 0 mV per °C for T < 25 °C Ripple current < 5% C20 (5-minute backup time) Battery test Manual/automatic (selectable) Deep discharge protection Yes Recharge according to battery temperature Yes 38 990-5451K-001 480 V UPS System Facility Planning 45. Per NEC 250.30. 46. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. 47. 125% for 480 V. 48. Minimum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. 49. Maximum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. Specifications for 1000 kW UPS Voltage (V) 380 400 415 440 480 Input Connections IEC: L1, L2, L3, PE 50 UL: L1, L2, L3 + G 51 Input voltage range (V)52 340-456 340-480 353-498 374-528 408-576 Frequency (Hz) 40-70 Nominal input current (A) 1633 1549 1492 1397 1291 Maximum input current (A)53 1842 1770 1704 1595 1514 Input current limitation (A) 1780 1664 1520 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 100 kA RMS Total harmonic distortion (THDI) <3% at 100% load, <4% at 50% load, 40% load, 0.98 at >20% load, 0.97 at >10% load Protection Contactors Ramp-in Adaptive 1-300 seconds Bypass Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE 54 UL 1250 kW I/O: L1, L2, L3, G or L1, L2, L3, N, G UL 1500 kW I/O55: L1, L2, L3, G Bypass voltage range (V) 342-418 360-440 374-457 396-484 432-528 Frequency (Hz) 50 or 60 Frequency range (Hz) Programmable: ±0.1, ±3, ±10. Default is ±3 Nominal bypass current (A) 1627 1545 1489 1405 1284 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 1250 kW I/O: 100 kA Icw 1500 kW I/O: 100 kA RMS (conditioned by an internal molded switch with 90 kA peak magnetic trip) Thyristor I²t (kA*s²) 1250 kW I/O: 9680 1500 kW I/O: 16245 1250 kW I/O: 9165 1500 kW I/O: 16245 BF2 magnetic trip 1250 kW I/O: 39 kA 1500 kW I/O: 39 kA Protection 1250 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 1250 kW I/O with GVXOPT001 installed: Molded switch with trip for backfeed protection 1500 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 990-5451K-001 39 Facility Planning 480 V UPS System 50. TN, TT, and IT power distribution systems are supported. 51. WYE source – solid grounded and high resistance grounded sources are supported. Corner (line) grounding is not permitted. 52. The system can operate at 600 V for 1 minute. 53. At nominal input voltage and full charge. 54. TN, TT, and IT power distribution systems with no earthed line conductors are supported. 55. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. Voltage (V) 380 400 415 440 480 Output Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE UL 1250 kw I/O: L1, L2, L3, G, GEC56 or L1, L2, L3, N, G UL 1500 kW I/O57: L1, L2, L3, G, GEC56 Overload capacity Normal operation: 150% for 1 minute, 125% for 10 minutes Battery operation: 128% for 10 seconds, 115% for 1 minute Bypass operation: 110%58 continuous, 1000% for 60 milliseconds for systems with 1250 kW I/O cabinet, and 1000% for 100 milliseconds for systems with 1500 kW I/O cabinet Output voltage tolerance Balanced load: ±1%, Unbalanced load: ±3% Dynamic load response ±5% after 2 ms, ±1% after 50 ms Output power factor 1 Nominal output current (A) 1519 1443 1391 1312 1203 Minimum short circuit rating59 Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating60 100 kA RMS Inverter output short circuit capabilities Varies with time. See graph and table values in Inverter Short–Circuit Capabilities (Bypass not Available), page 18. Total harmonic distortion (THDU) <2% at 100% linear load, <3% at 100% non-linear load Output frequency (Hz) 50/60 (synchronized to bypass), 50/60 Hz ±0.1% (free-running) Slew rate (Hz/sec) Programmable: 0.25, 0.5, 1, 2, 4, 6 Output performance classification (according to IEC/ EN62040-3) Double-conversion: VFI-SS-111 Load crest factor Up to 3 (THDU < 5%) Load power factor 0.7 leading to 0.5 lagging without derating Battery (VRLA) Charging power in % of output power 35% at ≤ 80% load, 12% at 100% load 40% at ≤ 80% load, 15% at 100% load Maximum charging power (kW) 120 at 100% load, 350 at <80% load 150 at 100% load, 400 at <80% load Nominal battery voltage (VDC) 480 Nominal float voltage (VDC) 546 End of discharge voltage (full load) (VDC) 384 End of discharge voltage (no load) (VDC) 420 Battery current at full load and nominal battery voltage (A) 2179 Battery current at full load and minimum battery voltage (A) 2724 Maximum short circuit rating 50 kA Maximum battery backup time Unlimited Temperature compensation (per cell) -3.3 mV per °C for T ≥ 25 °C, 0 mV per °C for T < 25 °C Ripple current < 5% C20 (5-minute backup time) Battery test Manual/automatic (selectable) Deep discharge protection Yes Recharge according to battery temperature Yes 40 990-5451K-001 480 V UPS System Facility Planning 56. Per NEC 250.30. 57. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. 58. 125% for 480 V. 59. Minimum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. 60. Maximum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. Specifications for 1100 kW UPS Voltage (V) 380 400 415 440 480 Input Connections IEC: L1, L2, L3, PE 61 UL: L1, L2, L3 + G 62 Input voltage range (V)63 340-456 340-480 353-498 374-528 408-576 Frequency (Hz) 40-70 Nominal input current (A) 1796 1704 1641 1540 1421 Maximum input current (A)64 2026 1947 1874 1759 1666 Input current limitation (A) 1958 1830 1672 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 100 kA RMS Total harmonic distortion (THDI) <3% at 100% load, <4% at 50% load, 40% load, 0.98 at >20% load, 0.97 at >10% load Protection Contactors Ramp-in Adaptive 1-300 seconds Bypass Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE 65 UL 1250 kW I/O: L1, L2, L3, G or L1, L2, L3, N, G UL 1500 kW I/O66: L1, L2, L3, G Bypass voltage range (V) 342-418 360-440 374-457 396-484 432-528 Frequency (Hz) 50 or 60 Frequency range (Hz) Programmable: ±0.1, ±3, ±10. Default is ±3 Nominal bypass current (A) 1789 1700 1639 1545 1412 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 1250 kW I/O: 100 kA Icw 1500 kW I/O: 100 kA RMS (conditioned by an internal molded switch with 90 kA peak magnetic trip) Thyristor I²t (kA*s²) 9680 (1250 kW I/O) 9165 (1250 kW I/O) BF2 magnetic trip 1250 kW I/O: 39 kA 1500 kW I/O: 39 kA Protection 1250 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 1250 kW I/O with GVXOPT001 installed: Molded switch with trip for backfeed protection 1500 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 990-5451K-001 41 Facility Planning 480 V UPS System 61. TN, TT, and IT power distribution systems are supported. 62. WYE source – solid grounded and high resistance grounded sources are supported. Corner (line) grounding is not permitted. 63. The system can operate at 600 V for 1 minute. 64. At nominal input voltage and full charge. 65. TN, TT, and IT power distribution systems with no earthed line conductors are supported. 66. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. Voltage (V) 380 400 415 440 480 Output Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE UL 1250 kw I/O: L1, L2, L3, G, GEC67 or L1, L2, L3, N, G UL 1500 kW I/O68: L1, L2, L3, G, GEC67 Overload capacity Normal operation: 150% for 1 minute, 125% for 10 minutes Battery operation: 128% for 10 seconds, 115% for 1 minute Bypass operation: 110%69 continuous, 1000% for 60 milliseconds for systems with 1250 kW I/O cabinet, and 1000% for 100 milliseconds for systems with 1500 kW I/O cabinet Output voltage tolerance Balanced load: ±1%, Unbalanced load: ±3% Dynamic load response ±5% after 2 ms, ±1% after 50 ms Output power factor 1 Nominal output current (A) 1671 1588 1530 1443 1323 Minimum short circuit rating70 Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating71 100 kA RMS Inverter output short circuit capabilities Varies with time. See graph and table values in Inverter Short–Circuit Capabilities (Bypass not Available), page 18. Total harmonic distortion (THDU) <2% at 100% linear load, <3% at 100% non-linear load Output frequency (Hz) 50/60 (synchronized to bypass), 50/60 Hz ±0.1% (free-running) Slew rate (Hz/sec) Programmable: 0.25, 0.5, 1, 2, 4, 6 Output performance classification (according to IEC/ EN62040-3) Double-conversion: VFI-SS-111 Load crest factor Up to 3 (THDU < 5%) Load power factor 0.7 leading to 0.5 lagging without derating Battery (VRLA) Charging power in % of output power 35% at ≤ 80% load, 12% at 100% load 40% at ≤ 80% load, 15% at 100% load Maximum charging power (kW) 132 at 100% load, 385 at <80% load 165 at 100% load, 440 at <80% load Nominal battery voltage (VDC) 480 Nominal float voltage (VDC) 546 End of discharge voltage (full load) (VDC) 384 End of discharge voltage (no load) (VDC) 420 Battery current at full load and nominal battery voltage (A) 2397 Battery current at full load and minimum battery voltage (A) 2996 Maximum short circuit rating 50 kA Maximum battery backup time Unlimited Temperature compensation (per cell) -3.3 mV per °C for T ≥ 25 °C, 0 mV per °C for T < 25 °C Ripple current < 5% C20 (5-minute backup time) Battery test Manual/automatic (selectable) Deep discharge protection Yes Recharge according to battery temperature Yes 42 990-5451K-001 480 V UPS System Facility Planning 67. Per NEC 250.30. 68. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. 69. 125% for 480 V. 70. Minimum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. 71. Maximum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. Specifications for 1250 kW UPS Voltage (V) 380 400 415 440 480 Input Connections IEC: L1, L2, L3, PE 72 UL: L1, L2, L3 + G 73 Input voltage range (V)74 340-456 340-480 353-498 374-528 408-576 Frequency (Hz) 40-70 Nominal input current (A) 2041 1937 1865 1750 1615 Maximum input current (A)75 2303 2212 2130 1999 1893 Input current limitation (A) 2225 2080 1900 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 100 kA RMS Total harmonic distortion (THDI) <3% at 100% load, <4% at 50% load, 40% load, 0.98 at >20% load, 0.97 at >10% load Protection Contactors Ramp-in Adaptive 1-300 seconds Bypass Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE 76 UL 1250 kW I/O: L1, L2, L3, G or L1, L2, L3, N, G UL 1500 kW I/O77: L1, L2, L3, G Bypass voltage range (V) 342-418 360-440 374-457 396-484 432-528 Frequency (Hz) 50 or 60 Frequency range (Hz) Programmable: ±0.1, ±3, ±10. Default is ±3 Nominal bypass current (A) 2033 1931 1862 1756 1605 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 1250 kW I/O: 100 kA Icw 1500 kW I/O: 100 kA RMS (conditioned by an internal molded switch with 90 kA peak magnetic trip) Thyristor I²t (kA*s²) 1250 kW I/O: 9680 1500 kW I/O: 16245 1250 kW I/O: 9165 1500 kW I/O: 16245 BF2 magnetic trip 1250 kW I/O: 39 kA 1500 kW I/O: 39 kA Protection 1250 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 1250 kW I/O with GVXOPT001 installed: Molded switch with trip for backfeed protection 1500 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 990-5451K-001 43 Facility Planning 480 V UPS System 72. TN, TT, and IT power distribution systems are supported. 73. WYE source – solid grounded and high resistance grounded sources are supported. Corner (line) grounding is not permitted. 74. The system can operate at 600 V for 1 minute. 75. At nominal input voltage and full charge. 76. TN, TT, and IT power distribution systems with no earthed line conductors are supported. 77. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. Voltage (V) 380 400 415 440 480 Output Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE UL 1250 kw I/O: L1, L2, L3, G, GEC78 or L1, L2, L3, N, G UL 1500 kW I/O79: L1, L2, L3, G, GEC78 Overload capacity Normal operation: 150% for 1 minute, 125% for 10 minutes Battery operation: 128% for 10 seconds, 115% for 1 minute Bypass operation: 110%80 continuous, 1000% for 60 milliseconds for systems with 1250 kW I/O cabinet, and 1000% for 100 milliseconds for systems with 1500 kW I/O cabinet Output voltage tolerance Balanced load: ±1%, Unbalanced load: ±3% Dynamic load response ±5% after 2 ms, ±1% after 50 ms Output power factor 1 Nominal output current (A) 1899 1804 1739 1640 1504 Minimum short circuit rating81 Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating82 100 kA RMS Inverter output short circuit capabilities Varies with time. See graph and table values in Inverter Short–Circuit Capabilities (Bypass not Available), page 18. Total harmonic distortion (THDU) <2% at 100% linear load, <3% at 100% non-linear load Output frequency (Hz) 50/60 (synchronized to bypass), 50/60 Hz ±0.1% (free-running) Slew rate (Hz/sec) Programmable: 0.25, 0.5, 1, 2, 4, 6 Output performance classification (according to IEC/ EN62040-3) Double-conversion: VFI-SS-111 Load crest factor Up to 3 (THDU < 5%) Load power factor 0.7 leading to 0.5 lagging without derating Battery (VRLA) Charging power in % of output power 35% at ≤ 80% load, 12% at 100% load 40% at ≤ 80% load, 15% at 100% load Maximum charging power (kW) 150 at 100% load, 437 at <80% load 187.5 at 100% load, 500 at <80% load Nominal battery voltage (VDC) 480 Nominal float voltage (VDC) 546 End of discharge voltage (full load) (VDC) 384 End of discharge voltage (no load) (VDC) 420 Battery current at full load and nominal battery voltage (A) 2724 Battery current at full load and minimum battery voltage (A) 3405 Maximum short circuit rating 50 kA Maximum battery backup time 1 hour Temperature compensation (per cell) -3.3 mV per °C for T ≥ 25 °C, 0 mV per °C for T < 25 °C Ripple current < 5% C20 (5-minute backup time) Battery test Manual/automatic (selectable) Deep discharge protection Yes Recharge according to battery temperature Yes 44 990-5451K-001 480 V UPS System Facility Planning 78. Per NEC 250.30. 79. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. 80. 125% for 480 V. 81. Minimum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. 82. Maximum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. Specifications for 1500 kW UPS Voltage (V) 380 400 415 440 480 Input Connections IEC: L1, L2, L3, PE 83 UL: L1, L2, L3 + G 84 Input voltage range (V)85 340-456 340-480 353-498 374-528 408-576 Frequency (Hz) 40-70 Nominal input current (A) 2449 2325 2238 2100 1937 Maximum input current (A)86 2763 2654 2555 2398 2271 Input current limitation (A) 2670 2496 2280 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 100 kA RMS Total harmonic distortion (THDI) <3% at 100% load, <4% at 50% load, 40% load, 0.98 at >20% load, 0.97 at >10% load Protection Contactors Ramp-in Adaptive 1-300 seconds Bypass Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE 87 UL 1250 kW I/O: L1, L2, L3, G or L1, L2, L3, N, G UL 1500 kW I/O88: L1, L2, L3, G Bypass voltage range (V) 342-418 360-440 374-457 396-484 432-528 Frequency (Hz) 50 or 60 Frequency range (Hz) Programmable: ±0.1, ±3, ±10. Default is ±3 Nominal bypass current (A) 2440 2318 2234 2107 1926 Minimum short circuit rating Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating 1250 kW I/O: 100 kA Icw 1500 kW I/O: 100 kA RMS (conditioned by an internal molded switch with 90 kA peak magnetic trip) Thyristor I²t (kA*s²) 16245 (1500 kW I/O) BF2 magnetic trip 1250 kW I/O: 39 kA 1500 kW I/O: 39 kA Protection 1250 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 1250 kW I/O with GVXOPT001 installed: Molded switch with trip for backfeed protection 1500 kW I/O with preinstalled backfeed breaker BF2: Molded switch with trip for backfeed protection 990-5451K-001 45 Facility Planning 480 V UPS System 83. TN, TT, and IT power distribution systems are supported. 84. WYE source – solid grounded and high resistance grounded sources are supported. Corner (line) grounding is not permitted. 85. The system can operate at 600 V for 1 minute. 86. At nominal input voltage and full charge. 87. TN, TT, and IT power distribution systems with no earthed line conductors are supported. 88. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. Voltage (V) 380 400 415 440 480 Output Connections IEC 1250 kW I/O and 1500 kW I/O: L1, L2, L3, N, PE or L1, L2, L3, PE UL 1250 kw I/O: L1, L2, L3, G, GEC89 or L1, L2, L3, N, G UL 1500 kW I/O90: L1, L2, L3, G, GEC89 Overload capacity 150% for 1 minute, 125% for 10 minutes (normal operation) 115% for 1 minute (battery operation) 110% continuous,1000% for 100 milliseconds (bypass operation) Output voltage tolerance Balanced load: ±1%, Unbalanced load: ±3% Dynamic load response ±5% after 2 ms, ±1% after 50 ms Output power factor 1 Nominal output current (A) 2279 2165 2087 1968 1804 Minimum short circuit rating91 Dependent on upstream protection. See section for ‘Recommended upstream protection and cable sizes – IEC’ for details. Maximum short circuit rating92 100 kA RMS Inverter output short circuit capabilities Varies with time. See graph and table values in Inverter Short–Circuit Capabilities (Bypass not Available), page 18. Total harmonic distortion (THDU) <2% at 100% linear load, <3% at 100% non-linear load Output frequency (Hz) 50/60 (synchronized to bypass), 50/60 Hz ±0.1% (free-running) Slew rate (Hz/sec) Programmable: 0.25, 0.5, 1, 2, 4, 6 Output performance classification (according to IEC/ EN62040-3) Double-conversion: VFI-SS-111 Load crest factor Up to 3 (THDU < 5%) Load power factor 0.7 leading to 0.5 lagging without derating Battery (VRLA) Charging power in % of output power 35% at ≤ 80% load, 12% at 100% load 40% at ≤ 80% load, 15% at 100% load Maximum charging power (kW) 525 at < 80% load, 180 at 100% load, 600 at <80% load, 225 at 100% load Nominal battery voltage (VDC) 480 Nominal float voltage (VDC) 546 End of discharge voltage (full load) (VDC) 384 End of discharge voltage (no load) (VDC) 420 Battery current at full load and nominal battery voltage (A) 3269 Battery current at full load and minimum battery voltage (A) 4086 Maximum short circuit rating 50 kA Maximum battery backup time 1 hour Temperature compensation (per cell) -3.3 mV per °C for T ≥ 25 °C, 0 mV per °C for T < 25 °C Ripple current < 5% C20 (5-minute backup time) Battery test Manual/automatic (selectable) Deep discharge protection Yes Recharge according to battery temperature Yes 46 990-5451K-001 480 V UPS System Facility Planning 89. Per NEC 250.30. 90. 4-wire connection with neutral is not compliant per FCC regulations for the 1500 kW I/O cabinet. 91. Minimum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. 92. Maximum short circuit rating for output takes backfeeding energy through the bypass of parallel UPSs into consideration. Recommended Upstream Protection and Cable Sizes – UL CAUTION HAZARD OF FIRE • Connect only to a circuit with the below specifications. • Connect only to a circuit provided with a maximum branch circuit overcurrent protection, as specified in the UPS rating tables below, in accordance with the National Electrical Code, ANSI/ NFPA70, and the Canadian Electrical Code, Part I, C22.1. Failure to follow these instructions can result in injury or equipment damage. NOTE: Overcurrent protection is to be provided by others. NOTE: All wiring must comply with all applicable national and/or electrical code (National Electrical Code, ANSI/NFPA 70). Cable sizes in this manual are based on Table 310.15 of the National Electrical Code 2014 (NEC) with the following assertions: • 90 °C conductors (THHN) for 75 °C termination • Not more than 3 current carrying conductors in each conduit • An ambient temperature of max. 30 °C • Use of copper or aluminium conductors • 100% rated breakers • Nominal operating conditions If the ambient room temperature is greater than 30 °C, use larger or additional parallel conductors in accordance with the correction factors of the NEC. The maximum allowable conductor size is 600 kcmil. Equipment Grounding Conductors (EGC) are sized in accordance with NEC Article 250.122 and Table 250.122 Minimum size equipment conductor for grounding equipment. NOTE: Always consider the EGC size according to the complete electrical installation. NOTE: The use of aluminium conductors can limit the number of parallel Lithium-ion battery cabinets. Contact Schneider Electric for more information. NOTICE RISK OF EQUIPMENT DAMAGE To ensure correct load sharing in bypass operation in a parallel system, the following recommendations apply: • The bypass cables must be of the same length for all UPSs. • The output cables must be of the same length for all UPSs. • The input cables must be of the same length for all UPSs in a single mains system. • Cable formation recommendations must be followed. • The reactance of busbar layout in the bypass/input and output switchgear must be the same for all UPSs. If the above recommendations are not followed the result can be uneven load sharing in bypass and overload of individual UPSs. Failure to follow these instructions can result in equipment damage. 990-5451K-001 47 Facility Planning 480 V UPS System Recommended Upstream Protection and Cable Sizes for 500 kW UPS Maximum OCPD (A) Cable size per phase (AWG/kcmil) Copper / Aluminum EGC cable size (AWG/kcmil)93 Copper / Aluminum Input 800 (Ir = 1.0) 2x500 / 3x400 1x1/0 / 1x3/0 Bypass 700 (Ir = 1.0) 2x350 / 2x500 1x1/0 / 1x3/0 Output 700 (Ir = 1.0) 2x350 / 2x500 1x1/0 / 1x3/0 Battery 1600 (Ir = 0.9) 4x500 / 5x500 1x4/0 / 1x350 Recommended Upstream Protection and Cable Sizes for 625 kW UPS Maximum OCPD (A) Cable size per phase (AWG/kcmil) Copper / Aluminum EGC cable size (AWG/kcmil)93 Copper / Aluminum Input 1000 (Ir = 1.0) 3x400 / 3x600 1x2/0 / 1x4/0 Bypass 800 (Ir= 1.0) 2x600 / 3x400 1x1/0 / 1x3/0 Output 800 (Ir = 1.0) 2x600 / 3x400 1x1/0 / 1x3/0 Battery 2000 (Ir = 0.9) 5x500 / 6x500 1x250 / 1x400 Recommended Upstream Protection and Cable Sizes for 750 kW UPS Maximum OCPD (A) Cable size per phase (AWG/kcmil) Copper / Aluminum EGC cable size (AWG/kcmil)93 Copper / Aluminum Input 1200 (Ir = 1.0) 3x600 / 4x500 1x3/0 / 1x250 Bypass 1000 (Ir = 1.0) 3x400 / 3x600 1x2/0 / 1x4/0 Output 1000 (Ir = 1.0) 3x400 / 3x600 1x2/0 / 1x4/0 Battery 2500 (Ir = 0.9) 6x500 / 7x600 1x350 / 1x600 Recommended Upstream Protection and Cable Sizes for 800 kW UPS Maximum OCPD (A) Cable size per phase (AWG/kcmil) Copper / Aluminum EGC cable size (AWG/kcmil)93 Copper / Aluminum Input 1600 (Ir = 0.8) 4x400 / 4x600 1x4/0 / 1x350 Bypass 1000 3x400 / 3x600 1x2/0 / 1x4/0 Output 1000 3x400 / 3x600 1x2/0 / 1x4/0 Battery 2500 (Ir = 0.9) 6x500 / 7x600 1x350 / 1x600 48 990-5451K-001 480 V UPS System Facility Planning 93. If the conductors are run in conduits, there must be one conductor in each conduit. Recommended Upstream Protection and Cable Sizes for 1000 kW UPS Maximum OCPD (A) Cable size per phase (AWG/kcmil) Copper / Aluminum EGC cable size (AWG/kcmil)94 Copper / Aluminum Input 1600 (Ir = 1.0) 4x600 / 5x600 1x4/0 / 1x350 Bypass 1600 (Ir = 0.8) 4x400 / 4x600 1x4/0 / 1x350 Output 1600 (Ir = 0.8) 4x400 / 4x600 1x4/0 / 1x350 Battery 3000 (Ir = 1.0) 8x500 / 9x600 1x400 / 1x600 Recommended Upstream Protection and Cable Sizes for 1100 kW UPS NOTE: For a 1250 I/O cabinet, it is preferred to use flexible copper power cables with as small a diameter as possible. The number of power cables needed for this kW rating will make large and inflexible power cables more difficult to install. Maximum OCPD (A) Cable size per phase (AWG/kcmil) Copper / Aluminum EGC cable size (AWG/kcmil)94 Copper / Aluminum Input 2000 (Ir = 0.9) 5x500 / 6x500 1x250 / 1x400 Bypass 1600 (Ir = 0.9) 4x500 / 5x500 1x4/0 / 1x350 Output 1600 (Ir = 0.9) 4x500 / 5x500 1x4/0 / 1x350 Battery 3000 (Ir = 1.0) 8x500 / 9x600 1x400 / 1x600 Recommended Upstream Protection and Cable Sizes for 1250 kW UPS NOTE: For a 1250 I/O cabinet, it is preferred to use flexible copper power cables with as small a diameter as possible. The number of power cables needed for this kW rating will make large and inflexible power cables more difficult to install. Maximum OCPD (A) Cable size per phase (AWG/kcmil) Copper / Aluminum EGC cable size (AWG/kcmil)94 Copper / Aluminum Input 2000 (Ir = 1.0) 5x600 / 6x600 1x250 / 1x400 Bypass 1600 (Ir = 1.0) 4x600 / 5x600 1x4/0 / 1x350 Output 1600 (Ir = 1.0) 4x600 / 5x600 1x4/0 / 1x350 Battery 4000 (Ir = 0.9) 9x600 / 11x600 2x250 / 2x400 990-5451K-001 49 Facility Planning 480 V UPS System 94. If the conductors are run in conduits, there must be one conductor in each conduit. Recommended Upstream Protection and Cable Sizes for 1500 kW UPS Maximum OCPD (A) Cable size per phase (AWG/kcmil) Copper / Aluminum EGC cable size (AWG/kcmil)95 Copper / Aluminum Input 250096 6x600/ 8x600 1x350 / 1x400 Bypass 200096 5x600/ 6x600 1x250 / 1x350 Output 200096 5x600/ 6x600 1x250 / 1x350 Battery 500097 11x600/ 14x600 1x700 kcmil/ – Recommended Bolt and Lug Sizes for Copper Cables Cable Size Terminal Bolt Diameter Cable Lug Type Crimping Tool Die 1/0 AWG M12 x 35 mm LCCF1/0–12–X CT930 CD-920–2/0 Black P45 2/0 AWG M12 x 35 mm LCCF2/0–12–X CT930 CD-920–3/0 Orange P50 3/0 AWG M12 x 35 mm LCCF3/0–12–X CT930 CD-920–4/0 Purple P54 250 kcmil M12 x 35 mm LCCF250–12–X CT-940CH/CT-2940 CD-920–300 White P66 300 kcmil M12 x 35 mm LCCF300–12–6 CT-940CH/CT-2940 CD-920–350 Red P71 400 kcmil M12 x 35 mm LCCF400–12–6 CT-940CH/CT-2940 CD-920–500 Brown P87 500 kcmil M12 x 35 mm LCCF500–12–6 CT-940CH/CT-2940 CD-920–500A Pink P99 600 kcmil M12 x 40 mm LCCF600–12–6 CT-940CH/CT-2940 CD-920–750 Black P106 Recommended Bolt and Lug Sizes for Aluminium Cables Cable Size Terminal Bolt Diameter Cable Lug Type Crimping Tool Die 2/0 AWG M12 x 40 mm LAB2/0-12-5 CT930 Olive P54 3/0 AWG M12 x 40 mm LAB3/0-12-5 CT930 Ruby P60 250 kcmil M12 x 40 mm LAB250-12-5 CT930 Red P71 300 kcmil M12 x 40 mm LAB300-12-2 CT930 Blue P76 400 kcmil M12 x 40 mm LAB400-12-2 CT930 Green P94 500 kcmil M12 x 40 mm LAB500-12-2 CT930 Pink P99 600 kcmil M12 x 40 mm LAB600-12-2 CT930 Black P106 50 990-5451K-001 480 V UPS System Facility Planning 95. If the conductors are run in conduits, there must be one conductor in each conduit. 96. Long-time setting (Ir) = 1.0 97. Long-time setting (Ir) = 0.9 Weights and Dimensions UPS Shipping Weights and Dimensions Weight kg (lbs) Height mm (in) Width mm (in) Depth mm (in) 1250 kW I/O cabinet (GVXI1250KDNBF2 or GVXI1250KD) 800 (1764) 2140 (84.3) 1400 (55.1) 1060 (41.8) 1500 kW I/O cabinet (GVXI1500KD) 1060 (2337) 2140 (84.3) 2120 (83.5) 1060 (41.8) Galaxy VX 250 kW power cabinet (GVXP250KD) 560 (1235) 2140 (84.3) 760 (29.9) 1060 (41.8) NOTE: The Galaxy VX UPS consist of one 1250 kW I/O cabinet or one 1500 kW I/O cabinet and a minimum of two 250 kW power cabinets depending on your chosen configuration. Weights and Dimensions for UPSs with 1250 kW I/O Cabinet Commercial reference Weight kg (lbs) Height mm (in) Width mm (in) Depth mm (in) • GVX500K500NGS • GVX500K750NGS • GVX500K1000NGS • GVX500K1250NGS Total – Power cabinets – I/O cabinet 1700 (3748) 2 x 540 (2 x 1190) 620 (1367) 1970 (77.6) 2400 (94.5) 2 x 600 (2 x 23.6) 1200 (47.2) 900 (35.4) • GVX625K625NGS • GVX625K1000NGS • GVX750K500NGS • GVX750K750NGS • GVX750K1000NGS • GVX750K1250NGS Total – Power cabinets – I/O cabinet 2240 (4938) 3 x 540 (3 x 1190) 620 (1367) 1970 (77.6) 3000 (118.1) 3 x 600 (3 x 23.6) 1200 (47.2) 900 (35.4) • GVX800K800NGS • GVX1000K750NGS • GVX1000K1000NGS • GVX1000K1250NGS Total – Power cabinets – I/O cabinet 2780 (6129) 4 x 540 (4 x 1190) 620 (1367) 1970 (77.6) 3600 (141.7) 4 x 600 (4 x 23.6) 1200 (47.2) 900 (35.4) • GVX1100K1100NGS • GVX1250K1000NGS • GVX1250K1250NGS Total – Power cabinets – I/O cabinet 3320 (7319) 5 x 540 (5 x 1190) 620 (1367) 1970 (77.6) 4200 (165.4) 5 x 600 (5 x 23.6) 1200 (47.2) 900 (35.4) • GVX1500K1100NGS • GVX1500K1250NGS Total – Power cabinets – I/O cabinet 3860 (8510) 6 x 540 (6 x 1190) 620 (1367) 1970 (77.6) 4800 (189.0) 6 x 600 (6 x 23.6) 1200 (47.2) 900 (35.4) 990-5451K-001 51 Facility Planning 480 V UPS System Weights and Dimensions for UPSs with 1500 kW I/O Cabinet Commercial reference Weight kg (lbs) Height mm (in) Width mm (in) Depth mm (in) • GVX500K1500GS Total – Power cabinets – I/O cabinet 1956 (4312) 2 x 540 (2 x 1190) 876 (1931) 1970 (77.6) 3200 (126.0) 2 x 600 (2 x 23.6) 2000 (78.7) 900 (35.4) • GVX750K1500GS Total – Power cabinets – I/O cabinet 2496 (5503) 3 x 540 (3 x 1190) 876 (1931) 1970 (77.6) 3800 (149.6) 3 x 600 (3 x 23.6) 2000 (78.7) 900 (35.4) • GVX1000K1500GS Total – Power cabinets – I/O cabinet 3036 (6693) 4 x 540 (4 x 1190) 876 (1931) 1970 (77.6) 4400 (173.2) 4 x 600 (4 x 23.6) 2000 (78.7) 900 (35.4) • GVX1250K1500GS Total – Power cabinets – I/O cabinet 3576 (7884) 5 x 540 (5 x 1190) 876 (1931) 1970 (77.6) 5000 (196.9) 5 x 600 (5 x 23.6) 2000 (78.7) 900 (35.4) • GVX1500K1500GS Total – Power cabinets – I/O cabinet 4116 (9074) 6 x 540 (6 x 1190) 876 (1931) 1970 (77.6) 5600 (220.5) 6 x 600 (6 x 23.6) 2000 (78.7) 900 (35.4) • GVX1750K1500GS Total – Power cabinets – I/O cabinet 4656 (10265) 7 x 540 (7 x 1190) 876 (1931) 1970 (77.6) 6200 (244.1) 7 x 600 (7 x 23.6) 2000 (78.7) 900 (35.4) 52 990-5451K-001 480 V UPS System Facility Planning Clearance Clearance for UPSs with 1250 kW I/O Cabinet NOTE: Clearance dimensions are published for airflow and service access only. Consult with the local safety codes and standards for additional requirements in your local area. NOTE: The UPS system can be placed up against a wall and there is no requirement for rear or side access. Clearance for UPSs with 1500 kW I/O Cabinet NOTE: Clearance dimensions are published for airflow and service access only. Consult with the local safety codes and standards for additional requirements in your local area. NOTE: The UPS system can be placed up against a wall with no requirement for rear or side access. Front View 990-5451K-001 53 Facility Planning 480 V UPS System Guidance for Organizing Battery Cables NOTE: For 3rd party batteries, use only high rate batteries for UPS applications. NOTE: When the battery bank is placed remotely, the organizing of the cables is important to reduce voltage drop and inductance. The distance between the battery bank and the UPS must not exceed 200 m (656 ft). Contact Schneider Electric for installations with a longer distance. NOTE: To minimize the risk of electromagnetic radiation, it is highly recommended to follow the below guidance and to use grounded metallic tray supports. Cable Length 200 kW Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities Introduction SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 5- eBus Depots EcoStruxure Value Proposition Applications Overview Reference Architectures 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories How does it work? Introduction to eBus Depots There are three main use cases recommended for the electrical installation, depending on the customer’s needs: Use case 1: “Keep it simple, grid supply” Build and enable the electrical infrastructure to supply energy to the eBuses. Use case 2: “Self-consume, grid tied” Build and enable the electrical infrastructure while integrating the renewable energy sources. Manage energy sources for the eBuses, intended to optimize both technical and economic parameters. Use case 3: “Run off grid” Build electrical infrastructure with the ability to disconnect from the grid to help: • Increase availability (lack of supply from the grid) • Optimize energy supply prices • Enhance stability across the internal network (“microgrid”) once disconnected from external energy sources. Public eBus Depot Use Cases Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities Introduction SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 5- eBus Depots EcoStruxure Value Proposition Applications Overview Reference Architectures 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories Main components of the electrical architecture Introduction to eBus Depots Public Main Components of the Electrical Architecture for eBus Depots Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories EcoStruxure Power Value Proposition Apps, analytics, and services Edge Control Connected products Fleet Management (Third party) for eBus Depots EV charger Circuit breaker Cloud-Based Advisor Services for Asset Management, EV Charging and distributed energy resources (renewables) Uninterruptible power supply Power meter Power quality solutions Panel server 2. Operational Management • Real-time monitoring and control of power system status and identification of abnormal temperature, insulation faults or power disturbances • EV Charging Expert to optimize the use of energy between every charging point • Microgrid Automation to manage Distributed Energy Resources (DERs) and improve real-time grid stability and reliability 3. Analysis & Optimization • Cloud-based predictive power asset maintenance with expert recommendation provided by our Schneider Electric service experts • Consulting services including network audits, microgrid sizing services, power systems engineering and sustainable energy procurement • Microgrid optimization using a cloud-based platform with necessary algorithms to get the most out of the local energy resources • EV advisor for advanced management of the charging process, connected to a route-planning application (third-party) 1. Primary Equipment • MV/LV range of power Connected Products for protection, power correction and monitoring • Battery Energy Storage Systems (BESSs) to improve grid flexibility and stability • High powered DC electric vehicle charging units AVEVA System Platform EcoStruxure Power Operation / Power Monitoring Expert EcoStruxure EV Charging Expert Simulation Engine EcoStruxure Microgrid Operation Our solution to control and supply energy to eBus depots Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Specific pillars for eBus depots EcoStruxure Power Value Proposition EcoStruxure Power provides applications to support the challenges of eBus depots for Railway and Urban Transportation, with the following pillars: Reliable Electrification Electrical Distribution Monitoring and Alarming Capacity Management Power Event Analysis Power Quality Monitoring, Correction, and Compliance Power Source and Load Control Safety and Comfort Enhance safety and comfort in passenger stations and tunnels Continuous Thermal Monitoring Guided Procedures Through Extended Reality Digitalization Operate centrally and maintain infrastructure efficiently Backup Power Testing Circuit Breaker Settings Monitoring Asset Performance Decarbonization Reduce energy consumption and carbon footprint Basic Energy Awareness Advanced Energy Performance Effective Energy Accounting Energy and Environmental Compliance Electrification (eBus Depot) Advanced Microgrid Improve reliability of electrical infrastructure Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Capacity Management è Visualize real-time or historical power system capacity è Monitor and trend circuit or equipment loading è Provide information for capacity planning Reliable Electrification Power Event Analysis è Provide a user-friendly graphical tool to simplify and save time in event analysis è Provide an aggregated view of events in the same dashboard è Enable root cause analysis Reliable Electrification Power Quality Monitoring, Correction, and Compliance è Power Quality Monitoring and Compliance: Monitor persistent steady state and event- based disturbances to better understand and analyze power quality disturbances è Power Quality Correction: Correct over/under voltages, harmonics, etc. Reliable Electrification Power Source and Load Control è Help isolate faults with relay automation and circuit breaker coordination è Help preserve critical loads by automatically transferring to alternate power è Help restore power quickly è Get real-time visibility, automation and control of the entire electrical infrastructure Reliable Electrification ■■■ ■■■ ■■■ ■■■ è Provide real-time status of the electrical distribution system è Help identify anomalies and notify the right personnel è Aggregate onboard alarm data in an easy-to-understand way è Take advantage of native integration of intelligent electrical devices Reliable Electrification Electrical Distribution Monitoring and Alarming ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Continuous Thermal Monitoring è Monitor the temperature of busbar, cable, transformer, and withdrawable circuit breaker connections è Help detect poor connections at an early stage è Provide temperature alarming and reporting for fast response Guided Procedures Through XR è Use Extended Reality to perform step-by-step guidance è Benefit from “X-ray” vision and virtually overlaid contextual asset and site information, live data, events and alarms è Take advantage of remote collaboration Safety and Comfort Safety and Comfort Backup Power Testing è Automatically record key backup power test parameters such as run time, engine loading, exhaust and engine temperatures è Perform automated backup power test reporting Digitalization Circuit Breaker Settings Monitoring è Compare current circuit breaker settings with commissioned settings è Help detect inappropriate setting modifications periodically è Provide information for capacity planning Digitalization Asset Performance è Make asset health visible across the entire system è Streamline inspections using continuous asset health monitoring è Optimize maintenance planning with analytics and expert advice Digitalization ■■■ ■■ ■■ ■ ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Effective Energy Accounting Identify areas for possible energy conservation measures: è Utility Bill Verification: Identify billing errors by comparison with a shadow bill è Cost Allocation: Allocate energy costs to terminals or departments for accurate billing è Power Factor correction: Mitigate harmonic effects and power quality issues Decarbonization Basic Energy Awareness è Energy Monitoring: Increase awareness of energy usage by creating easy-to- understand graphical dashboards and reports from data è Cost Allocation: Identify "quick-win" opportunities for energy savings Decarbonization è Energy Efficiency Compliance: Report effectively about local/global energy and environmental building code compliance è Greenhouse Gas Reporting: Track and report emissions effectively to help cut carbon emissions Decarbonization Energy and Environmental Compliance ■■ ■ ■ Advanced Microgrid è Enhance power system reliability, despite grid instability often resulting from powerful storms and grid unavailability è Reduce carbon emissions and optimize cost efficiency by leveraging Distributed Energy Resources (DERs) Decarbonization ■■ Advanced Energy Performance è Energy Performance: Normalize energy data (e.g. with respect to building area) to give context. Analyze energy performance in context using KPIs è Energy Benchmarking: Compare energy usage with respect to other comparable facilities è Energy Modeling and Verification: Model the energy usage versus energy drivers Decarbonization ■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable è Power the bus depot with an end-to-end electrical distribution solution for charging your electrical buses è Integrate and manage local power generation and batteries for self-consumption of renewable energy or for resiliency purposes Decarbonization Electrification (EV Charging for eBus Depot) ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems eBus Depots 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Reference Electrical and Digital Architectures Typical electrical architecture Reference digital architecture Find the Schneider Electric products necessary to implement the selected applications. Then find their location in the electrical architecture. Find how the products, software solutions and cloud services are connected in the digital architecture. Public Typical Electrical Architecture for e-Bus Depots Public Reference Digital Architecture for e-Bus Depots Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities WHY READ THIS SECTION? SECTION 3 SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories The objective of this section is to: • Introduce tunnel systems • Review EcoStruxure Power value propositions and the associated applications for tunnel systems • Provide reference electrical and digital architectures EcoStruxure Power Digital Solutions and Services for: à Tunnel Systems Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories What is it? Introduction to Tunnel Systems Railway tunnels allow crossing of geographical landforms while respecting the layout limitations of the railway lines. They involve major civil engineering works and the supply of systems to improve the safe use of the infrastructure. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Access ControlVentilation How does it work? Introduction to Tunnel Systems A typical tunnel system consists of multiple technical systems that work in coordination in order to fulfill the operational plan. These include: Telecom Fire Detection Power Supply Drainage Lighting Weather Forecasting Signaling Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Main components of the electrical architecture Introduction Public Main Components of the Electrical Architecture for Tunnel Systems Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories EcoStruxure Power Value Proposition Apps, analytics, and services Edge Control Connected products for Tunnel Systems Cloud-Based Advisor Services for asset management, data integrity, and workforce empowerment with extended reality guidance AVEVA System Platform Protection relay Remote terminal unit Circuit breaker Safety control unit RIO drop Control unit Power quality meter Protection device UPS Power quality solutions Automatic transfer switch Variable speed drive Energy meter Panel server 2. Operational Management Edge Control for all systems such as elevators, escalators, lighting, HVAC, drainage, ventilation, etc. These systems can be: • Option 1: centrally controlled (from the Control Center) using Supervisory Control and Data Acquisition (SCADA) • Option 2: locally controlled using onsite HMIs or mobile apps A software interface is used to exchange the control perimeter between the local tunnel system and the Control Center. 3. Analysis & Optimization • Cloud-based predictive power asset maintenance with expert recommendation provided by our Schneider Electric service experts • Consulting Services including network and power quality audits • Augmented reality guidance for complicated or rarely performed procedures AVEVA System Platform EcoStruxure Power Operation / Power Monitoring Expert Cooling Local HMI Our solution to control and supply energy to tunnel systems 1. Primary Equipment Connected products include protective and electrical network automation devices, power meters, power conditioning units (UPS and power quality solution), and building automation. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Specific pillars for tunnel systems EcoStruxure Power Value Proposition EcoStruxure Power provides applications to support the challenges of tunnel systems for Railway and Urban Transportation, with the following pillars: Reliable Electrification Electrical Distribution Monitoring and Alarming Capacity Management Power Event Analysis Power Quality Monitoring, Correction, and Compliance Power Source and Load Control Safety and Comfort Enhance safety and comfort in passenger stations and tunnels Continuous Thermal Monitoring Guided Procedures Through Extended Reality Digitalization Operate centrally and maintain infrastructure efficiently Backup Power Testing Circuit Breaker Settings Monitoring Asset Performance Decarbonization Reduce energy consumption and carbon footprint Basic Energy Awareness Advanced Energy Performance Energy and Environmental Compliance Effective Energy Accounting Improve reliability of electrical infrastructure Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Tunnel Systems 6- Tunnel Systems 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Capacity Management è Visualize real-time or historical power system capacity è Monitor and trend circuit or equipment loading è Provide information for capacity planning Reliable Electrification Power Event Analysis è Provide a user-friendly graphical tool to simplify and save time in event analysis è Provide an aggregated view of events in the same dashboard è Enable root cause analysis Reliable Electrification Power Quality Monitoring, Correction, and Compliance è Power Quality Monitoring and Compliance: Monitor persistent steady state and event- based disturbances to better understand and analyze power quality disturbances è Power Quality Correction: Correct over/under voltages, harmonics, etc. Reliable Electrification Power Source and Load Control è Help isolate faults with relay automation and circuit breaker coordination è Help preserve critical loads by automatically transferring to alternate power è Help restore power quickly è Get real-time visibility, automation and control of the entire electrical infrastructure Reliable Electrification ■■ ■■■ ■■■ ■■■ è Provide real-time status of the electrical distribution system è Help identify anomalies and notify the right personnel è Aggregate onboard alarm data in an easy-to-understand way è Take advantage of native integration of intelligent electrical devices Reliable Electrification Electrical Distribution Monitoring and Alarming ■■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction 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Then find their location in the electrical architecture. Find how the products, software solutions and cloud services are connected in the digital architecture. Public Typical Electrical Architecture for Tunnel Systems Public Reference Digital Architecture for Tunnel Systems Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities WHY READ THIS SECTION? SECTION 3 SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories The objective of this section is to: • Introduce depots and workshops • Review EcoStruxure Power value propositions and the associated applications for depots and workshops • Provide reference electrical and digital architectures EcoStruxure Power Digital Solutions and Services for: à Depots and Workshops Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories What is it? Introduction to Depots and Workshops A depot or workshop is a railway facility where preventive and corrective maintenance tasks are carried out on rolling stock. The difference between the two is not totally clear, but the former is usually more focused on train storage and their periodic maintenance, while the latter is more focused on major repairs. However, it is common for both types of services to be carried out within the same building. Main line Stabling Area Yard Area Pway & Infrastructure Building Workshop Building Car Delivery Test Track Depot Control Center Administrative Building 1 4 5 A train depot/workshop has the following main areas: 1. Train yard 2. Train workshop building 3. Train wash plant 4. Test track 5. Depot control center Wash Plant Wheel Lathe Store 2 3 Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Drainage Traction Power How does it work? Introduction to Depots and Workshops Typical depots and workshops consist of multiple technical systems that work in coordination in order to fulfill the operational plan. These include: Power Supply Microgrid Management Lighting Washing Maintenance Safety Process HVAC*Fire Detection * Heating, Ventilation, Air Conditioning Access Control Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Main components of the electrical architecture Introduction Public Main Components of the Electrical Architecture for Depots and Workshops Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our solution to control and supply energy to depots and workshops EcoStruxure Power Value Proposition Apps, analytics, and services Edge Control Connected products for Depots and Workshops Cloud-Based Advisor Services for asset management, data integrity, and workforce empowerment with extended reality guidance AVEVA System Platform Protection relay Remote terminal unit Circuit breaker Safety control unit Control unit Power quality meter Protection device UPS Power quality solutions Automatic transfer switch Variable speed drive Energy meter Panel server 2. Operational Management Edge Control for all systems such as depot power, traction power, lighting, HVAC, drainage, etc. These systems can be: • Option 1: centrally controlled (from the Control Center) using Supervisory Control and Data Acquisition (SCADA) • Option 2: locally controlled using onsite HMIs or mobile apps A software interface is used to exchange the control perimeter between the depot and the Control Center. 3. Analysis & Optimization • Cloud-based predictive power asset maintenance with expert recommendation provided by our Schneider Electric service experts • Consulting Services including network and power quality audits • Augmented reality guidance for complicated or rarely performed procedures AVEVA System Platform EcoStruxure Power Operation / Power Monitoring Expert Cooling Local HMI EcoStruxure Microgrid Operation Control Unit Drive controller 1. Primary Equipment Connected products include protective and electrical network automation devices, power meters, power conditioning units (UPS and power quality solution), and building automation. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public 7- Depots and Workshops Depots and Workshops SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 4 – Design Considerations SECTION 5 – Customer Stories Specific pillars for depots and workshops EcoStruxure Power Value Proposition EcoStruxure Power provides applications to support the challenges of depots and workshops for Railway and Urban Transportation, with the following pillars: Reliable Electrification Safety and Comfort Enhance safety and comfort in passenger stations and tunnels Digitalization Operate 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Introduction to the Control Center The Control Center is a central location from which the following facilities (described in the previous sections) are operated: • Traction Substations • Overhead Lines • Auxiliary Power System • Passenger Stations • Tunnel Systems • Datacenters Its purpose is to achieve compliance with the operational plan, with the minimum necessary resources. Comment: • Initially, the responsibility was located at the local levels of the facilities. • Now, process automation makes it possible to delegate responsibility to a higher hierarchy facility and increase the operational efficiency. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories Real-time Operation Asset Management Objective Add advanced facility maintenance strategies to traditional corrective and preventive maintenance. This helps optimize asset availability without increasing maintenance costs. Objective Optimize operations with the analytics applied to data acquired from the field devices. This helps to empower the workforce. Operational Efficiency How does it work? (1/2) Introduction to the Control Center The control center is the facility that centrally manages the railway installations. The most relevant element of this facility is the control room, from which the system operators are mandated to perform the following functions: How • Monitor and control the facilities including the implementation of automated systems that facilitate any changes in the configuration of the tasks. • Manage operations for all the facilities (full delegation, exceptions for abnormal situations). • Manage emergency scenarios for passenger stations and tunnel systems. Objective Manage the operational plan of the facilities remotely and centrally. This helps to optimize the state of operation under various situations. How Collect data from field devices to monitor asset health and perform: • Condition-based maintenance: Proactive monitoring depending on the condition of the asset. Maintenance is triggered when critical parameters vary beyond their "normal" range. • Predictive maintenance: a maintenance task is performed when measured variables of an asset deviate from those indicated as normal by a digital model of the asset. How Use data collected at operational level to implement advanced functionalities such as: • Electrical simulation: commonly used for operator training or operation support, and during the facility electrical design phase. • Basic and advanced reporting: advanced representation of information and generation of new data, using data processing techniques and AI models. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY SECTION 4 – Design Considerations SECTION 5 – Customer Stories A Redundancy-based Strategy The Control Center is responsible for the operations of all the facilities (except in abnormal situations mainly related to maintenance and telecom network issues). Therefore, it has a huge responsibility, and its availability is critical. To improve availability of the control center, essential services are usually implemented with redundancy: • Redundancy of the components inside the control center • Redundancy of the control center in other locations (emergency control center). How does it work? (2/2) Introduction to the Control Center In case of failure of a component or of unavailability of the control center, the redundant component / control center takes over the function/service until repair/availability. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories EcoStruxure Power Value Proposition Apps, analytics, and services Edge Control Connected products for Control Centers Cloud-Based Advisor Services for asset management, data integrity and workforce empowerment with extended reality guidance AVEVA Insight EcoStruxure XR Operator Advisor EcoStruxure EV Advisor EcoStruxure Microgrid Advisor EcoStruxure Building Advisor AVEVA System Platform EcoStruxure Power Operation / Power Monitoring Expert EcoStruxure Building Operation Simulation Engine EcoCare Membership * EcoStruxure Cybersecurity Admin Expert 2. Operational Management Among the usual tasks to be carried out by the operators of the control center, we can highlight the following: • Assurance of power supply to trains and rail consumers • Mitigation of the impact of electrical faults in the railway traction scope. • Implementation of the different operational / emergency scenarios defined for passenger stations and tunnels. • Central management of the cybersecurity for the full architecture. 3. Analysis & Optimization Applications for advanced asset management, analysis and optimization of operations: • Predictive and condition-based maintenance for electrical assets • Integration, contextualization, analysis, and representation of information • Advanced management of microgrids and electric chargers, including technical and economic aspects. • Consulting Services, including network and power quality audits • Augmented reality guidance for complicated or rarely performed procedures 1. Primary Equipment Data provided by connected products from the different facilities Energy control of traction, non-traction and catenary systems Passenger Stations Tunnels Our solution to control and supply energy to control centers Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Specific pillars for control centers EcoStruxure Power Value Proposition EcoStruxure Power provides applications to support 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operation within a simulated but highly realistic environment to enhance safety and operational efficiency è Track and review trainee actions to analyze and challenge them Digitalization ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Simulate Before Operate è Provide operators with a list of potential side effects, prior to executing a command è Empower employees to feel more confident when operating their facilities by providing real-time guidance è Reduce human error that could lead to outages or safety concerns Digitalization Cybersecurity Central Management è Integrate cybersecurity solutions allowing the operations team to have visibility of key cybersecurity data è Help manage/maintain cybersecurity control points è Align to cybersecurity standards and best practices to strengthen OT security Digitalization Asset Preventive Maintenance è Minimize inventory costs and improve spare part availability è Manage mobile work for more accurate and timely data collection è Receive proactive maintenance information by identifying labor/material/tools/drawings on work order Digitalization Asset Analytics è Analyze utilization, efficiency, and condition-management of assets. Receive alerts and notifications è Provide automated analytics using supervised or unsupervised machine learning è Create dynamic data visualizations and asset frameworks for contextual data viewing Digitalization Massive Data Archive and Contextualization è Collect and store in one single place real-time data from operating assets with sub- second granularity è Contextualize and visualize data Digitalization ■■ ■■■ ■■ ■■ ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information Rail Power Design è Visualize and analyze traction power systems using synchronized geospatial and schematic views è Simulate and analyze operation of combined DC and AC power supply networks è Model traction power-specific devices with built-in components and engineering libraries Digitalization Effective Energy Accounting Identify areas for possible energy conservation measures: è Utility Bill Verification: Identify billing errors by comparison with a shadow bill è Cost Allocation: Allocate energy costs to terminals or departments for accurate billing è Power Factor correction: Mitigate harmonic effects and power quality issues Decarbonization Basic Energy Awareness è Energy Monitoring: Increase awareness of energy usage by creating easy-to- understand graphical dashboards and reports from data è Cost Allocation: Identify "quick-win" opportunities for energy savings Decarbonization Advanced Microgrid è Enhance power system reliability, despite grid instability often resulting from powerful storms and grid unavailability è Reduce carbon emissions and optimize cost efficiency by leveraging Distributed Energy Resources (DERs) Decarbonization ■■■ ■■ ■■ ■■ Advanced Energy Performance è Energy Performance: Normalize energy data (e.g. with respect to building area) to give context. Analyze energy performance in context using KPIs è Energy Benchmarking: Compare energy usage with respect to other comparable facilities è Energy Modeling and Verification: Model the energy usage versus energy drivers Decarbonization ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Our Digital Solutions and Services: Applications Overview ■■■ Essential ■■ Recommended ■ Desirable Click on the blue links to have more information è Energy Efficiency Compliance: Report effectively about local/global energy and environmental building code compliance è Greenhouse Gas Reporting: Track and report emissions effectively to help cut carbon emissions Decarbonization Energy and Environmental Compliance è Power the bus depot with an end-to-end electrical distribution solution for charging your electrical buses è Integrate and manage local power generation and batteries for self-consumption of renewable energy or for resiliency purposes Decarbonization Building Automation è Monitor and control the electromechanical systems present in the passenger station è Automate processes within the passenger station è Implement operational and emergency scenarios Decarbonization Electrification (EV Charging for eBus Depot) ■■■ ■■ ■■ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities Introduction EcoStruxure Value Proposition Applications Overview Reference Architectures SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 5- eBus Depots 6- Tunnel Systems 8- Control Center Control Center BIBLIOGRAPHY 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market 7- Depots and Workshops BIBLIOGRAPHY 4- Passenger Stations SECTION 4 – Design Considerations SECTION 5 – Customer Stories Reference Electrical and Digital Architectures Typical reference architecture Typical digital architecture Find the Schneider Electric digital solutions and services relevant to implement the selected applications. Then find their location in the reference architecture. Find how the products, software solutions and cloud services are connected in the digital architecture. Public Typical Reference Architecture for the Control Center Public Reference Digital Architecture for the Control Center Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 4 – Design Considerations SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Communications Protocols Time Synchronization Integration with BMS Cybersecurity Environmental Data Program BIBLIOGRAPHY SECTION 5 – Customer Stories WHY READ THIS SECTION? Design Considerations à Control Center Solutions à Communication Protocols à Time Synchronization à Integration with BMS à Cybersecurity à Environmental Data Program The objective of this section is to: • Provide the details of the critical system design components to be considered while designing digital architecture • Addresses design considerations of the electrical installation in the context of communications, data, time and cybersecurity à Control Strategies for Passenger Stations à Control Strategies for Traction substations Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Communications Protocols Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program The control center centralizes the operation of railway facilities. Schneider Electric offers the following solutions for effective management and control: How to Choose a Solution for Operation Control Centers Management of Energy Management of Passenger Stations Control of Railway Tunnels Control of Datacenters AVEVA System Platform EcoStruxure Power Monitoring Expert EcoStruxure Building Operation EcoStruxure IT Expert AVEVA System Platform AVEVA System Platform Basic functionalities EcoStruxure Power Operation Complex systems Building approach Industrial approach Additional analysis EcoStruxure Power Monitoring Expert • Continuous thermal monitoring • Power event analysis • Power quality monitoring • Energy usage analysis • Energy efficiency & power quality compliance • Good capabilities for integration with external systems • Industrial interoperability protocols • Management of power supply • Monitoring of environmental conditions • Railways • Building element integration • Building management • Interoperability protocols • Urban Transportation • Higher integration needs of external systems • Industrial interoperability protocols • Basic operation and monitoring • Alarm management • Access control • Automatism and interlocks • Basic reporting • Continuous thermal monitoring • Power event analysis • Power quality monitoring • Energy usage analysis • Energy efficiency & power quality compliance • Advanced alarm management • Advanced reporting & data analytics tools • Emergency control center • Graphical event replay • Scalability Additional analysis EcoStruxure Power Monitoring Expert • Continuous thermal monitoring • Power event analysis • Power quality monitoring • Energy usage analysis • Energy efficiency & power quality compliance Tunnel Management Additional analysis EcoStruxure Power Monitoring Expert • Continuous thermal monitoring • Power event analysis • Power quality monitoring • Energy usage analysis • Energy efficiency & power quality compliance Datacenter Management Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Control Strategies for Passenger Stations Passenger stations can be conceptualized in various ways, depending on the approach to automation and the perception of the facility. Surface-installed passenger station Underground passenger station Application • Mainlines or in high-speed rail systems Control strategy • Considered as a specialized type of building • Alignment with building management system Typical equipment • Floor controllers (AS-P) • Room controllers (RP-C) • Building Operation & Building Advisor for centralizing station information. Telecommunication Protocols • KNX • DALI • Other standard telecontrol protocols. Application • Urban transportation Control strategy • Considered as an industrial facility • Use of industrial automation for critical components like ventilation Typical equipment • PLCs based solutions (M580 and M340) • AVEVA System Platform for centralizing information Telecommunication Protocols • OPC (for advanced data modeling and cybersecurity features). • Modbus (for interconnexion with legacy systems) Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Control Strategies for Traction Substations Alternating Current (AC) Direct Current (DC) Application Mainly in high performance systems such as mainlines or in high- speed rail systems • Railway systems with very high energy demand • High-speed travel • Railway systems with a very high frequency of train movements Control Strategy • Use elements borrowed from electrical distribution Typical equipment • Specialized controllers for managing electrical devices with a native implementation of most of the necessary functions for substation automation Interoperability standard • IEC 61850: describes the implementation of the functions present in a substation from both a constructive and functional perspective Advantage • Fully adapted to control an electrical process • Analysis of electrical events • Excellent performance • Maintenance management & engineering tools • Good interoperability due to the use of IEC 61850 • Cybersecurity requirements Drawback • Higher price Application Mainly urban transportation • Systems with lower energy demand (tramways) • Networks with a strong tradition in this technology (metros) Control Strategy • Choose a general-purpose programmable logic controller (PLC) as the main element for their automation Typical equipment • Use general-purpose programmable logic controllers (PLCs) for automation Interoperability standard • Modbus (and variants) Advantage • Simple configuration • Price competitive Drawback • Limitation in meeting usual standards of the electrical world • Limited performance • Limitations due to Modbus: deficiencies in electrical object modeling, event dating, and cybersecurity. Can be addressed using non-standard versions of the protocol or OPC UA protocol (widely used in industrial environments). Control strategy is different whether the system is supplied with alternating or direct current: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Communications Protocols Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Modern electrical distribution systems, especially in critical infrastructure like railways and urban transportation, use various industrial protocols for data communication from devices such as circuit breakers, relays, controllers, and sensors. Key protocols include: Commonly used for high-speed medium voltage automation. Provides: • Consistent measurement naming • Fast device-to-device communication (GOOSE messaging) • Communication to a SCADA system IEC 61850 Modbus RTU and Modbus TCP/IP Common in low voltage systems for metering, protection, and control. Can convert serial Modbus to Modbus TCP/ IP for data integration with a power monitoring or SCADA software . Wireless (IEC 802.15-4, e.g. Zigbee) Enables low-powered simple data communication for energy and condition monitoring sensors. Can be aggregated and converted to Modbus TCP/IP for integration with a power monitoring or SCADA software (using a data concentrator and protocol converter device) EcoStruxure Power natively integrates with Schneider Electric devices to obtain real-time, historical event and data logs, as well as waveforms. However, it is common for 3rd party devices to store event logs and waveform data in proprietary formats. The EcoStruxure Power platform can acquire data from any device using the open protocols mentioned above, provided the data is available in non-vendor-proprietary formats. • Communications Learn more about: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Time Synchronization Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Environmental Data Program Communications Protocols Time Synchronization Why consider time synchronization of connected products? To operate, EcoStruxure Power applications collect data from the connected products of the electrical installation (such as relays, trip units, power meter, sensors). When applications analyze and correlate timestamped data from multiple connected products, it is crucial to make sure that their internal clocks are accurate relative to other devices and local time. The setting of devices to a single time reference is called time synchronization. The choice of the time synchronization solution must be defined during the system design phase. It depends on the time criticality of the applications deployed to monitor and control the different parts of the installation. Refer to next page for further explanations about time criticality. • "How to Optimize Time-Synchronization and Data Recording for EcoStruxure Power Digital Applications" Technical Guide For a detailed coverage of time synchronization, refer to: • Data recording and Timestamping section in the EcoStruxure Power Design Guide Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Time Synchronization Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Environmental Data Program Communications Protocols What is the time criticality of an application? Time Synchronization The time criticality of an application defines the level of time accuracy required for data timestamping to enable the proper operation of the application. EcoStruxure Power categorizes applications into three levels of time criticality: Example of time criticality: • Continuous Thermal Monitoring: This application monitors the progressive rise in busbar connection temperature to help prevent fires. It has a low time criticality. • Power Event Analysis: This application reconstructs the sequence of events among multiple electrical equipment to help understand the cause(s) of an incident. It has a high time criticality. Refer to next page to learn how to select the appropriate time synchronization solution based on the time criticality. • Time criticality of applications Learn more about: Digital Application Time Critical Time Accuracy Upper Limit Time Accuracy Lower Limit High ± 1 ms ± 10 ms Medium ± 10 ms ± 1 s Low ± 1 s ± 10 s Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Time Synchronization Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Environmental Data Program Communications Protocols How to select the time synchronization solution based on time criticality? Time Synchronization There are many options available for time synchronization protocols, which can make it challenging to develop a cohesive strategy for all connected devices. To achieve optimal performance while minimizing costs, it is common to enforce the most accurate protocols only in the sensitive areas of electrical distribution (e.g., the electrical supply of core industrial processes) and use less accurate solutions in areas with lower sensitivity (e.g., utilities). The table below provides an overview of the solutions based on achieved time criticality and related costs: To summarize the table : • PTP provides the best performance versus cost option available today for highly time-critical applications, but is not available on all devices • IRIG-B offers similar performance to PTP but comes with a much higher installation cost. • NTP is the next best alternative for medium time-criticality needs. • SNTP or Modbus are adequate for low time-critical applications. Application Time Critical Typical Time Accuracy Protocol Media Protocol Typical Cost High ± 1 ms Ethernet PTP (IEEE 1588) $ $ High ± 1 ms Serial IRIG-B $ $ $ Medium ± 10 ms to 100 ms Ethernet NTP $ Medium ± 100 ms Serial DCF77 $ $ Low ± 1 s Ethernet SNTP $ Low ± 1 s Ethernet Over Modbus / ION from Edge Control $ Low ± 1 s Serial 1 per 10 $ $ Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Integration with BMS Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Time Synchronization Environmental Data Program Communications Protocols Why integrate mechanical and electrical systems? Integration with Building Automation Systems (BMS) • Data Integration and Interoperability between Systems Learn more about: Need for data aggregation Facility infrastructure is experiencing a convergence of information and operational systems. This is particularly true for Railway and Urban Transportation applications, where mechanical and electrical systems are essential infrastructure. These systems are rapidly generating increasing amounts of data, with the addition of new sensors, meters, and other smart equipment. It is crucial to have robust software system with proper data aggregation from these devices. Examples of mechanical and electrical systems integration in Railway • Energy performance monitoring : Track and model facility energy usage; • Asset management: View mechanical and electrical asset performance in one place; • Fault management: Detect faults and respond through an integrated interface. Benefits of systems integration Integrating the systems: • Creates a unified interface for visualizing, analyzing, and reporting data, simplifying daily tasks for operations and maintenance staff; • Enables applications to utilize context from both systems to optimize the decision-making processes; • Enhances overall Operational efficiency Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Integration with BMS Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Time Synchronization Environmental Data Program Communications Protocols Why plan the integration at the design phase? Integration with Building Automation Systems (BMS) • Data Integration and Interoperability between Systems Learn more about: Costly retrofit of existing installations Traditionally, Power Management Systems (electrical systems) and Building Management Systems (including mechanical systems) are designed in silos. The consequence is that it leaves the end user with little to no electrical data in operational systems. Retrofitting this into an existing system can be quite costly. Therefore, it is essential to design the proper IoT electrical systems far in advance. Advantages of early system integration Enabling the BMS and PMS to integrate directly to relevant data allows the systems to perform as designed. Additionally, it also: • Reduces cost and complexity by minimizing excessive wiring of electrical devices to mechanical control systems. • Helps system integrators by enabling a seamless interface to manage facility operations and maintenance; Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Integration with BMS Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Time Synchronization Environmental Data Program Communications Protocols How is data acquired and integrated within the architecture? (1/2) Integration with Building Automation Systems (BMS) Data acquisition Digital electrical monitoring and control software acquires data from intelligent electrical devices via open communication protocols. This includes: • Real-time information • Historical power events • Data logs • Electrical signal waveforms • Service diagnostics. By default, BMS (Building Management Systems) cannot retrieve certain data from the electrical distribution, such as event logs, waveforms, and diagnostic data. Trying to do this directly with the BMS would require a tremendous amount of engineering. It is more efficient and native to let a PMS (Power Management System) collect the data from the electrical distribution and then integrate the PMS with the BMS. • Data Integration and Interoperability between Systems Learn more about: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Integration with BMS Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Time Synchronization Environmental Data Program Communications Protocols How is data acquired and integrated within the architecture? (2/2) Integration with Building Automation Systems (BMS) Data Integration The method/tool to integrate the data depends on the data type, and on the direction of the transfer: The integration is performed through: • An Extract Transform Load functions Used for historical building management data to enable energy data correlation. The integration is performed through: • EcoStruxure Web Services Used for real-time data, alarms, and historical data • Web interface integration (Single Sign On) Used for power and energy dashboards, graphical diagrams, trends, reports, and configuration pages EcoStruxure Building Operation (EBO) EcoStruxure Power Operation (EPO) with Advanced Reporting and Dashboards EcoStruxure Building Operation (EBO) EcoStruxure Power Operation (EPO) with Advanced Reporting and Dashboards PublicExample of Combined Solution with EcoStruxure Building Operation and EcoStruxure Power Operation with Advanced Reporting and Dashboards Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols ACCESS CONTROL Seven pillars to strengthen cybersecurity Cybersecurity Protect electrical components by verifying the identity of any user requesting access to a component before activating the communication with that component. When used in conjunction with security event logging, this will include ensuring 'non-repudiation,' for example, a person cannot deny that they performed a particular action. Access Control DATA CONFIDENTIALITY USE CONTROL DATA INTEGRITY DATA FLOW TIMELY

RESPONSE TO EVENTS RESOURCE AVAILABILITY Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Protect against unauthorized actions on component resources by verifying that the necessary privileges have been granted before allowing a user to perform the actions. This must address what a hacker can potentially do if they access the system and counteract that by only giving the minimum level of access necessary for that user to perform their role. Use Control USE CONTROL DATA CONFIDENTIALITY DATA INTEGRITY DATA FLOW TIMELY RESPONSE TO EVENTS RESOURCE AVAILABILITY ACCESS CONTROL Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Ensure that the components will perform as intended during operational and non-operational states, such as energy production and storage, or a maintenance shutdown. Consider a Circuit Breaker that is detecting potential issues in its operation: if the SCADA system is hacked and is forced to indicate everything is okay, that could cause an unexpected and dangerous event. Data Integrity DATA INTEGRITY DATA CONFIDENTIALITY USE CONTROL DATA FLOW TIMELY RESPONSE TO EVENTS RESOURCE AVAILABILITY ACCESS CONTROL Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Protection of component-generated confidential or sensitive nature information, whether at rest or in transit. Also, protection of data to avoid hackers who aim to break in. Data regarding energy profiles and usage could provide information into confidential Railway operations. Data Confidentiality DATA CONFIDENTIALITY USE CONTROL DATA INTEGRITY DATA FLOW TIMELY RESPONSE TO EVENTS RESOURCE AVAILABILITY ACCESS CONTROL Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Ensure the connection of the device to a segmented network where disconnection strategy, unidirectional gateway, firewall, and demilitarized zones are defined to avoid unnecessary data flow. Network segmentation is a strategy that can stop a cyberattack from going from one connected system to another (for example, from the electrical communication network to the business network). Data Flow DATA FLOW DATA CONFIDENTIALITY USE CONTROL DATA INTEGRITY TIMELY RESPONSE TO EVENTS RESOURCE AVAILABILITY ACCESS CONTROL Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Detect, identify and respond to security violations by notifying the proper authority, reporting needed evidence of the violation, and taking timely corrective action when incidents are discovered in mission- critical or safety-critical situations. Timely Response to Events TIMELY RESPONSE TO EVENTS DATA CONFIDENTIALITY USE CONTROL DATA INTEGRITY DATA FLOW RESOURCE AVAILABILITY ACCESS CONTROL Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY 1 2 3 5 4 6 7 SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Seven pillars to strengthen cybersecurity Cybersecurity Ensure the availability of the application or device against the degradation or denial of essential services. Resource Availability RESOURCE AVAILABILITY DATA CONFIDENTIALITY USE CONTROL DATA INTEGRITY DATA FLOW TIMELY RESPONSE TO EVENTS ACCESS CONTROL Cybersecurity is no longer a question of competitive advantage or even minimizing damage. It is a fundamental requirement for doing business today. Here are the seven essential pillars for improving it: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Recommendations for selecting your partners for an optimal cybersecurity journey Cybersecurity The IEC 62443 standard provides essential guidelines for enhancing the security of connected electrical distribution systems, including network, control, and safety solutions. When selecting partners, it is important that they understand the standard well and implement it effectively. It's crucial to choose a partner with robust internal processes who can certify that products and solutions are developed according to well-defined procedures. At Schneider Electric, we have dedicated services to support throughout the cybersecurity journey. SOLUTION PROVIDERS SERVICE PROVIDERS CONSULTANT Find an electrical power distribution specialist with a deep understanding of cybersecurity requirements. They should: • Help you with the risk assessment; • Define the levels of security you require, compliant with IEC 62443; • Provide guidance on implementing best practices for cybersecurity. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Recommendations for selecting your partners for an optimal cybersecurity journey Cybersecurity The IEC 62443 standard provides essential guidelines for enhancing the security of connected electrical distribution systems, including network, control, and safety solutions. When selecting partners, it is important that they understand the standard well and implement it effectively. It's crucial to choose a partner with robust internal processes who can certify that products and solutions are developed according to well-defined procedures. At Schneider Electric, we have dedicated services to support throughout the cybersecurity journey. CONSULTANT SERVICE PROVIDERS SOLUTION PROVIDERS Choose an electrical system technology provider that has adopted the IEC 62443 standard and has a secure development lifecycle process in place that: • Ensures systems are resilient in case of cyberattack; • Provides a formal process to inform and assist customers if any security vulnerabilities are discovered; • Fully tests and validates the security of all components and systems; • Demonstrates third-party cybersecurity certification; • Delivers customized and flexible solutions that align with your business requirements. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Recommendations for selecting your partners for an optimal cybersecurity journey Cybersecurity The IEC 62443 standard provides essential guidelines for enhancing the security of connected electrical distribution systems, including network, control, and safety solutions. When selecting partners, it is important that they understand the standard well and implement it effectively. It's crucial to choose a partner with robust internal processes who can certify that products and solutions are developed according to well-defined procedures. At Schneider Electric, we have dedicated services to support throughout the cybersecurity journey. CONSULTANT SOLUTION PROVIDERS SERVICE PROVIDERS Choose partners with the required capabilities: • A system integrator with deep IT and OT experience including cybersecurity within the context of critical operational systems • Cybersecurity services that can deliver quick response to help assess and recover from a cyberattack. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Cybersecurity BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Time Synchronization Environmental Data Program Communications Protocols Certified secure system architecture according to IEC 62443-3-3 with documented processes and solutions for a secure system. Cybersecurity system configuration software for consistent security policy deployment. Consulting services from design, implementation, operations and maintenance to tailor your security solutions to your strategy and budget. Our solutions to support cybersecurity journey Cybersecurity At Schneider Electric, we can: • Provide a selection of cybersecurity certified products • Provide certified system architectures and solutions • Deliver lifecycle services Lifecycle servicesCertified products Certified systems & solutions • Cybersecurity Learn more about: Certified products developed according to IEC 62443 functional requirements with Secure Development Lifecycle processes. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Time Synchronization Cybersecurity Environmental Data Program BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Communications Protocols Environmental Data Program Governments are committing to carbon neutrality by 2050, leading to new regulations promoting sustainability: ESG reporting is becoming crucial. The Corporate Sustainability Reporting Directive (CSRD) expands disclosure requirements to nearly 50,000 companies, including those outside the EU. This enhances transparency and accountability. Consumers demand sustainable practices, with a rise in repairing, reselling, and reusing products. However, greenwashing remains a challenge, as some companies make unsubstantiated sustainability claims. Regulators are cracking down on false claims, emphasizing the need for credible and verifiable environmental data. Consumer Expectations and Greenwashing Risks The need to address ESG regulations (ESG = Environmental, Social, and Governance) At Schneider Electric, we have deployed an Environmental Data Program to address this need. Discover more next page Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 4 – Design Considerations SECTION 2 – How EcoStruxure Power Can Support the Railway Industry SECTION 3 – Digital Solutions and Services across the Facilities SECTION 1 – Introduction to the Railway and Urban Transportation Market Control Center Solutions Control Strategies for Passenger Stations Control Strategies for Traction Substations Time Synchronization Cybersecurity Environmental Data Program BIBLIOGRAPHY SECTION 5 – Customer Stories Integration with BMS Communications Protocols Next-level transparency for better-informed product choices Environmental Data Program The Environmental Data Program is a framework for how we, at Schneider Electric, measure, categorize, and compare the environmental attributes and footprint of our products. Using a rigorous, fact-based methodology, the program provides environmental data from across the product lifecycle. Use Better: How sustainable a product is, including environmental footprint, materials and substances, packaging, and energy efficiency. Use Longer: How a product's lifetime can be effectively extended in terms of repairability and updatability. Use Again: How a product can be reused, from dismantling and remanufacturing to recyclability and manufacturer take back. With this transparent, fact-based data, customers and partners are empowered to make conscious environmental choices and accurately evaluate and report on sustainability performance. All our hardware offers have an associated environmental data available on se.com product pages. • Schneider Electric Environmental Program Learn more about: Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 5 – Customer Stories Railway: Europe Urban Transportation: US SECTION 3 – Digital Solutions and Services across the Facilities SECTION 5 SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center SECTION 4 – Design Considerations 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market WHY READ THIS SECTION? BIBLIOGRAPHY Urban Transportation: Europe Customer Stories The objective of this section is to: • Showcase our solutions provided across globe in the Railway and Urban Transportation sectors, addressing our customers' challenges and key needs. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 5 – Customer Stories SECTION 4 – Design Considerations Railway: Europe Urban Transportation: US SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market BIBLIOGRAPHY Urban Transportation: Europe Solution Provided Railway: A Leading Railway Operator in Europe Manage and operate efficiently a country-wide network: • Nearly 6.000 km mainlines railway network with almost 340 electrical substations; • Nearly 4.000 km of reliable high speed national rail network with almost 175 traction electrical facilities. Services • Maintenance services: corrective and preventive • Engineering and electrical substation design • Cybersecurity Edge Control • AVEVA System Platform for energy and building management at Control Center level • EcoStruxure Power Automation System as the substation automation solution • EcoStruxure Power Monitoring Expert for power management with Power Quality improvements Connected products • AC MV Panels for traction network: 25 kV AC high speed and 3.3 kV DC mainlines • Cabinets for auxiliary power line • Overhead line disconnectors (OHL): 25 kV AC high speed and 3.3 kV DC mainlines • PowerLogic T500 (formerly Saitel) for data acquisition and concentration • Building Management System for Passenger Stations • Tunnel Automation System Customer Challenges • Real-time single view of the national rail network, through integrated main and back-up control centers • Optimized energy through integrated monitoring and energy management systems Customer Benefits Public Solution Provided for a Leading Railway Operator in Europe Apps, analytics, and services Edge Control Connected products AVEVA System Platform EcoStruxure Power Monitoring Expert EcoStruxure Power Automation System Cybersecurity Consulting Digitalization Consulting Electrical Engineering Maintenance Services Commissioning and Training MV switchgear, control units, protection relays, power meters, overhead line controllers Note: Pictures displayed here may not represent the actual product available on site. They are used for pictorial demonstration only. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 5 – Customer Stories Railway: Europe Urban Transportation: US SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market SECTION 4 – Design Considerations BIBLIOGRAPHY Urban Transportation: Europe Customer Challenges Urban Transportation: Brookville Smart Energy Bus Depot in US • Electrification Converting municipal bus fleet to electric • Resilience Extreme weather and extended past power outages • Sustainability GHG reduction targets of 80% by 2027 and 100% by 2035 Services • EcoStruxure Microgrid Advisor implementing: - Tariff Management, - Self-consumption - Demand charge reduction • EcoStruxure Power Advisor for power management with Power Quality improvements Edge Control • EcoStruxure Power Operation for power management • Load Management System for optimizing the charging process from technical and economical point of view • EcoStruxure Microgrid Operation to integrate removable energy and manage the potential islanded situation from the grid Connected products • EV Charger as main charging element to provide energy to the bus fleet • Battery Storage System to store energy and help in the optimization of the charging process • Energy Control Center, integrating all LV equipment needed Solution Provided Watch now Customer Benefits • 44 buses transitioning from diesel to electric, and powered by on-site low-carbon energy • 62% of reduced lifetime emissions expected from the microgrid (equivalent to 155,000 tons of GHG) • 99.9% resilience and reliability of operations, sized to handle peek demand Customer Benefits Public Solution Provided for Brookville Smart Energy Bus Depot in the US Apps, analytics, and services Edge Control Connected products Energy Control Center Battery Storage System EV Charger Charge Pilot Controller EcoStruxure Power Operation EcoStruxure Microgrid Operation Load Management System EcoStruxure Power Advisor EcoStruxure Microgrid Advisor Note: Pictures displayed here may not represent the actual product available on site. They are used for pictorial demonstration only. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 5 – Customer Stories Railway: Europe SECTION 3 – Digital Solutions and Services across the Facilities SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market SECTION 4 – Design Considerations Urban Transportation: US BIBLIOGRAPHY Urban Transportation: Europe Solution Provided Urban Transportation: A Leading Metro Operator in Europe Services • ETAP eTraX Simulation Engine for: - Modeling, design, and analysis - Predictive simulation of power networks - Operator training simulation (OTS) Edge Control • AVEVA System Platform to operate energy systems and passenger stations from the control center level • Modicon M580 to automate energy systems and passenger stations Connected products • MV panel solutions: RM6 and SM AirSeT • PowerLogic P5 to implement electrical protection functions • Modicon M380 to implement basic automation and information acquisition Customer Benefits • Centralize view for informed decision-making in energy management and passenger stations. • Improve safety and operational efficiency with end-to-end visibility across facilities. • Facilitate seamless integration with legacy and modern systems. Customer Challenges • Improvement of operational efficiency with new extended remote operation capabilities. • Open platform integrating multiple external systems with many certified system integrators. • Enhanced modeling, design, analysis, operation planning, predictive simulation and automation services enabled by ETAP real-time solution. Customer Benefits Public Solution Provided for Leading Metro Operator in Europe Apps, analytics, and services Edge Control Connected products Simulation Engine Modicon M580 SM AirSeT RM6 (SeT series) LV Switchgear EcoStruxure Power Automation System PowerLogic P5 Modicon M340 Note: Pictures displayed here may not represent the actual product available on site. They are used for pictorial demonstration only. Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities BIBLIOGRAPHY Reference Document Useful Links BIBLIOGRAPHY SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center SECTION 4 – Design Considerations SECTION 5 – Customer Stories 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities Reference Document BIBLIOGRAPHY SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center SECTION 4 – Design Considerations SECTION 5 – Customer Stories 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Useful Links Design Guide Reference Documents Digital Applications for Large Buildings and Critical Facilities The Digital Applications Design Guide provides comprehensive details on the building blocks of EcoStruxure Power: the IoT applications are driven by a software layer to control the traditional electrical distribution infrastructure. Developed to help engineering consultants and designers, this guide is an invaluable resource for specifying, designing and prescribing EcoStruxure Power architectures capable of performing one or more of the business-driven applications described within. Access the Design Guide online from the Landing page (IEC/NEMA) Download the PDF View online Download IEC Download NEMA Reference Guide EcoStruxure Power for Railway and Urban Transportation Public SECTION 3 – Digital Solutions and Services across the Facilities Reference Document Useful Links BIBLIOGRAPHY SECTION 2 – How EcoStruxure Power Can Support the Railway Industry 2- Traction Substations 3- Auxiliary Powers Systems 4- Passenger Stations 5- eBus Depots 6- Tunnel Systems 7- Depots and Workshops 8- Control Center SECTION 4 – Design Considerations SECTION 5 – Customer Stories 1- Overhead Lines SECTION 1 – Introduction to the Railway and Urban Transportation Market Transportation landing page on se.com Useful links Landing page Public Schneider Electric Industries SAS 35, rue Joseph Monier CS 30323 92506 Rueil Malmaison Cedex France www.se.com © 2025 Schneider Electric. All Rights Reserved. All trademarks are owned by Schneider Electric SE, its subsidiaries and affiliated companies. All other brands are trademarks of their respective owners 2025/01/23 ESXP2RG004EN eConversion Premium protection and sustainability for highly critical applications A unique high-efficiency mode available for Galaxy V-series UPSs se.com The next step in your sustainability journey eConversion mode: the unbeatable combination of power quality and efficiency Protect power to your load, reduce your electricity consumption, and meet your sustainability goals with up to 99% efficient, Class 1-compliant eConversion mode for Galaxy V-series UPSs. This patented high-efficiency mode achieves Class 1 categorization (the highest protection class), equaling Double Conversion, the legacy default operating mode of 3-phase UPSs. In eConversion mode, the inverter operates continuously, ensuring that if power fluctuates, your UPS can protect the load with no transfer time. eConversion mode also recharges batteries and provides power factor correction and harmonics compensation, making it a versatile solution for protecting both IT and non-IT loads. Operating at up to 99% efficiency isn't just good for the environment, it's good for your balance sheet. Within 10 years, the electricity savings of operating your UPS in eConversion typically equals up to 3x the price of the UPS. Delivering premium power protection and optimized total cost of ownership, eConversion is both the recommended operating mode for your Galaxy V-series UPS and an effortless step toward a more profitable business and a more sustainable world. 2 eConversion Third-party certified performance eConversion is the first UL-verified high efficiency mode. It has passed the rigorous testing of this 3rd-party, industry-leading certification agency. Class 1 protection Choose eConversion mode with confidence; its performance has been certified Class 1 per IEC ® 62040-3, the same class as Double Conversion. Excellent load protection, including patented zero-break transfer design The UPS continues to deliver input power factor correction, harmonic filtering, and no-break transfer to Double Conversion mode or battery operation. Maximum availability, third-party certified Enjoy the highest energy efficiency available today without sacrificing load protection. Every Galaxy V-series UPS includes eConversion mode and delivers these benefits: eConversion meets Class 1 of IEC 62040-3: zero-break transfer during power outage. 1000.11 10 Nominal Value (Voltage %) 100% 80% 60% 40% 20% 0% -20% -40% -60% -80% -100% 1,000 Overvoltage transient limit Undervoltage transient limit +10% -10% Transient duration in milliseconds (ms) eConversion Over 10 years of field deployment Since its launch in 2014, eConversion has been successfully deployed all over the world. Join thousands of customers who use it daily to protect their critical loads. Continuously charging batteries With eConversion mode, your batteries are ready when you need runtime. Ideal for IT and non-IT applications • Data centers • Factories • Commercial offices • Transportation • Hospitals Sustainably reduce your operating costs Using eConversion mode achieves 99% efficiency, which provides significant savings every year on your electricity bill. Compared to Double Conversion, the savings are typically equivalent to up to 3 times the UPS acquisition price after 10 years. Optimize your energy consumption eConversion power savings accrue fast. For example, Galaxy VL with eConversion mode conserves every year as much power as the electricity generated by 30 rooftop solar installations, equivalent to the electricity required to recharge 50 electric cars. Up to 3x reduction in electricity use 4 = = 1x 31x 53x Galaxy VL in eConversion Rooftop solar installations Cars powered $$$$ UPS Price + Electricity Electricity savings = up to 3x UPS price $$$ $$ $ 0 Year 1 Year 5 Year 10 eConversion 99% efficiency Double Conversion eConversion Double Conversion 97% efficiency Total Cost of Ownership, optimized UPS eConversion savings over 10 years UPS kW rating Electricity savings* Carbon emissions (metric tons) savings Equivalent solar rooftop production Cars powered Galaxy VS 150 kW $41,000 135 10 16 Galaxy VM 225 kW $73,000 243 17 28 Galaxy VL 500 kW $146,000 484 31 53 Galaxy VXL 1250 kW $394,200 1314 88 150 Galaxy VX 1500 kW $684,000 2300 154 263 *Model dependent; based on a market electricity price: $0.15 /kWh and CO2 emissions factor of 0.5 kg/kWh. The annual electricity and carbon emissions savings are done by comparing the UPS efficiency in Double Conversion mode to its efficiency in eConversion mode. Carbon emissions are calculated based on the world average reported by the International Energy Agency (IEA): https://www.iea.org/reports/global-energy-co2-status-report-2019/emissions Calculate your efficiency and carbon emissions savings using the eConversion vs Double Conversion calculator, using this link or the QR code on page 6: https://www.se.com/ww/en/work/solutions/system/s1/data-center-and-network-systems/ trade-off-tools/econversion-vs-double-conversion-calculator/ eConversion A unique combination eConversion, Double Conversion, or ECO mode? A comparative study For decades, Double Conversion has been used as the default mode in 3-phase UPSs. The main disadvantage is the very high amount of electricity used 24 hours a day, 365 days a year to permanently regulate the output with a very tight +/-1% voltage tolerance. The cost of electricity used to perform permanent regulation typically represents up to 3x the UPS price over 10 years, while permanently re-creating a perfect sinewave has no extra benefit to the load as even the most critical loads are insensitive to a +/-10% voltage. Legacy 3-phase 'Default' mode Legacy 'High-efficiency' mode Most important for the availability of critical loads is the no-break transfer, certified by Class 1 protection (the highest category). In eConversion, the load is powered by the grid as long as it is within tolerance, but the inverter is kept operating in parallel. This ensures a no-break transfer in case of an outage, surge, or short circuit, and ensures third-party certified, Class 1 output, which denotes the highest availability. In comparison, using ECO mode (the legacy high-efficiency mode) reduces load availability and is therefore not a preferred mode of operation for applications requiring maximum protection. Double Conversion eConversion ECO mode Voltage fluctuation ««« Frequency fluctuation ««« Recharge batteries ««« No transfer time ««« PF Correction ««« Protection class Class 1 Efficiency 96-97% Voltage fluctuation «« Frequency fluctuation «« Recharge batteries ««« No transfer time ««« PF Correction ««« Protection class Class 1 Efficiency 99% Voltage fluctuation «« Frequency fluctuation «« Recharge batteries Option No transfer time No PF Correction No Protection class Class 3 Efficiency 99% Bypass switch Bypass switch Bypass switch Battery Battery Battery DC/DC DC/DC DC/DC AC in AC in AC in M2 M2 M2 M1 M1 M1 AC in AC in AC inLoad Load Load Inverter Inverter InverterPFC rectifier PFC rectifier PFC rectifier May be on to allow battery recharge Calculate your savings 6 Use our eConversion vs Double Conversion Calculator to quickly assess your potential energy savings, operating cost optimization, and CO2 emissions reduction by comparing the cost of running your Galaxy V-series UPS in eConversion mode vs Double Conversion mode. Scan this QR code with your phone camera, or access the calculator from the Schneider Electric Data Center Trade Off ToolsTM Web page: https://www.se.com/ww/en/work/solutions/system/s1/data-center-and-network- systems/trade-off-tools/econversion-vs-double-conversion-calculator/ If you have site-specific questions, our trained Field Service Representatives can perform a technical assessment of your site before you activate eConversion mode. To learn more, contact your Schneider Electric representative. On-screen savings meter If you already have a Galaxy V-series UPS, start using eConversion mode and watch the savings add up! eConversion Schneider Electric Industries SAS 35 rue Joseph Monier 92500 Rueil-Malmaison, France Tel : +33 (0)1 41 29 70 00 © 2024 Schneider Electric. All Rights Reserved. Schneider Electric | Life Is On is a trademark and the property of Schneider Electric SE, its subsidiaries, and affiliated companies • 998-22187559 To learn more about eConversion mode, contact your Schneider Electric representative or visit https://www.se.com/ww/en/work/solutions/eConversion- high-efficiency-UPS-mode About Schneider Electric: At Schneider Electric, we believe access to energy and digital is a basic human right. We empower all to make the most of their energy and resources, ensuring Life Is On everywhere, for everyone, at every moment. We provide energy and automation digital solutions for efficiency and sustainability. We combine world-leading energy technologies, real-time automation, software and services into integrated solutions for Homes, Buildings, Data Centers, Infrastructure, and Industries. We are committed to unleash the infinite possibilities of an open, global, innovative community that is passionate about our Meaningful Purpose, Inclusive and Empowered values. www.se.com 3-Phase Uninterruptible Power Supply (UPS) Secure Power Portfolio www.se.com Public 2 Contents I. Overview 3 II. Our Portfolio 4 III. Products 3-Phase UPSs 5 Galaxy VS (10-150 kW) 6 Galaxy VM (160-225 kVA) 7 Galaxy VL (200-500 kW) 8 Galaxy VX (500-1500 kW) 9 Galaxy VXL (500-1250 kW) 10 Easy UPS 3S (10-40 kVA) 11 Easy UPS 3M (60-200 kVA) 12 Easy UPS 3M Advanced (100-250 kW) 13 Easy UPS 3L (250-600 kVA) 14 Galaxy 3L (250-600 kVA) 15 Easy UPS 3-Phase Modular (50-250 kW) 16 Galaxy PX (100-250 kW) 17 Symmetra PX (10-500 kVA) 18 Galaxy PW 2nd Gen (10-200 kVA) 19 3-Phase Lithium-ion Battery Cabinets 20 Galaxy Lithium-ion Battery Cabinets 21 3-Phase IT Power Distribution 22 Galaxy Power Distribution Units (PDUs) 23 Galaxy RPP 24 Configurable and Modular Power Distribution Units 25 Upsilon Static Transfer Switches 26 IV. Key Applications and Segments by Product 28 2 Schneider's purpose is to empower all to make the most of our energy and resources, bridging progress and sustainability for all. We call this Life Is On. Our mission is to be your digital partner for Sustainability and Efficiency. Schneider Electric is a world leader in power protection, solving today's energy challenges while setting the standard for quality and innovation with fully integrated solutions, enterprise-wide networks, data centers, mission-critical systems, and industrial/manufacturing processes. Overview Empowering all to make the most of our energy and resources, bridging progress and sustainability for all. 3 Public 4 Our Portfolio Fully integrated, end-to-end 3-phase UPS solutions help maintain your enterprise-wide networks, data centers, mission-critical systems, and industrial manufacturing processes. Our global portfolio of world-class products and services uniquely combines to offer end- to-end critical power solutions, providing customers with robust power protection, anytime/anywhere visibility, and peace of mind with EcoStruxure IT software and flexible service plans throughout the life cycle of their installations. Galaxy V Series UPSs Maximize your availability and sustainability and optimize your total cost of ownership. Our modular Galaxy V Series UPSs deliver superior performance in a compact footprint, with up to 99% efficiency in eConversion mode, scalability and internal redundancy options, and Galaxy Lithium-ion battery solutions, making them ideal for the data center or business-critical applications. Easy UPS 3-phase UPSs Quickly deploy power protection that optimizes your capital expenses. Easy UPS 3-phase range UPSs feature robust electrical specifications, ruggedizing features, and a compact, lightweight footprint that are ideal for commercial or industrial applications. Modular Data Centers Schneider Electric 3-phase UPSs are ideal for Modular Data Center applications. Contact your Schneider Electric representative to learn how you can increase your infrastructure capacity while shrinking your infrastructure footprint. 5 Products 3-phase UPSs Galaxy VS For external batteries: 10-75 kW (208V), 20-150 kW (400V/480V) With internal smart battery modules: 10-50 kW (208V), 10-100 kW (400V), 20-100 kW (480V) Sold: Worldwide 6 SE.com Features Applications & Segments • IT • Small and medium data centers • Business-critical applications • Edge • Commercial and industrial facilities • Marine • Healthcare, Oil & Gas, Transportation, Minerals, Metals, Mining, Power, Grid • High efficiency in eConversion mode (up to 99%) • Maximum availability with modular architecture • Innovative Live Swap of power modules • Parallel for capacity or redundancy—up to 4 UPSs • Internal redundancy with N+1 power modules • Flexible modular, classic, & Lithium-ion battery solutions • Compact design with optimized footprint • Touchscreen display with NMC • NMC with Secure Subscription License • EcoStruxure connected • Green Premium solution • Start-up service included Options • Battery flexibility, including Lithium-ion batteries • Single and parallel wallmount maintenance bypass panel • Classic and Modular Battery Cabinets • Battery Breaker Box and Battery Breaker Kit • IP52/NEMA 12 Kit • Seismic kits (OSHPD) • Network management card embedded with ethernet (NMP) and Modbus • Galaxy VS 20 kW (480V in, 400V out) up to 80 kW Internal Input Transformer for NAM Overview Galaxy VS is a highly efficient, modular, simple-to-deploy 3-phase UPS that delivers top performance to edge, small, and medium data centers, as well as critical infrastructure in commercial and industrial facilities. It offers increased availability, reduced operating costs, and first-class power protection for critical infrastructure. Galaxy VM For external batteries: 160-200 kVA (400V), 160-225 kVA (480V) Sold: Worldwide (except Japan) Features Applications & Segments • Mission-critical environments • Medium data centers • Industrial plants and applications • Facility infrastructure • Healthcare • Telecommunications • Highly efficient eConversion mode (up to 98.5%) • Integrated backfeed protection • Single-cabinet top and bottom cable entry • Full front-service access • Flexible modular, classic, and Lithium-ion battery solutions • Large color touch-screen display with built-in NMC • 65 kAIC rating standard • Compact footprint • Smart Power Test (SPoT) mode • OSHPD certified cabinets • Integrated casters for ease of mobility • EcoStruxure connected • Start-up service included Options • Classic and Modular Battery Cabinets • Management cards • Fuse kits • Wall-mounted battery breaker boxes • Parallel system bypass cabinets • Dust filter kits • System bypass cabinets • 208V transformers • Flywheel and Lithium-ion battery compatible • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License 7 Overview Galaxy VM is a highly efficient, modular 3-phase UPS that seamlessly integrates into medium data centers, industrial, or facilities applications. SE.com Public 8 Galaxy VL Applications & Segments • Mission-critical environments • Medium and large data centers • Colocation facilities • Computer rooms • Edge computing, Internet DC, Cloud computing • Light industry and commercial buildings • Infrastructure and transportation 8 For external batteries: 200-500 kW (400V/480V) Sold: Worldwide Overview Galaxy VL is a highly efficient, scalable 3-phase UPS featuring a modular, redundant design and low TCO for medium and large data centers and mission-critical environments. Minimize your total cost of ownership while expanding your business and maximizing your availability, reliability, and sustainability. With up to 99% efficiency in eConversion mode and fast power expansion with Live Swap, Galaxy VL is the most compact galaxy in the UPS universe. Make your data center or co-location facility more sustainable today. SE.com Features • Highly efficient eConversion mode (up to 99%) • Compact design, optimized footprint • Innovative Live Swap • Lithium-ion battery option • Parallel for capacity or redundancy—up to 6 UPSs • Scalable, modular design enables N+1 internal redundancy • Smart Power Test (SPoT) mode • Fault-tolerant design • Touchscreen display with NMC • Secure NMC Subscription License • Full front-service access • EcoStruxure connected • Green Premium solution • Startup service included Options • Classic battery cabinets • SKRU kit • Remote Centralized Display Box • Bottom Entry Cabinet 65kAIC Kit • Seismic (with option kit) • Replaceable dust filters • Backfeed protection options • Battery Breaker Box/Kit • NMC embedded with ethernet (NMP) and Modbus • Maintenance bypass cabinets Galaxy VX Features Applications & Segments • Mission-critical environments • Large/extra-large data centers • Industrial applications • Facility infrastructure • Cloud and Service providers • Colocation facilities • Finance, semiconductor, and manufacturing environments • Telecommunications, Healthcare • Highly efficient eConversion mode (up to 99%) • Cabinet-level scalability for capacity or redundancy • Dual mains input, top and bottom cable entry • Parallel for capacity or redundancy — up to 4 UPSs • Flywheel and Lithium-ion battery compatible • Internal redundancy with N+1 power cabinets • Smart Power Test (SPoT) mode • Touchscreen display with NMC • EcoStruxure connected • Startup service included Options • Battery pull box • Network Management Card (AP9640 / AP9641 / AP9643) with Secure NMC Subscription License • SmartSlot cards • Replaceable dust filters • Single feed kit 9 For external batteries: 500 scalable to 1500 kW N+1 (400V/480V) Sold: Worldwide Overview Galaxy VX is a highly efficient, modular 3-phase UPS scalable from 500 to 1500 kW in a single unit with high performance and flexible operating modes. Its scalability accommodates the changing needs of your rapidly expanding business, and its exceptional performance and abundance of cost-saving features reduce your energy costs and total cost of ownership. Galaxy VX is the ideal UPS for today's large data centers, cloud and colocation facilities, as well as mission-critical applications. SE.com • Parallel cable kit • Maintenance bypass cabinets • Classical battery cabinets Public 10 Galaxy VXL 10 For external batteries: 500-1250 kW (400V) Sold: All IEC countries worldwide SE.com Features Applications & Segments • Large and extra-large data centers • Colocation facilities • Computer rooms • Light industry & commercial buildings • Cloud & Service Provider facilities • Semiconductor industry • Manufacturing critical line • Energy and Chemicals • Bank, Finance, Insurance • Pre-fabricated systems • High efficiency eConversion mode (up to 99%) • Compact design, optimized footprint only 1.2m2 • Innovative Live Swap • Lithium-ion battery integration • EcoStruxure connected • Scalable, modular design enables N+1 internal redundancy • Reliable and fault-tolerant design • Sustainable solution • Full front access • Unity power factor @40°C, kVA=kW • Touchscreen display with NMC • High short circuit level 100kA • Secure NMC Subscription License • Smart Power Test (SPoT) mode • Startup service included Options • Battery Breaker Box/Kit • Empty Battery Cabinet Overview Galaxy VXL is a highly efficient, compact, and modular 3-phase UPS with Live Swap. With its industry-leading compact design, high-density technology, and fault-tolerant architecture, Galaxy VXL maximizes availability, operational efficiency, and critical load protection while minimizing TCO. This UPS delivers up to 97.5% efficiency in double conversion mode and up to 99% in eConversion mode, reducing the UPS Carbon emissions by a factor of two. Galaxy VXL offers proactive asset management services to give you peace of mind anytime, anywhere. Start-up service is included. • Galaxy Lithium-ion Battery Cabinets • Air filter kit • Parallel Communications Kit • Seismic kit, and other options Public 11 Easy UPS 3S For external batteries: 10-40 kVA (400V) With and/or for internal batteries: 10-40 kVA (208V/400V) Sold: US, Canada, Mexico, and all IEC countries worldwide, except Japan Features Applications & Segments • Small data centers • Commercial buildings & light industrial applications • Business-critical applications • Healthcare, Telecommunication, Transportation, Manufacturing facilities • Non-IT • Easy to install and start up; minimal footprint • Delivers up to 96% efficiency • Wide operating temperature range and strong overload protection • Replaceable dust filters • Strong protection against harsh environments with robust electrical specifications • Conformal coating • Easy Loop Test to verify UPS performance before you connect your load • Parallel for capacity or redundancy—up to 4 UPSs • Easy to manage with mimic panel • EcoStruxure connected • Long life battery string ready Options • Cold Start kit • Parallel maintenance bypass, up to 2 units for 400V or 3 units for 208V • Battery Breaker Box and Battery Breaker Kit • Empty battery cabinets • Standard 7Ah or 9Ah battery modules • NMC with Secure Subscription License • Start-up service 11 Overview Easy UPS 3S (400V) is an easy to install, use, and service 3-Phase UPS available for external batteries or with and/or for internal batteries designed for small data centers and other business critical applications. Easy UPS 3S (208V) is an easy to install, use, and service 3-Phase UPS for internal batteries designed for small data centers, commercial buildings, non-IT, and light industrial applications. SE.com: 400V / 208V Public 12 Easy UPS 3M For external batteries: 60-200 kVA (400V) and 50-100 kVA (208V) With internal batteries: 60-80 kVA (400V) Sold: 208V countries of South America and Caribbean Islands, and all IEC countries worldwide, except Japan 12 SE.com Features Applications & Segments • Small and medium data centers and computer rooms • Electrical rooms • Business-critical applications • Commercial buildings • Healthcare, Telecommunication, Transportation, Manufacturing facilities • Start-up included • Easy deployment and compact footprint • Delivers up to 95.5% efficiency • Wide operating temperature range and strong overload protection • Strong protection against harsh environments with robust electrical specifications • Easy Loop Test to verify UPS performance before you connect your load • IP20 protection (extra protection with IP30, IP40, and/or IPX2 Option Kits) • Replaceable dust filters • Parallel for capacity or redundancy— up to 6 UPSs • Front and rear access service • Easy to manage with touchscreen display • Embedded NMC with Subscription License • EcoStruxure connected Options • Parallel and unitary maintenance bypass panel • Modular Battery cabinet • Classic Battery Cabinets with batteries • Empty battery cabinets • Battery Breaker Box and Battery Breaker Kit • Battery string or high-capacity battery string • Lithium-ion battery option Overview Easy UPS 3M 60-200 kVA (400V) and 50-100 kVA (208V) for external batteries, and 60-80 kVA (400V) with internal batteries is an easy to install, connect, use, and service 3-Phase UPS for small and medium data centers, electrical rooms, and other business-critical applications. Public 13 Easy UPS 3M Advanced For external batteries: 100-250 kW (400V) Sold: India Features Applications & Segments • Small and medium data centers • Commercial buildings • Light industrial applications • Government & Public Sector Units • Healthcare, Telecommunication, Transportation, Retail, Process Automation • Start-up included to optimizes your system's performance, quality, and safety • Scalable 100 kW to 250 kW for pay as you grow • Modular design, enabling easy serviceability • Easy deployment and compact footprint • Delivers up to 96% efficiency • Single frame capable up to 250 kW in capacity with Internal N+1 redundancy for up to 200 kW N+1 • Wide operating temperature range and strong overload protection • Pluggable Draw In/Out type power module • kVA = kW up to 40°C • Replaceable dust filters • Front and rear access service • Easy to manage with 7" touchscreen display • EcoStruxure connected • Made in India enables direct sales to Government, Public Sector Units, and Infrastructure Projects Options • Power module • Maintenance Bypass Panel • Battery Breaker Box and Battery Breaker Kit 13 Overview Easy UPS 3M Advanced—part of the Easy UPS 3-phase range—is an easy-to-install, connect, use, service, and scale 100-250 kW (400V) 3-Phase UPS made in India that is ideal for small and medium businesses, data centers, and other mission-critical applications in India. SE.com • Battery Temperature Sensors • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License Public 14 Easy UPS 3L For external batteries: 250-600 kW (400V) Sold: All IEC countries worldwide, except Japan and China Applications & Segments • Medium and large commercial buildings • Light industrial applications • Computer room and regional data centers • Healthcare, Telecommunication, Transportation, Financial, Government • Non-IT 14 Overview Easy UPS 3L 250-600 kVA (400V) is an easy to configure, use, and service 3-Phase UPS that delivers high availability and predictability to medium and large commercial buildings and light industrial applications. SE.com Features • Easy deployment and compact footprint • Delivers up to 96% efficiency • Power Module for fault-tolerant design • Streamlined installation and service • Protection against harsh environments with robust electrical specifications and ruggedizing features, including conformal coating • Replaceable dust filter • 1+1 redundant UPSs can share a common battery bank, reducing battery costs • IP20 (extra protection with IP31 option kit) • Smart Test mode optimizes site acceptance testing costs without requiring a load bank • Parallel up to 5 UPSs for capacity or 5+1 UPSs for redundancy • Supports 4+4 redundant configurations • Top cable entry • EcoStruxure connected • Embedded NMC with Secure NMC Subscription License • Start-up service included Options • Maintenance Bypass Panel • Classic Battery Cabinets • Empty battery cabinets • Battery Breaker Box and Battery Breaker Kit • Cold Start kit • Lithium-ion battery option Public 15 Galaxy 3L For external batteries: 250-600 kW (400V) Sold: China Features Applications & Segments • Medium and large data centers, and colocation facilities • Commercial and light industrial applications • Edge applications and computer rooms • Telecommunication, Healthcare, Government Transportation, Manufacturing, Finance • Easy deployment and compact footprint • Delivers up to 96% efficiency • Fault-tolerant design • Protection against harsh environments with robust electrical specifications and ruggedizing features • 1+1 redundant UPSs can share a common battery bank, reducing battery costs • Top cable entry • Replaceable dust filter • Embedded Network Management Card • IP20 (extra protection with IP31 option kit) • Smart Test mode optimizes site acceptance testing costs without requiring a load bank • Parallel up to 5 UPSs for capacity or 5+1 UPSs for redundancy • Supports 4+4 redundant configurations • 7-inch display • EcoStruxure connected • Start-up included Options • Maintenance Bypass Panel • Battery Breaker Box and Battery Breaker Kit • Classic Battery Cabinets • Empty battery cabinets • Cold Start kit 15 Overview Galaxy 3L 250-600 kVA (400V) is an easy to configure, use, and service 3-Phase UPS that delivers high availability and predictability to medium and large data centers, commercial buildings, and light industrial applications in China. SE.com • Bottom entry Cabinet • Lithium-ion battery option Public 16 Easy UPS 3-Phase Modular For external batteries: 50-250 kW (400V) Sold: All IEC countries worldwide, except Japan and China 16 Overview Easy UPS 3-Phase Modular 50-250 kW (400V) delivers robust power protection and availability in a capital-expenditure-friendly package. It is easy to select, quote, install, and maintain, with modular, redundant, scalable options and Live Swap modules in a compact footprint. SE.com Features Applications & Segments • Easy to select, configure, start up, use, and service • Up to 96% efficiency in double conversion mode • Third-party verified Live Swap functionality for fast MTTR and expansion with no scheduled downtime • Add Live Swap power modules as demand grows • Modular design with 50 kW power module enables N+1 redundancy to increase availability • Scalable design: pay as you grow • Up to 250 kW N+1 in a black one-rack design to conserve valuable real estate • Unity power factor @40°C • EcoStruxure connected for peace of mind anytime, anywhere • Parallel 4+0, increasing power capacity to 1 MW • Neutral Lithium-ion Function • Start-up service included • Bottom Entry Cabinet • Empty Battery Cabinet • Battery Breaker Box and Battery Breaker Kit • Maintenance Bypass Panel • Parallel Communications Kit • Redundant Intelligence Module • Lithium-ion battery option • Classic Battery Cabinet • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License • Other options: Depth Adapter, Backfeed Kit, Wide Seismic Kit, Battery Temperature Sensor • Small and medium data centers • Telecommunication • Transportation • Healthcare • Process Automation Options • Commercial buildings • Retail Public 17 Galaxy PX UPS 100-250 kW (400V) Sold: China Features Applications & Segments • Simple to select, configure, start up, use, and service • Up to 96% efficiency in double conversion mode • Third-party verified Live Swap functionality for fast MTTR and expansion with no scheduled downtime • Compact footprint with 10-inch touchscreen display • Modular design with 50 kW power module enables N+1 redundancy to increase availability • Parallel 4+0, increasing power capacity to 1 MW • Up to 250 kW N+1 in a black one-rack design to conserve valuable real estate • Scalable design: optimize capex, pay as you grow • Unity power factor @40°C • EcoStruxure connected for peace of mind anytime, anywhere • Neutral Lithium-ion Function • Start-up service included Options • Bottom Entry Cabinet • Depth Adapter • Neutral Disconnection Kit for 250 KW • Battery Temperature Sensor • Parallel Communications Kit • Lithium-ion battery option • 600mm wide Seismic Kit for 250 kW • Backfeed Kit 250 kW • Network Management Card • Redundant Intelligence Module 17 Overview Galaxy PX 100-250 kW (400V) UPS delivers robust power protection and availability in a capital-expenditure- friendly package. It is simple to select, quote, install, and maintain, with modular, redundant, scalable options, and Live Swap modules in a compact footprint. SE.com • Small & medium data centers • Telecommunication • Transportation • Healthcare • Process Automation• Commercial buildings • Retail Symmetra PX 400V: 16-500 kW with Symmetra PX 48 All-in-One, 96/160, & 250/500 208V: 10-100 kW with Symmetra PX 20, 40, & 100 480V: 100-500 kW with Symmetra PX 100 & 250/500 Sold: Worldwide 250/500 20 40 48 AIO 96/160 100 250/500 18 SE.com Features Applications & Segments • Data closet • Small, medium, and large data centers • Line up and match NetShelter form factor • Configurable for N+1 internal redundancy • Redundant intelligent modules • Scalable power capacity • Modular power, battery, bypass, and intelligent control modules • Parallel up to 4 UPSs (Symmetra PX 250/500 only) • Dual mains input, top or bottom feed • Embedded power distribution (PX20, 48) • EcoStruxure connected • Network Management Card with Secure NMC Subscription Licenses • Start-up service included Options • Secondary network management card (HTTP/Telnet/SNMP) • Seismic kits (OSHPD) • Battery breaker enclosure Overview Symmetra PX is a high performance, right-sized, modular, scalable, 3-phase UPS that offers power protection with high availability and efficiency for small, medium, and large data centers and mission-critical environments. Made up of dedicated and redundant modules, this architecture can scale power and runtime as demand grows or as higher levels of availability are required. • Extended runtime battery frames • Classic battery cabinets: PX100, 96/160, 250/500 • Lithium-ion battery option for Symmetra PX 250/500 • High-density zones of large data centers • Mission-critical environments • Maintenance bypass cabinets with distribution: PX40, 100, 96/160, 250/500 • Configurable power distribution: PX20, 40, 100 • Modular power distribution: PX48, 96/160, 100 Public 19 Galaxy PW 2nd Gen Features Applications & Segments • Petroleum Petrochemical Gas • Metallurgy • Power Plant • Medical • Semiconductor • Transportation • Food & Beverage • Mining • Manufacturing • Supports dual input • Overload capacity: 125% 10 min; 150% 1 min • Parallel up to 3+1 (4+0) • ISTA 2B • Robust design for harsh environments • Phase rotation check • Standard protection class: IP31 • Operating temperature: 0-40°C • Supports DC cold start • Designed for easy service • Start-up service included Options • AP9547 Network Management Card with Secure NMC Subscription License • Replaceable dust filters • Parallel Communications Kit • Backfeed Kits 19 10-200 kVA (400V) transformer-based UPS Sold: Europe, Middle East & Africa, Pacific, and Greater China Overview Galaxy PW 2nd Gen is a 10-200 kVA (400V) transformer-based UPS for industrial applications. The DC busbar voltage covers 220VDC and 384VDC, and uses a reliable 6-pulse or 12-pulse SCR rectifier. SE.com • Cable Adapter Kits for Galaxy Pwi • IP42 Kit (ETO) Products 3-phase UPSs Products 3-phase Lithium-ion Battery Cabinets 20 Public 21 Galaxy Lithium-ion Battery Cabinets Features Applications & Segments • Data centers, colocation, computer rooms • Edge computing, Internet DC, cloud computing • Computer rooms • Light industrial and commercial buildings • Infrastructure and transportation • Telecommunications and networking • Critical power infrastructures • Emergency lighting • UP9540A fire tested compliance • 67Ah LMO/NCM battery system • Double your battery life vs. VRLA solutions • Up to 70% more compact footprint frees up floor space for revenue-generating equipment • Boost availability with 2-3x faster recharge rates than VRLA solutions • Built-in 3-level battery management system (BMS) • Green Premium solution • Aesthetic match with Galaxy V Series UPSs • Self feeding SMPS simplifies installation • Fast, simple installation — cabinet ships pre- assembled, except battery modules, and rolls quickly into place • Enhance employee protection with modular touch- safe design, breaker covers, and built-in fuse protection at the battery cell and cabinet level • Seismic kit • EcoStruxure connected • Start-up service options available 21 For Galaxy VS, VM, VL, VX, VXL; Symmetra PX 250/500; Symmetra MW; Easy UPS 3M; Easy UPS 3L/Galaxy 3L; Easy UPS 3-Phase Modular; and Galaxy PX Sold: Worldwide Overview A Galaxy Lithium-ion Battery Cabinet are compact, lightweight, long-lasting, and sophisticated energy storage solution for Galaxy V series and Easy 3-phase UPSs in data centers, industrial processes, and critical infrastructures. This UL9540A-compliant battery solution reduces battery footprint and weight by up to 70%, allowing more effective use of space. Lithium-ion batteries reduce total cost of ownership, both by doubling battery life and by operating at higher temperatures, reducing cooling requirements. SE.com 22 Products 3-phase IT Power Distribution Public 23 Power Distribution Units (PDUs) Features Applications • Small, medium, and large data centers • Colocation facilities • Compartmental design simplifies asset access allocation • Meets the demanding scalability needs of any data center of any size • Factory installed and tested Square D breaker panel configured to meet the unique needs of your site • Easy to install and service with top and bottom cable entry • Low total cost of ownership • Seismic cabinet (OSHPD) • 7-inch display interface • EcoStruxure connected 23 Overview Power Distribution Units are reliable, scalable, and intelligent high-density power distribution solutions ideal for installation in the electrical rooms of data centers. SE.com 400 & 500 kVA (480V) Sold: US, Central America Options • Copper or aluminum transformers • Main input switch or breaker • Main output breaker • Advanced metering • Wide range of 250 Amp, 400 Amp, and 600 Amp branch breaker options from Schneider Electric's PowerPact J- and L-frame breaker series • EPO • Cloud service providers • Industrial applications 400 & 500 kVA (Aluminum) and 400 kVA (Copper) 500 kVA (Copper) Public 24 Galaxy RPP Features Applications • Data centers • Colocation facilities • Cloud service providers • Compact footprint and easy front-access design • Supports installation against walls, back-to-back, or in your EcoStruxure Pod Data Center • Flexible configuration, with factory installed and tested Square D breaker panels configured to your site requirements • Meets the demanding scalability needs of any large data center • PowerLogic Branch Circuit Power Meter monitors single or dual feed installations • Compartmental design simplifies asset access allocation • Top and bottom cable entry • Compatible with all Schneider Electric Power Distribution Units • 7-inch touchscreen display • EcoStruxure connected 24 Overview Galaxy RPP (Remote Power Panels) 250 and 400 Amp (120V/208V) offers highly configurable, highly modular, high-density row-level power distribution for data centers and colocation facilities. SE.com 250 & 400 Amp (120V/208V) Sold: US, Canada, Central America Options • L-frame or J-frame main input breakers • NP, NQ, or IP2X panelboard • QO, QOB, or EDB distribution breakers • Surge protection devices • Start-up service options available Configurable and Modular Power Distribution Units • Top or bottom cable entry (60/150 kW PDU) • Flexible configure-to-order options • Factory assembled and tested • Scalable • Modbus supported • Integrated monitoring • Network enabled • No side access required • Preconfigured cord sets • Compatible with StruxureWare Data Center Expert • Branch circuit monitoring • Power distribution modules with locking connectors (Modular) 25 Features Applications • Small, medium, or large data centers Overview Modular Power Distribution Units (PDUs) mitigate the need to predict the future requirements and configurations of your data center. Configurable Power Distribution Units bring agility, availability, and speed of deployment to your data center. Our factory-tested power distribution units are built to your exact specifications, support overhead or underfloor distribution, and feature a convenient, portable rack form factor. Options 120/208/230/400/480/600V: 72-277 kW (Modular) 208V/480V/600V: 40-150 kW (Configurable) Sold: Worldwide; product availability varies by region Modular Configurable • Shielding troughs Startup service SE.com: Configurable and Modular Upsilon Static Transfer Switches 30-630A standard; 800-1250A on request Sold: All IEC regions worldwide • Industrial applications • Data centers • Telecommunication centers • Infrastructure • Simplifies installation and maintenance while minimizing space requirements • Independent control boards, dual cooling systems, and power supplies ensure high reliability performance • Small footprint reduces required floor space • Text and mimic diagrams display modes of operation, system parameters, and alarms • Allows isolation of a source for maintenance without interrupting power to the protected loads Options • Communication: JBus/Modbus card (supplied as standard), status information card (supplied as standard) • Open frame version Overview Upsilon Static Transfer Switches (STS) provides true redundance and exceptional high reliability for automatic power supply transfer to a range of equipment from two independent and redundant power sources. Static Transfer Switches automatically transfer power to a stable alternate source in less than 4ms under normal operating conditions. Even under extreme conditions, such as 180 degrees out of phase, the STS will have detection and automatic transfer times that are up to 10 times faster than many other switches. 26 SE.com • PDU (36 16A circuit breakers incorporated in the H = 1900 cell, up to 100 A) • Connection at the top of the unit Features Applications & Segments 27 Key Applications and Segments by Product 28 IT data centers Medium data centers Large data centers Colocation facilities Cloud computing Commercial facilities Industrial facilities Healthcare Transportation Telecommunications Energy & Chemical Metal, Minerals, and Mining Consumer Packaged Goods Semi Conductor Galaxy VS Galaxy VM Galaxy VL Galaxy VX Galaxy VXL Easy UPS 3S Easy UPS 3M Easy UPS 3M Advanced Easy UPS 3L Galaxy 3L Easy UPS 3-Phase Modular Galaxy PX Symmetra PX Galaxy PW 2nd Gen Galaxy Lithium-ion Battery Cabinets Power Distribution Units (PDUs) Galaxy RPP Configurable and Modular PDUs Upsilon Static Transfer Switches ü Key Applications and Segments by Product To learn more about Schneider Electric 3-Phase UPS products and solutions, contact your Schneider Electric representative or visit www.se.com. Schneider Electric 35 rue Joseph Monier 92500 Rueil Malmaison France ©2024 Schneider Electric. All Rights Reserved. Schneider Electric | Life Is On, Galaxy, and EcoStruxure are trademarks and the property of Schneider Electric SE, its subsidiaries, and affiliated companies. All other trademarks are the property of their respective owners. Product specifications are subject to change without notice and are provided "as is" without warranty of any kind, express or implied. See apc.com for the most up to date product specifications. • 998-19858418_GMA-US 28 3-Phase Uninterruptible Power Supply (UPS) Secure Power Portfolio www.se.com Public 2 Contents I. Overview 3 II. Our Portfolio 4 III. Products 3-Phase UPSs 5 Galaxy VS (10-150 kW) 6 Galaxy VM (160-225 kVA) 7 Galaxy VL (200-500 kW) 8 Galaxy VX (500-1500 kW) 9 Galaxy VXL (500-1250 kW) 10 Easy UPS 3S (10-40 kVA) 11 Easy UPS 3M (60-200 kVA) 12 Easy UPS 3M Advanced (100-250 kW) 13 Easy UPS 3L (250-600 kVA) 14 Galaxy 3L (250-600 kVA) 15 Easy UPS 3-Phase Modular (50-250 kW) 16 Galaxy PX (100-250 kW) 17 Symmetra PX (10-500 kVA) 18 Galaxy PW 2nd Gen (10-200 kVA) 19 3-Phase Lithium-ion Battery Cabinets 20 Galaxy Lithium-ion Battery Cabinets 21 3-Phase IT Power Distribution 22 Galaxy Power Distribution Units (PDUs) 23 Galaxy RPP 24 Configurable and Modular Power Distribution Units 25 Upsilon Static Transfer Switches 26 IV. Key Applications and Segments by Product 28 2 Schneider's purpose is to empower all to make the most of our energy and resources, bridging progress and sustainability for all. We call this Life Is On. Our mission is to be your digital partner for Sustainability and Efficiency. Schneider Electric is a world leader in power protection, solving today's energy challenges while setting the standard for quality and innovation with fully integrated solutions, enterprise-wide networks, data centers, mission-critical systems, and industrial/manufacturing processes. Overview Empowering all to make the most of our energy and resources, bridging progress and sustainability for all. 3 Public 4 Our Portfolio Fully integrated, end-to-end 3-phase UPS solutions help maintain your enterprise-wide networks, data centers, mission-critical systems, and industrial manufacturing processes. Our global portfolio of world-class products and services uniquely combines to offer end- to-end critical power solutions, providing customers with robust power protection, anytime/anywhere visibility, and peace of mind with EcoStruxure IT software and flexible service plans throughout the life cycle of their installations. Galaxy V Series UPSs Maximize your availability and sustainability and optimize your total cost of ownership. Our modular Galaxy V Series UPSs deliver superior performance in a compact footprint, with up to 99% efficiency in eConversion mode, scalability and internal redundancy options, and Galaxy Lithium-ion battery solutions, making them ideal for the data center or business-critical applications. Easy UPS 3-phase UPSs Quickly deploy power protection that optimizes your capital expenses. Easy UPS 3-phase range UPSs feature robust electrical specifications, ruggedizing features, and a compact, lightweight footprint that are ideal for commercial or industrial applications. Modular Data Centers Schneider Electric 3-phase UPSs are ideal for Modular Data Centers. Contact your Schneider Electric representative to learn how you can increase your infrastructure capacity while shrinking your infrastructure footprint. 5 Products 3-Phase UPSs Galaxy VS For external batteries: 10-75 kW (208V), 20-150 kW (400V/480V) With internal smart battery modules: 10-50 kW (208V), 10-100 kW (400V), 20-100 kW (480V) Sold: Worldwide 6 SE.com Features Applications & Segments • IT • Small and medium data centers • Business-critical applications • Edge • Commercial and industrial facilities • Marine • Healthcare, Oil & Gas, Transportation, Minerals, Metals, Mining, Power, Grid • High efficiency in eConversion mode (up to 99%) • Maximum availability with modular architecture • Innovative Live Swap of power modules • Parallel for capacity or redundancy—up to 4 UPSs • Internal redundancy with N+1 power modules • Flexible modular, classic, & Lithium-ion battery solutions • Compact footprint • Touchscreen display with NMC • NMC with Secure Subscription License • EcoStruxure connected • Green Premium solution • Start-up service included Options • Battery flexibility, including Lithium-ion batteries • Single and parallel wallmount maintenance bypass panel • Classic and Modular Battery Cabinets • Battery Breaker Box and Battery Breaker Kit • IP52/NEMA 12 Kit • Seismic kits (OSHPD) • Network management card embedded with ethernet (NMP) and Modbus • Galaxy VS 20 kW (480V in, 400V out) up to 80 kW Internal Input Transformer for NAM Overview Galaxy VS is a highly efficient, modular, simple-to-deploy 3-phase UPS that delivers top performance to edge, small, and medium data centers, as well as critical infrastructure in commercial and industrial facilities. It offers increased availability, reduced operating costs, and first-class power protection for critical infrastructure. Galaxy VM For external batteries: 160-200 kVA (400V), 160-225 kVA (480V) Sold: Worldwide (except Japan) Features Applications & Segments • Mission-critical environments • Medium data centers • Industrial plants and applications • Facility infrastructure • Healthcare • Telecommunications • Highly efficient eConversion mode (up to 98.5%) • Integrated backfeed protection • Single-cabinet top and bottom cable entry • Full front-service access • Flexible modular, classic, and Lithium-ion battery solutions • Large color touch-screen display with built-in NMC • 65 kAIC rating standard • Compact footprint • Smart Power Test (SPoT) mode • OSHPD certified cabinets • Integrated casters for ease of mobility • EcoStruxure connected • Start-up service included Options • Classic and Modular Battery Cabinets • Management cards • Fuse kits • Wall-mounted battery breaker boxes • Parallel system bypass cabinets • Dust filter kits • System bypass cabinets • 208V transformers • Flywheel and Lithium-ion battery compatible • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License 7 Overview Galaxy VM is a highly efficient, modular 3-phase UPS that seamlessly integrates into medium data centers, industrial, or facilities applications. SE.com Public 8 Galaxy VL Applications & Segments • Mission-critical environments • Medium and large data centers • Colocation facilities • Computer rooms • Edge computing, Internet DC, Cloud computing • Light industry and commercial buildings • Infrastructure and transportation 8 For external batteries: 200-500 kW (400V/480V) Sold: Worldwide Overview Galaxy VL is a highly efficient, scalable 3-phase UPS featuring a modular, redundant design and low TCO for medium and large data centers and mission-critical environments. Minimize your total cost of ownership while expanding your business and maximizing your availability, reliability, and sustainability. With up to 99% efficiency in eConversion mode and fast power expansion with Live Swap, Galaxy VL is the most compact galaxy in the UPS universe. Make your data center or co-location facility more sustainable today. SE.com Features • Highly efficient eConversion mode (up to 99%) • Compact design, optimized footprint • Innovative Live Swap • Lithium-ion battery option • Parallel for capacity or redundancy—up to 6 UPSs • Scalable, modular design enables N+1 internal redundancy • Smart Power Test (SPoT) mode • Fault-tolerant design • Touchscreen display with NMC • Secure NMC Subscription License • Full front-service access • EcoStruxure connected • Green Premium solution • Startup service included Options • Classic battery cabinets • SKRU kit • Remote Centralized Display Box • Bottom Entry Cabinet 65kAIC Kit • Seismic (with option kit) • Replaceable dust filters • Backfeed protection options • Battery Breaker Box/Kit • NMC embedded with ethernet (NMP) and Modbus • Maintenance bypass cabinets Galaxy VX Features Applications & Segments • Mission-critical environments • Large/extra-large data centers • Industrial applications • Facility infrastructure • Cloud and Service providers • Colocation facilities • Finance, semiconductor, and manufacturing environments • Telecommunications, Healthcare • Highly efficient eConversion mode (up to 99%) • Cabinet-level scalability for capacity or redundancy • Dual mains input, top and bottom cable entry • Parallel for capacity or redundancy — up to 4 UPSs • Flywheel and Lithium-ion battery compatible • Internal redundancy with N+1 power cabinets • Smart Power Test (SPoT) mode • Touchscreen display with NMC • EcoStruxure connected • Startup service included Options • Battery pull box • Network Management Card (AP9640 / AP9641 / AP9643) with Secure NMC Subscription License • SmartSlot cards • Replaceable dust filters • Single feed kit 9 For external batteries: 500 scalable to 1500 kW N+1 (400V/480V) Sold: Worldwide Overview Galaxy VX is a highly efficient, modular 3-phase UPS scalable from 500 to 1500 kW in a single unit with high performance and flexible operating modes. Its scalability accommodates the changing needs of your rapidly expanding business, and its exceptional performance and abundance of cost-saving features reduce your energy costs and total cost of ownership. Galaxy VX is the ideal UPS for today's large data centers, cloud and colocation facilities, as well as mission-critical applications. SE.com • Parallel cable kit • Maintenance bypass cabinets • Classical battery cabinets Public 10 Galaxy VXL 10 For external batteries: 500-1250 kW (400V) Sold: All IEC countries worldwide SE.com Features Applications & Segments • Large and extra-large data centers • Colocation facilities • Computer rooms • Light industry & commercial buildings • Cloud & Service Provider facilities • Semiconductor industry • Manufacturing critical line • Energy and Chemicals • Bank, Finance, Insurance • Pre-fabricated systems • High efficiency eConversion mode (up to 99%) • Compact design, optimized footprint only 1.2m2 • Innovative Live Swap • Lithium-ion battery integration • EcoStruxure connected • Scalable, modular design enables N+1 internal redundancy • Reliable and fault-tolerant design • Sustainable solution • Full front access • Unity power factor @40°C, kVA=kW • Touchscreen display with NMC • High short circuit level 100kA • Secure NMC Subscription License • Smart Power Test (SPoT) mode • Startup service included Options • Battery Breaker Box/Kit • Empty Battery Cabinet Overview Galaxy VXL is a highly efficient, compact, and modular 3-phase UPS with Live Swap. With its industry-leading compact design, high-density technology, and fault-tolerant architecture, Galaxy VXL maximizes availability, operational efficiency, and critical load protection while minimizing TCO. This UPS delivers up to 97.5% efficiency in double conversion mode and up to 99% in eConversion mode, reducing the UPS Carbon emissions by a factor of two. Galaxy VXL offers proactive asset management services to give you peace of mind anytime, anywhere. Start-up service is included. • Galaxy Lithium-ion Battery Cabinets • Air filter kit • Parallel Communications Kit • Seismic kit, and other options Public 11 Easy UPS 3S For external batteries: 10-40 kVA (400V) With and/or internal batteries: 10-40 kVA (208V/400V) Sold: US, Canada, Mexico, and all IEC countries worldwide, except Japan Features Applications & Segments • Small data centers • Commercial buildings & light industrial applications • Business-critical applications • Healthcare, Telecommunication, Transportation, Manufacturing facilities • Non-IT • Easy to install and start up; minimal footprint • Delivers up to 96% efficiency • Wide operating temperature range and strong overload protection • Replaceable dust filters • Strong protection against harsh environments with robust electrical specifications • Conformal coating • Easy Loop Test to verify UPS performance before you connect your load • Parallel for capacity or redundancy—up to 4 UPSs • Easy to manage with remote panel • EcoStruxure connected • Long life battery string ready Options • Cold Start kit • Parallel maintenance bypass, up to 2 units for 400V or 3 units for 208V • Battery Breaker Box and Battery Breaker Kit • Empty battery cabinets • Standard 7Ah or 9Ah battery modules • NMC with Secure Subscription License • Start-up service 11 Overview Easy UPS 3S (400V) is an easy to install, use, and service 3-Phase UPS available for external batteries or for internal batteries designed for small data centers and other business critical applications. Easy UPS 3S (208V) is an easy to install, use, and service 3-Phase UPS for internal batteries designed for small data centers, commercial buildings, non-IT, and light industrial applications. SE.com: 400V / 208V Public 12 Easy UPS 3M For external batteries: 60-200 kVA (400V) and 50-100 kVA (208V) With internal batteries: 60-80 kVA (400V) Sold: 208V countries of South America and Caribbean Islands, and all IEC countries worldwide, except Japan 12 SE.com Features Applications & Segments • Small and medium data centers and computer rooms • Electrical rooms • Business-critical applications • Commercial buildings • Healthcare, Telecommunication, Transportation, Manufacturing facilities • Start-up included • Easy deployment and compact footprint • Delivers up to 95.5% efficiency • Wide operating temperature range and strong overload protection • Strong protection against harsh environments with robust electrical specifications • Easy Loop Test to verify UPS performance before you connect your load • IP20 protection (extra protection with IP30, IP40, and/or IPX2 Option Kits) • Replaceable dust filters • Parallel for capacity—up to 6 UPSs • Front and rear access service • Easy to manage with touchscreen display • Embedded NMC with Subscription License • EcoStruxure connected Options • Parallel and unitary maintenance bypass panel • Modular Battery cabinet • Classic Battery Cabinets with batteries • Empty battery cabinets • Battery Breaker Box and Battery Breaker Kit • Battery string or high-capacity battery string • Lithium-ion battery option Overview Easy UPS 3M (400V) and 50-100 kVA (208V) for external batteries, and 60-80 kVA (400V) with internal batteries is an easy to install, connect, use, and service 3-Phase UPS for small and medium data centers, electrical rooms, and other business-critical applications. Public 13 Easy UPS 3M Advanced For external batteries: 100-250 kW (400V) Sold: India Features Applications & Segments • Small and medium data centers • Commercial buildings • Light industrial applications • Government & Public Sector Units • Healthcare, Telecommunication, Transportation, Retail, Process Automation • Start-up included to optimizes your system's performance, quality, and safety • Scalable 100 kW to 250 kW for pay as you grow • Modular design, enabling easy serviceability • Easy deployment and compact footprint • Delivers up to 96% efficiency • Single frame capable up to 250 kW in capacity with Internal N+1 redundancy for up to 200 kW N+1 • Wide operating temperature range and strong overload protection • Pluggable Draw In/Out type power module • kVA = kW up to 40°C • Replaceable dust filters • Front and rear access service • Easy to manage with 7" touchscreen display • EcoStruxure connected • Made in India enables direct sales to Government, Public Sector Units, and Infrastructure Projects Options • Power module • Maintenance Bypass Panel • Battery Breaker Box and Battery Breaker Kit 13 Overview Easy UPS 3M Advanced—part of the Easy UPS 3-Phase range—is an easy-to-install, connect, use, service, and scale 100-250 kW (400V) 3-Phase UPS made in India that is ideal for small and medium businesses, data centers, and other mission-critical applications in India. SE.com • Battery Temperature Sensors • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License Public 14 Easy UPS 3L For external batteries: 250-600 kW (400V) Sold: All IEC countries worldwide, except Japan and China Applications & Segments • Medium and large commercial buildings • Light industrial applications • Computer room and regional data centers • Healthcare, Telecommunication, Transportation, Financial, Government • Non-IT 14 Overview Easy UPS 3L 250-600 kVA (400V) is an easy to configure, use, and service 3-phase UPS that delivers high availability and predictability to medium and large commercial buildings and light industrial applications. SE.com Features • Easy deployment and compact footprint • Delivers up to 96% efficiency • Power Module for fault-tolerant design • Streamlined installation and service • Protection against harsh environments with robust electrical specifications and ruggedizing features, including conformal coating • Replaceable dust filter • 1+1 redundant UPSs can share a common battery bank, reducing battery costs • IP20 (extra protection with IP31 option kit) • Smart Test mode optimizes site acceptance testing costs without requiring a load bank • Parallel up to 5 UPSs for capacity or 5+1 UPSs for redundancy • Supports 4+4 redundant configurations • Top cable entry • EcoStruxure connected • Embedded NMC with Secure NMC Subscription License • Start-up service included Options • Maintenance Bypass Panel • Classic Battery Cabinets • Empty battery cabinets • Battery Breaker Box and Battery Breaker Kit • Cold Start kit • Lithium-ion battery option Public 15 Galaxy 3L For external batteries: 250-600 kW (400V) Sold: China Features Applications & Segments • Medium and large data centers, and colocation facilities • Commercial and light industrial applications • Edge applications and computer rooms • Telecommunication, Healthcare, Government Transportation, Manufacturing, Finance • Easy deployment and compact footprint • Delivers up to 96% efficiency • Fault-tolerant design • Protection against harsh environments with robust electrical specifications and ruggedizing features • 1+1 redundant UPSs can share a common battery bank, reducing battery costs • Top cable entry • Replaceable dust filter • Embedded Network Management Card • IP20 (extra protection with IP31 option kit) • Smart Test mode optimizes site acceptance testing costs without requiring a load bank • Parallel up to 5 UPSs for capacity or 5+1 UPSs for redundancy • Supports 4+4 redundant configurations • 7-inch display • EcoStruxure connected • Start-up included Options • Maintenance Bypass Panel • Battery Breaker Box and Battery Breaker Kit • Classic Battery Cabinets • Empty battery cabinets • Cold Start kit 15 Overview Galaxy 3L 250-600 kVA (400V) is an easy to configure, use, and service 3-phase UPS that delivers high availability and predictability to medium and large data centers, commercial buildings, and light industrial applications in China. SE.com • Bottom entry Cabinet • Lithium-ion battery option Public 16 Easy UPS 3-Phase Modular For external batteries: 50-250 kW (400V) Sold: All IEC countries worldwide, except Japan and China 16 Overview Easy UPS 3-Phase Modular 50-250 kW (400V) delivers robust power protection and availability in a capital- expenditure-friendly package. It is easy to select, quote, install, and maintain, with modular, redundant, scalable options and Live Swap modules in a compact footprint. SE.com Features Applications & Segments • Easy to select, configure, start up, use, and service • Up to 96% efficiency in double conversion mode • Third-party verified Live Swap functionality for fast MTTR and expansion with no scheduled downtime • Add Live Swap power modules as demand grows • Modular design with 50 kW power module enables N+1 redundancy to increase availability • Scalable design: pay as you grow • Up to 250 kW N+1 in a block one-rack design to conserve valuable real estate • Unity power factor @40°C • EcoStruxure connected for peace of mind anytime, anywhere • Parallel 4+0, increasing power capacity to 1 MW • Neutral Lithium-ion Function • Start-up service included • Bottom Entry Cabinet • Empty Battery Cabinet • Battery Breaker Box and Battery Breaker Kit • Maintenance Bypass Panel • Parallel Communications Kit • Redundant Intelligence Module • Lithium-ion battery option • Classic Battery Cabinet • Network Management Card (AP9640 / AP9641) with Secure NMC Subscription License • Other options: Depth Adapter, Backfeed Kit, Wide Seismic Kit, Battery Temperature Sensor • Small and medium data centers • Telecommunication • Transportation • Healthcare • Process Automation Options • Commercial buildings • Retail Public 17 Galaxy PX 100-250 kW (400V) Sold: China Features Applications & Segments • Simple to select, configure, start up, use, and service • Up to 96% efficiency in double conversion mode • Third-party verified Live Swap functionality for fast MTTR and expansion with no scheduled downtime • Compact footprint with 10-inch touchscreen display • Modular design with 50 kW power module enables N+1 redundancy to increase availability • Parallel 4+0, increasing power capacity to 1 MW • Up to 250 kW N+1 in a block one-rack design to conserve valuable real estate • Scalable design: pay as you grow • Unity power factor @40°C • EcoStruxure connected for peace of mind anytime, anywhere • Neutral Lithium-ion Function • Start-up service included Options • Bottom Entry Cabinet • Depth Adapter • Neutral Disconnection Kit for 250 KW • Battery Temperature Sensor • Parallel Communications Kit • Lithium-ion battery option • 600mm wide Seismic Kit for 250 kW • Backfeed Kit 250 kW • Network Management Card • Redundant Intelligence Module 17 Overview Galaxy PX 100-250 kW (400V) UPS delivers robust power protection and availability in a capital-expenditure- friendly package. It is simple to select, quote, install, and maintain, with modular, redundant, scalable options, and Live Swap modules in a compact footprint. SE.com • Small & medium data centers • Telecommunication • Transportation • Healthcare • Process Automation• Commercial buildings • Retail Symmetra PX 400V: 16-500 kW with Symmetra PX 48 All-in-One, 96/160, & 250/500 208V: 10-100 kW with Symmetra PX 20, 40, & 100 480V: 100-500 kW with Symmetra PX 100 & 250/500 Sold: Worldwide 250/500 20 40 48 AIO 96/160 100 250/500 18 SE.com Features Applications & Segments • Data closet • Small, medium, and large data centers • Line up and match NetShelter form factor • Configurable for N+1 internal redundancy • Redundant intelligent modules • Scalable power capacity • Modular power, battery, bypass, and intelligent control modules • Parallel up to 4 UPSs (Symmetra PX 250/500 only) • Dual mains input, top or bottom feed • Embedded power distribution (PX20, 48) • EcoStruxure connected • Network Management Card with Secure NMC Subscription Licenses • Start-up service included Options • Secondary network management card (HTTP/Telnet/SNMP) • Seismic kits (OSHPD) • Battery breaker enclosure Overview Symmetra PX is a high performance, right-sized, modular, scalable, 3-phase UPS that offers power protection with high availability and efficiency for small, medium, and large data centers and mission-critical environments. Made up of dedicated and redundant modules, this architecture can scale power and runtime as demand grows or as higher levels of availability are required. • Extended runtime battery frames • Classic battery cabinets: PX100, 96/160, 250/500 • Lithium-ion battery option for Symmetra PX 250/500 • High-density zones of large data centers • Mission-critical environments • Maintenance bypass cabinets with distribution: PX40, 100, 96/160, 250/500 • Configurable power distribution: PX20, 40, 100 • Modular power distribution: PX48, 96/160, 100 Public 19 Galaxy PW 2nd Gen Features Applications & Segments • Petroleum Petrochemical Gas • Metallurgy • Power Plant • Medical • Semiconductor • Transportation • Food & Beverage • Mining • Manufacturing • Supports dual input • Overload capacity: 125% 10 min; 150% 1 min • Parallel up to 3+1 (4+0) • ISTA 2B • Robust design for harsh environments • Phase rotation check • Standard protection class: IP31 • Operating temperature: 0-40°C • Supports DC cold start • Designed for easy service • Start-up service included Options • AP9547 Network Management Card with Secure NMC Subscription License • Replaceable dust filters • Parallel Communications Kit • Backfeed Kits 19 10-200 kVA (400V) transformer-based UPS Sold: Europe, Middle East & Africa, Pacific, and Greater China Overview Galaxy PW 2nd Gen is a 10-200 kVA (400V) transformer-based UPS for demanding industrial applications. The DC busbar voltage covers 220VDC and 384VDC, and uses a reliable 6-pulse or 12-pulse SCR rectifier. SE.com • Cable Adapter Kits for Galaxy Pwi • IP42 Kit (ETO) Products 3-phase Lithium-ion Battery Cabinets 20 Public 21 Galaxy Lithium-ion Battery Cabinets Features Applications & Segments • Data centers, colocation, computer rooms • Edge computing, Internet DC, cloud computing • Computer rooms • Light industrial and commercial buildings • Infrastructure and transportation • Telecommunications and networking • Critical power infrastructures • Emergency lighting • UP9540A fire tested compliance • 67Ah LMO/NCM battery system • Double your battery life vs. VRLA solutions • Up to 70% more compact footprint frees up floor space for revenue-generating equipment • Boost availability with 2x faster recharge rates than VRLA solutions • Built-in 3-level battery management system (BMS) • Green Premium solution • Aesthetic match with Galaxy V Series UPSs • Self feeding SMPS simplifies installation • Fast, simple installation — cabinet ships pre- assembled, except battery modules, and rolls quickly into place • Enhance employee protection with modular touch- safe design, breaker covers, and built-in fuse protection at the battery cell and cabinet level • Seismic kit • EcoStruxure connected • Start-up service options available 21 For Galaxy VS, VM, VL, VX, VXL; Symmetra PX 250/500; Symmetra MW; Easy UPS 3L/Galaxy 3L; Easy UPS 3-Phase Modular; and Galaxy PX Sold: Worldwide Overview A Galaxy Lithium-ion Battery Cabinet are compact, lightweight, long-lasting, and sophisticated energy storage solution for Galaxy V series and Easy 3-phase UPSs in data centers, industrial processes, and critical infrastructures. This UL9540A-compliant battery solution reduces battery footprint and weight by up to 70%, allowing more effective use of space. Lithium-ion batteries reduce total cost of ownership, both by doubling battery life and by operating at higher temperatures, reducing cooling requirements. SE.com 22 Products 3-phase IT Power Distribution Public 23 Power Distribution Units (PDUs) Features Applications • Small, medium, and large data centers • Colocation facilities • Compartmental design simplifies asset access allocation • Meets the demanding scalability needs of any data center of any size • Factory installed and tested Square D breaker panel configured to meet the unique needs of your site • Easy to install and service with top and bottom cable entry • Low total cost of ownership • Seismic cabinet (OSHPD) • 7-inch display interface • EcoStruxure connected 23 Overview Power Distribution Units are reliable, scalable, and intelligent high-density power distribution solutions ideal for installation in the electrical rooms of data centers. SE.com 400 & 500 kVA (480V) Sold: US, Central America Options • Copper or aluminum transformers • Main input switch or breaker • Main output breaker • Advanced metering • Wide range of 250 Amp, 400 Amp, and 600 Amp branch breaker options from Schneider Electric's PowerPact J- and L-frame breaker series • EPO • Cloud service providers • Industrial applications 400 & 500 kVA (Aluminum) and 400 kVA (Copper) 500 kVA (Copper) Public 24 Galaxy RPP Features Applications • Data centers • Colocation facilities • Cloud service providers • Compact footprint and easy front-access design • Supports installation against walls, back-to-back, or in your EcoStruxure Pod Data Center • Flexible configuration, with factory installed and tested Square D breaker panels configured to your site requirements • Meets the demanding scalability needs of any large data center • PowerLogic Branch Circuit Power Meter monitors single or dual feed installations • Compartmental design simplifies asset access allocation • Top and bottom cable entry • Compatible with all Schneider Electric Power Distribution Units • 7-inch touchscreen display • EcoStruxure connected 24 Overview Galaxy RPP (Remote Power Panels) 250 and 400 Amp (120V/208V) offers highly configurable, highly modular, high-density row-level power distribution for data centers and colocation facilities. SE.com 250 & 400 Amp (120V/208V) Sold: US, Canada, Central America Options • L-frame or J-frame main input breakers • NP, NQ, or IP2X panelboard • QO, QOB, or EDB distribution breakers • Surge protection devices • Start-up service options available Configurable and Modular Power Distribution Units • Top or bottom cable entry (60/150 kW PDU) • Flexible configure-to-order options • Factory assembled and tested • Scalable • Modbus supported • Integrated monitoring • Network enabled • No side access required • Preconfigured cord sets • Compatible with StruxureWare Data Center Expert • Branch circuit monitoring • Power distribution modules with locking connectors (Modular) 25 Features Applications • Small, medium, or large data centers Overview Modular Power Distribution Units (PDUs) mitigate the need to predict the future requirements and configurations of your data center. Configurable Power Distribution Units bring agility, availability, and speed of deployment to your data center. Our factory-tested power distribution units are built to your exact specifications, support overhead or underfloor distribution, and feature a convenient, portable rack form factor. Options 120/208/230/400/480/600V: 72-277 kW (Modular) 208V/480V/600V: 40-150 kW (Configurable) Sold: Worldwide; product availability varies by region Modular Configurable • Shielding troughs Startup service SE.com: Configurable and Modular Upsilon Static Transfer Switches 30-630A standard; 800-1250A on request Sold: All IEC regions worldwide • Industrial applications • Data centers • Telecommunication centers • Infrastructure • Simplifies installation and maintenance while minimizing space requirements • Independent control boards, dual cooling systems, and power supplies ensure high reliability performance • Small footprint reduces required floor space • Text and mimic diagrams display modes of operation, system parameters, and alarms • Allows isolation of a source for maintenance without interrupting power to the protected loads Options • Communication: JBus/Modbus card (supplied as standard), status information card (supplied as standard) • Open frame version Overview Upsilon Static Transfer Switches (STS) provides true redundance and exceptional high reliability for automatic power supply transfer to a range of equipment from two independent and redundant power sources. Static Transfer Switches automatically transfer power to a stable alternate source in less than 4ms under normal operating conditions. Even under extreme conditions, such as 180 degrees out of phase, the STS will have detection and automatic transfer times that are up to 10 times faster than many other switches. 26 SE.com • PDU (36 16A circuit breakers incorporated in the H = 1900 cell, up to 100 A) • Connection at the top of the unit Features Applications & Segments 27 Key Applications and Segments by Product 28 IT data centers Medium data centers Large data centers Colocation facilities Cloud computing Commercial facilities Industrial facilities Healthcare Transportation Telecommunications Energy & Chemical Metal, Minerals, and Mining Consumer Packaged Goods Semi Conductor Galaxy VS Galaxy VM Galaxy VL Galaxy VX Galaxy VXL Easy UPS 3S Easy UPS 3M Easy UPS 3M Advanced Easy UPS 3L Galaxy 3L Easy UPS 3-Phase Modular Galaxy PX Symmetra PX Galaxy PW 2nd Gen Galaxy Lithium-ion Battery Cabinets Power Distribution Units (PDUs) Galaxy RPP Configurable and Modular PDUs Upsilon Static Transfer Switches ü Key Applications and Segments by Product To learn more about Schneider Electric 3-Phase UPS products and solutions, contact your Schneider Electric representative or visit www.se.com. Schneider Electric 35 rue Joseph Monier 92500 Rueil Malmaison France ©2024 Schneider Electric. All Rights Reserved. Schneider Electric | Life Is On, Galaxy, and EcoStruxure are trademarks and the property of Schneider Electric SE, its subsidiaries, and affiliated companies. All other trademarks are the property of their respective owners. Product specifications are subject to change without notice and are provided "as is" without warranty of any kind, express or implied. See apc.com for the most up to date product specifications. • 998-19858418_GMA-US 28 General 05/2024 EcoStruxure™ Power for Semiconductor Fabs Utilizing a Digital Twin for Electrical Distribution to Drive Efficient Facilities Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Purpose of the Document Target Audience This document is intended to address End User Engineering, Operations and Maintenance, Consultants, EPCs (Engineering, Procurement, and Construction) and Service teams and other qualified personnel. Objective To understand the challenges of designing and operating a Semiconductor Fab with an efficient and sustainable electrical distribution strategy. Table of Contents Overview of capabilities Previous Next Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Table of Contents SECTION 1: Introduction to the Semiconductor Fab Introduces the context and the challenges of a Semiconductor Fab. SECTION 2: How Schneider Electric Can Support the Semiconductor Fab Industry EcoStruxure Power Describes the solutions that EcoStruxure Power provides for Semiconductor Fabs, with typical electrical and digital architectures. BIBLIOGRAPHY Contains useful documents to find out more about capabilities. Provides details about Green Premium. SECTION 3: Digital Solutions and Services Gives information about EcoStruxure Power capabilities by capabilities for Semiconductor Fabs, sorted by value proposition: • Transverse Lifecycle Capabilities • Capabilities to Improve Time To Market • Capabilities to Increase Efficiency • Capabilities to Improve Resiliency • Capabilities to Grow Sustainability Reference Guide EcoStruxure™ Power for Semiconductor Fabs General WHY READ THIS SECTION? SECTION 1 SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Semiconductor Fab Industry Semiconductor Fab Industry Challenges The objective of this section is to: • Introduce the growth, trends and challenges of the Semiconductor Fab industry • Present the 4 pillars to meet the Semiconductor Fab challenges. Introduction to the Semiconductor Fab Industry Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY SECTION 1 – Introduction to the Semiconductor Fab Industry Semiconductor Fab Industry Challenges Semiconductor Fab Market An industry driven by the growth of new technology Sources Chip Shortages Continue 17% Annual growth in chip demand from 2020-2022, while supply grew at only 6% per year. Strong Robust Growth +7% Robust growth till 2030. Hunt for Talent Intensifies +77% Rise in offer-related job vacancies from 2020. Geopolitical Impacts 65% Global share of value chain activities based in Asia, creating high supply chain risk. Focus on Sustainability +36% Semiconductor companies reinforced ESG* practices (2021 reporting). Acceleration of Digital Transformation +52% Increased use of cloud / automation in 2021. * ESG = Environmental, Social, and Governance Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY SECTION 1 – Introduction to the Semiconductor Fab Industry Semiconductor Fab Industry Challenges Strong Robust Growth: https://www.mckinsey.com/industries/semiconductors/our-insights/the-semiconductor-decade-a-trillion-dollar-industry Hunt for Talent Intensifies: https://asia.nikkei.com/Business/Business-Spotlight/Chip-talent-war-Taiwan-faces-critical-staffing-shortage Focus on Sustainability: https://arstechnica.com/science/2022/04/can-semiconductor-makers-meet-surging-demands-sustainably/ Geopolitical Impacts: https://www.voanews.com/a/race-for-semiconductors-influences-taiwan-conflict-/6696432.html Acceleration of Digital Transformation: https://quixy.com/blog/top-digital-transformation-statistics-trends- forecasts/ #:~:text=According%20to%20Markets%20and%20Markets,by%205.1%25%20according%20to%20Gartner. Chip Shortages Continue: https://www.mynewsdesk.com/rolandberger/pressreleases/global-semiconductor-shortage-to-persist-for-several-years-beyond- 2022-3151267 Sources Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY SECTION 1 – Introduction to the Semiconductor Fab Industry Semiconductor Fab Industry Challenges Semiconductor Fab Market The market trends: a changing landscape Significant investment for expansions and modernization A growing focus on efficiency and sustainability High demand for power and water to meet semiconductor production capacity Cybersecurity Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Semiconductor Fab Industry Semiconductor Fab Industry Challenges SECTION 1 – Introduction to the Semiconductor Fab Industry How can we reduce our operational costs? How can we improve power quality and minimize downtime? How can we reduce our carbon footprint and integrate more renewable, sustainable energy sources? How can we accelerate the design & build of new semiconductor fabs? Semiconductor Fab Industry Challenges Four pillars to drive efficiency, resiliency and sustainability KPIs The strong growth of the semiconductor industry leads to an increase in fabrication capacity. Creating or expanding this capacity is not without its challenges. Four pillars must be addressed: Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General WHY READ THIS SECTION? SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures The objective of this section is to: • Present the solutions to address the four pillars to meet the Semiconductor Fab Industry challenges • Explain how Schneider Electric EcoStruxure Power can support this industry • Give an example of electrical and digital architectures. How EcoStruxure Power Can Support the Semiconductor Fab Industry Reference Guide EcoStruxure™ Power for Semiconductor Fabs General EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures Solutions to Address the Four Pillars SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Solutions to Address the Four Pillars of Semiconductor Fabs The four pillars can be addressed by the following solutions: Improve Facility Performance Minimize Downtime Meet Sustainability KPIs Use Standardized Architecture Use standardized electrical distribution and digital tools to speed up the design, build and commissioning of new fabs. Turn data into business intelligence and leverage a digital twin to provide actionable insights to drive efficiency. Help assure optimum power quality and reliability while improving safety for your staff and guarding against cyber attacks Engage consultancy services to strategize, digitize and decarbonize. This guide describes the solutions developed by EcoStruxure Power to address these four pillars. Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab Example of Electrical & Digital Architectures Solutions to Address the Four Pillars EcoStruxure Power Value Proposition SECTION 3 – Digital Solutions and Services BIBLIOGRAPHY EcoStruxure Power Value Proposition Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Power Value Proposition Solutions to Address the Four Pillars EcoStruxure Power Value Proposition We are your end-to-end digital partner to design, build, operate and maintain semiconductor fabs with the utmost efficiency and resiliency towards a sustainable future. From electrical design to operations and maintenance Our collaborative environments, enhanced by the Electrical Distribution Digital Twin of your fab, enable high productivity operations. Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures SECTION 3 – Digital Solutions and Services BIBLIOGRAPHY Example of Electrical and Digital Architectures Typical front-end Semiconductor Fab Energy is key, whether for processes or for utilities: specific attention must be given to the design of the electrical architecture and associated digital architecture which will enable digital solutions and services. Front-end Semiconductor Fab PROCESS 50 % UTILITIES 50 % Ultrapure Water (UPW) Diffusion Photolithography Etching Ion Implantation 1 2 1 2 Subfab Cleanroom Others Clean Dry Air (CDA) and N2 Exhaust System Cooling Water System Physical Vapor Deposition (PVD) / Chemical Vapor Deposition (CVD) Chemical Mechanical Planarization (CMP) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures SECTION 3 – Digital Solutions and Services BIBLIOGRAPHY Example of Electrical Architecture Example of Electrical and Digital Architectures Typical electrical architecture for a Semiconductor Fab Electrical Architecture UTILITY 50 % Cooling Water System • Chilled Water (MV Chillers, Cooling Towers) • Process Cooling Water (PCW) • AHU, FCU, FFU, Dry Coil Exhaust System Clean Dry Air (CDA) and N2 Ultrapure Water (UPW) Others • Lighting • Wastewater • Air Recirculation • Make-Up Air Unit • Bulk Gases • Automated Materials Handling System (AMHS) • Abatement PROCESS 50 % Critical Process = Power Availability High Energy demand = Efficient Energy Management Diffusion Photolithography Etching Ion Implantation Chemical Mechanical Planarization (CMP) Physical Vapor Deposition (PVD)/ Chemical Vapor Deposition (CVD) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures SECTION 3 – Digital Solutions and Services BIBLIOGRAPHY Example of Electrical and Digital Architectures Suggested digital architecture (high-level view) for a Semiconductor Fab Example of Digital Architecture (High-Level View) General Example of Digital Architecture (High-Level View) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab Solutions to Address the Four Pillars EcoStruxure Power Value Proposition Example of Electrical & Digital Architectures SECTION 3 – Digital Solutions and Services BIBLIOGRAPHY Example of Electrical and Digital Architectures Corresponding detailed digital architecture for a Semiconductor Fab Example of Digital Architecture (Detailed View) General Example of Digital Architecture (Detailed View) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General WHY READ THIS SECTION? 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Digital Solutions & Services Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Introduction SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Improve Time to Market Introduction EcoStruxure Power provides capabilities to support the challenges of Semiconductor Fabs throughout their lifecycle These capabilities provide standardized designs and digital architectures, and enable easy simulation, to reduce cost of design and ownership. These capabilities use digitization to provide intelligent information to the workforce, allowing them to make smart decisions that reduce operating costs and increase efficiency. These capabilities use digitization to reduce unplanned downtime, increase reliability, and thus reduce production waste. These capabilities help track energy consumption and carbon emissions to meet sustainability requirements. Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities Solutions that support your project from the Design, Build, Commission to Operate & Maintain phases. Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Power system study+ Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry Transverse Lifecycle Capabilities Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Power system study+ Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry Electrical Digital Twin Benefits • Intelligent user-interface for all levels of AC and DC networks • Enables users, from the design to operate phases, to model, simulate, analyze and validate electrical power systems to predict their electrical network behavior • Takes the day-to-day system modeling and design tasks to a new level of speed, accuracy and ease Maintain a Digital Twin of your electrical distribution Transverse Lifecycle Capabilities Electrical Digital Twin Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry Green Premium Benefits • Green Premium™ products provide detailed information on their regulatory compliance, material content, environmental impact, and circularity attributes. Manage sustainability from design to end of life Transverse Lifecycle Capabilities Compliance and transparency (compliance certificates, circularity profiles, environmental footprint, etc.)1 Circular performance Durability, upgradeability, re-manufacture, recycled content, recyclability Well-being performance E.g. free of PVC, mercury, silicone, SVHC, lead, toxic heavy metal and compliant with California Prop 65 4 Resource performance Optimized energy performance Lower carbon emissions 2 3 * The Green Premium label was created to provide Schneider Electric's customers with more sustainable products and to be transparent with environmental information. Supporting your efforts for a LEED certified building Helping you achieve Living Building Challenge certification Green Premium Value Proposition Learn more about: • Green Premium Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry Cybersecurity Benefits • Provides a selection of cybersecurity certified products • Provides certified system architectures and solutions • Delivers lifecycle services Help secure the digital power distribution system Transverse Lifecycle Capabilities Learn more about: • Cybersecurity Certified products developed according to IEC 62443 functional requirements with Secure Development Lifecycle processes. Consulting services from design, implementation, operations and maintenance to tailor your security solutions to your digital power system. Lifecycle services Certified secure system architecture according to IEC 62443-3-3 with documented processes and solutions for a secure system. Cybersecurity system configuration software for consistent security policy deployment. Certified products Certified systems & solutions Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Asset performance Power quality monitoring and compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction Simulate before Operate Arc flash protection + + + + + + + + + AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & Microgrid energy storage sizing simulation + + + + + + + Power system study • Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability AC and DC Electrical Network Bus Design and Simulation Primary Department • Design • Construction Benefits • Single solution/environment - Unified AC & DC solution from HV to LV - One unique platform and one database • Efficient profile management - User-defined loading and generation profiles - External data profile based on field measurements • Scalability - Load growth study for future planning • Event simulations within the calculation period Optimize bus design allocation and simulation ETAP Electrical Network Model Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Electrical Network Short Circuit Simulation Primary Department • Design • Construction Benefits •

Expedite design studies with a wide range of calculation scenarios, including advanced fault analysis - IEC & ANSI duty calculation for balanced and unbalanced faults - Simultaneous fault at selected nodes - Inclusive 3-Phase and 1-Phase fault analysis - Pre-Fault system loading consideration Design and simulate unbalanced short circuits Electrical Network Short Circuit Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Network Load Flow and Voltage Drop Simulation Primary Department • Design • Construction Benefits • Simulation of bus voltages, branch power factors, currents, system losses, power generation versus loading • Use of ETAP Electrical Digital Twin model with powerful calculation engines and user-friendly interface • Simulation using multiple loading and generation conditions Perform power flow analysis and voltage drop calculations Network Load Flow and Voltage Drop Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Device Coordination and Selectivity Primary Department • Design • Construction Benefits • Verified and validated libraries • Graphically adjustable device settings • Detailed device settings reporting • Continuous synchronization with one-line and integrated equipment database Automatically detect and evaluate the system protection and coordination/selectivity Device Coordination and Selectivity in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Arc Fault Protection and Coordination Primary Department • Design • Construction Benefits • Evaluate, verify, and confirm the operation and selectivity of the protective devices for various types of faults for any location directly from the single-line diagram • Animation displayed on the single-line diagram • 3-phase / 1-phase sequence of operation Perform sequence of operation for arc fault and bolted fault Arc Fault Protection and Coordination in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Power Quality Simulation and Modeling Primary Department • Design • Construction Benefits • Simulate harmonic current and voltage sources: - To identify potential harmonic problems (report of harmonic voltage and current distortion limit violations) - To identify the need for a harmonics filter • Simulate and analyze the size of the harmonics filter your system will need to optimize performance and reduce nuisance trips Evaluate and validate distortion due to harmonics Power Quality Simulation and Modeling in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Renewable and Microgrid Energy Storage Sizing Simulation Primary Department • Design • Construction Benefits • Build renewable energy models combined with full spectrum power system analysis calculations for: - Accurate simulation - Predictive analysis - Equipment sizing - Field verification of wind, solar farms and other DERs • Enable designers and engineers to conceptualize the collector systems, determine wind penetration and perform grid interconnection studies Design and optimize the microgrid system Microgrid Energy Storage Sizing Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Power System Study Primary Department • Design • Construction • Facilities Electrical Department Benefits • Partner with a global team of experts, engaged with industry standards committees, to develop common safety standards and practices. • Create a standardized approach to Power System Studies to support multisite deployments with consistent results Work with engineering experts to provide Power System Studies Study (Analyze) Assess Design Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Increase Efficiency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Resiliency Capabilities to Grow Sustainability Capabilities to Increase Efficiency Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction Arc flash protection Simulate before Operate + + + + + + + + + AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Power system study Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Increase Efficiency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Resiliency Capabilities to Grow Sustainability Operator Training Simulation Primary Department • Facility Operations & Maintenance Benefits • Practice operation within a simulated but highly realistic environment to enhance safety and operational efficiency • Track and review trainee actions to analyze and challenge them Train new employees and build confidence on new systems + Capabilities to Increase Efficiency Principle of Operator Training Simulation Application Learn more about: • Operator Training Simulation (IEC / NEMA) Operator Training Simulation Reference Architecture General Operator Training Simulation Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Increase Efficiency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Resiliency Capabilities to Grow Sustainability Energy Monitoring and Usage Analysis Primary Department • Facility Operations & Maintenance Benefits • Bring awareness to utility consumption - Turn data into easy-to-interpret graphical dashboards and reports to raise awareness amongst key stakeholders • Identify “quick-win” opportunities for energy savings - By comparing and visualizing energy usage and cost for different utilities over different time periods - By identifying and prioritizing which areas lend themselves to a high energy-saving return on investment Determine where to focus energy conservation initiatives Capabilities to Increase Efficiency Energy Usage Analysis Dashboards in EcoStruxure Power Operation Learn more about: • Energy Monitoring (IEC / NEMA) Energy Monitoring and Usage Analysis Reference Architecture General Energy Monitoring and Usage Analysis Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Increase Efficiency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Resiliency Capabilities to Grow Sustainability Energy Performance, Modeling and Verification Primary Department • Facility Operations & Maintenance Benefits • Provide energy usage information based on equipment and processes • Compare model versus actual consumption • Compare pre-retrofit versus post-retrofit energy consumption to track improved performance and savings as a result of energy conservation initiatives Analyze the energy performance of a plant against a model baseline Capabilities to Increase Efficiency Energy Performance, Modeling and Verification Output in EcoStruxure Power Operation Energy Performance, Modeling and Verification Reference Architecture Learn more about: • Energy Performance (IEC / NEMA) • Energy Modeling and verification (IEC / NEMA) General Energy Performance Modeling and Verification Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Increase Efficiency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Resiliency Capabilities to Grow Sustainability Capacity Management Primary Department • Facility Operations & Maintenance Benefits • Monitor electrical network capacity • Track and review capacity efficiency • Minimize downtime by tracking the capacity of transformers, circuit breakers, UPSs, generators, etc. Monitor the capacity of electrical distribution Capabilities to Increase Efficiency Breaker Capacity Single-line Diagram in EcoStruxure Power Operation Capacity Management Reference Architecture Learn more about: • Capacity Management (IEC / NEMA) General Capacity Management Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Capabilities to Improve Resiliency Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Power system study Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Predictive Simulation Help employees make better decisions Primary Department • Facility Engineering • Design Engineering Benefits • Reduce safety risks by practicing emergencies and high-risk situations • Enhance operational efficiency by running “what-if” scenarios • Provide faster analysis response to incidents Capabilities to Improve Resiliency + Predictive Simulation Reference Architecture Principle of Predictive Simulation Application General Predictive Simulation Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Simulate Before Operate Empower operators with predictive outcomes Primary Department • Facility Operations & Maintenance Benefits • Provide operators with a list of potential side effects, prior to executing a command • Empower employees to feel more confident when operating their facilities by providing real time guidance • Reduce human error that could lead to outages or safety concerns Capabilities to Improve Resiliency + Simulate Before Operate Reference Architecture Principle of Simulate before Operate Application Learn more about: • Simulate Before Operate (IEC / NEMA) General Simulate Before Operate Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Electrical Distribution Monitoring and Alarming Monitor and control electrical network Primary Department • Facility Operations & Maintenance Benefits • Show real-time status of the power distribution • Customized single-line diagram • 24/7 power monitoring and alarm notification Capabilities to Improve Resiliency Electrical Distribution Monitoring and Alarming Single-line Diagram in EcoStruxure Power Operation Electrical Distribution Monitoring and Alarming Reference Architecture Learn more about: • Electrical distribution monitoring and alarming (IEC / NEMA) • Power Source and Load Control (IEC / NEMA) General Electrical Distribution Monitoring and Alarming Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Power Events Analysis Analyze the root causes of electrical events Primary Department • Facility Operations & Maintenance Benefits • Automatically classifies and describes any electrical events • Uses system intelligence to determine root cause and location of events • Shows context and sequence of events using the timeline analysis interface Capabilities to Improve Resiliency Event and Alarm Status view in EcoStruxure Power Operation Event and Alarm Status Timeline in EcoStruxure Power Operation Power Event Analysis Reference Architecture Learn more about: • Power Event Analysis (IEC / NEMA) General Power Events Analysis Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Asset Performance Benefit from a strategic maintenance approach Primary Department • Facility Operations & Maintenance Benefits • Move from reactive or preventive to condition-based (predictive) maintenance strategies for critical assets like circuit breakers, gensets, transformers, etc. • Provide event details and notification to the operator if a protection setting has been changed • Receive notifications and diagnostics reports from expert service engineers with recommendations to optimize maintenance by asset or site Capabilities to Improve Resiliency Asset Performance Reference Architecture Aging Diagram for Circuit Breakers in EcoStruxure Power Operation Gigafactory Learn more about: • Asset Performance (IEC / NEMA) General Asset Performance Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Power Quality Monitoring and Compliance Gain insights to improve power quality and comply with standards Primary Department • Facility Operations & Maintenance Benefits • Bring awareness of power quality • Enhance operational efficiency by making sure clean power is fed to sensitive process equipment • Help protect sensitive equipment by tracking power quality problems before they arise Capabilities to Improve Resiliency Power Quality and Compliance Dashboards in EcoStruxure Power Operation Power Quality and Compliance Report in EcoStruxure Power Operation Power Quality Monitoring and Compliance Reference Architecture Learn more about: • Power Quality Monitoring and Compliance (IEC / NEMA) General Power Quality Monitoring and Compliance Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Power Quality and Power Factor Correction Help protect sensitive equipment from power quality issues Primary Department • Facility Operations & Maintenance Benefits • Monitor sensitive process lines and busbars • Provide clean power to sensitive process equipment • Track Power Quality problems to help avoid downtime • Reduce financial impact of power factor on energy bill Capabilities to Improve Resiliency Galaxy VM Power Quality Information in EcoStruxure Power Operation Before and After Power Quality and Power Factor Correction Implementation Power Quality and Power Factor Correction Reference Architecture Learn more about: • Power Quality Correction (IEC / NEMA) • Power Factor Correction (IEC / NEMA) General Power Quality and Power Factor Correction Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Continuous Thermal Monitoring & Partial Discharge Monitoring Help prevent electrical fires and help protect employees and equipment Primary Department • Facility Operations & Maintenance Benefits • Provide early detection of internal arcing or temperature abnormalities in equipment that can cause damage - To help reduce the risk of equipment and electrical room damage - To improve service continuity • Enable optimized maintenance schedules by providing continuous monitoring vs calendar-based service Capabilities to Improve Resiliency Continuous Thermal Monitoring & Partial Discharge Monitoring Reference Architecture Learn more about: • Continuous Thermal monitoring (IEC / NEMA) Continuous Thermal Monitoring in the Single-line Diagram of EcoStruxure Power Operation General Continuous Thermal Monitoring and Partial Discharge Monitoring Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Improve Resiliency SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Grow Sustainability Arc Flash Protection Help protect employees and equipment Primary Department • Facility Operations & Maintenance Benefits • Help prevent loss of life and reduce the risk of equipment and electrical room damage • Improve maintenance team awareness to help troubleshoot and identify the root cause of arc flash events Arc Flash in a Switchboard Arc Flash Alert and Location in EcoStruxure Power Operation Capabilities to Improve Resiliency Arc Flash Protection Reference Architecture Learn more about: • Arc Flash Protection (IEC / NEMA) General Arc Flash Protection Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Capabilities to Grow Sustainability Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Thermal and partial discharge monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Power system study Grow Sustainability Improve Resiliency Increase Efficiency Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Carbon Neutrality Consulting Services Track and reduce carbon emissions to demonstrate the carbon neutrality of the company Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Get support from our consulting services to define your strategy for achieving carbon neutrality Capabilities to Grow Sustainability + Services Carbon neutrality Reduce Carbon Emissions Produce Renewable Energy Purchase Renewables/Offsets Energy Efficiency • Sustainable building design & operations – HVAC Efficiency – Lighting Efficiency – Operational Efficiency Behind-the-Meter Renewables • Solar Panels / Heating • Wind • Geothermal Purchase Renewables • Renewable Power Purchasing Agreements (PPA) • Renewable Energy Certificates (REC) • Biofuels Supporting Technologies • Microgrid with Smart Management • Battery Storage • Fuel Cells Purchase Offsets • Carbon Credits – Carbon Capture – Tree Planting 1 2 3 Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Energy Efficiency Compliance Comply with standards related to energy management systems Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Report and show facility compliance to local sustainability requirements - To benefit from tax credits - To gain credibility to participate in new projects Capabilities to Improve Sustainability EcoStruxure Power Operation Energy Star Compliance Dashboard EcoStruxure Resource Advisor Dashboard in EcoStruxure Power Operation Sustainable Organizations and Standards Energy Efficiency Compliance Reference Architecture Learn more about: • Energy Efficiency Compliance (IEC / NEMA) General Energy Efficiency Compliance Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Increase Efficiency Capabilities to Improve Resiliency Greenhouse Gas Reporting Track and report carbon emissions Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Track and report carbon emissions and waste (e.g., water) in one single place • Provide period-over-period usage comparison to detect a drift Capabilities to Improve Sustainability Greenhouse Gas Reporting Reference Architecture Learn more about: • Greenhouse Gas Reporting (IEC / NEMA) Greenhouse Gas Reporting and Dashboard Examples in EcoStruxure Power Operation General Greenhouse Gas Reporting Reference Architecture Reference Guide EcoStruxure™ Power for Semiconductor Fabs General Legal Information SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Reference Documents BIBLIOGRAPHY Reference Guide EcoStruxure™ Power for Semiconductor Fabs General Legal Information BIBLIOGRAPHY Reference Documents SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab Reference Documents Design Guide IEC EcoStruxure Power Design Guide Ref: ESXP2G001EN 02/2024 Digital Applications for Large Buildings and Critical Facilities The Digital Applications Design Guide provides comprehensive details on the building blocks of EcoStruxure Power: the IoT applications are driven by a software layer to control the traditional electrical distribution infrastructure. Developed to help engineering consultants and designers, this guide is an invaluable resource for specifying, designing and prescribing EcoStruxure Power architectures capable of performing one or more of the business-driven applications described within. NEMA EcoStruxure Power Design Guide Ref: 0100DB1802 01/2024 https://www.se.com/ww/en/downl oad/document/ESXP2G001EN/ https://www.se.com/us/en/download/ document/0100DB1802/ Web version PDF version Web version https://go.schneider- electric.com/WW_202004_Digital- Applications-for-Large-Buildings-and- Critical-Facilities_EA-LP.html PDF version https://go.schneider- electric.com/WW_202004_Digital- Applications-Design-Guide_EA-LP.html Landing page: https://www.se.com/ww/en/work/campaign/innovation/power-digital-applications-design-guide.jsp Reference Guide EcoStruxure™ Power for Semiconductor Fabs General Legal Information SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the Semiconductor Fab Industry SECTION 2 – How EcoStruxure Power Can Support the Semiconductor Fab BIBLIOGRAPHY Reference Documents Legal Information The information provided in this document contains general descriptions, technical characteristics and/or recommendations related to products/solutions. 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All other brands are trademarks of their respective owners 2024/05/28 ESXP2RG002EN PEP method for assessing 3-Phase UPS sustainability se.com Table of contents Life is On | Schneider Electric Introduction 1 Conclusion 5 Environmental declarations 2 UPS carbon footprint comparisons 3 UPS carbon calculation tool 4 • Common errors to avoid when comparing UPSs • Steps for accurate UPS comparisons • What is a PEP and how to read it • Product specific rules (PSR) for 3-phase UPS • Carbon profile of a typical 3-phase UPS Life is On | Schneider Electric Introduction Life is On | Schneider Electric Introduction As discussed in White Paper 64, Why Data Centers Must Prioritize Environmental Sustainability: Four Key Drivers, companies are seeking ways of decreasing their data center's environmental footprint and of their company in general. These needs apply to all data center sizes, from the largest multi-megawatt purpose-built data center to a single-rack micro data center in a branch office. Most vendors recognize these needs and therefore promote their product's sustainability as a means to help their customers attain their sustainability goals. As one of the leading companies in demonstrating sustainability1 , Schneider Electric believes that customers care about three key topics when it comes to sustainable products: 1 Schneider Electric recognized in Corporate Knights' Global 100 for the 12th year in a row 2 Sustainability data that is free and available to all customers and validates product claims, including documentation like environmental product disclosures and product end-of-life treatments. 3 Performance characteristics that improve a product's sustainability, including lower impact materials, energy efficiency, durability, repairability, and take-back. 1 Compliance with applicable regulations, particularly those related to hazardous substances. Includes mandatory compliance to hazardous substance regulations such as the European directive for Restriction of Hazardous Substances (RoHS); European Regulation for Registration, Evaluation (REACh); European directive for Waste from Electrical and Electronic Equipment (WEEE); China RoHS; and California Proposition 65. Life is On | Schneider Electric Environmental declarations An environmental product declaration (EPD) summarizes the environmental life cycle data of a product or service and is normally valid for five years. These documents help specifiers make Uninterruptible Power Supply (UPS) decisions based on environmental impacts like carbon footprint and water use, making it easier to compare UPSs of the same category. The International Organization for Standardization (ISO) publishes the standards that underly EPDs, in particular ISO 14025. EPDs must be based on life cycle assessment (LCA) data or life cycle inventory analysis (LCI) data, which are governed by the ISO 14040 standard. For more information on ISO standards, see Schneider Electric White Paper 70. Note that ISO 14040 is generic and applies to all types of products and services. The following sections explain how to read an EPD, explain three key concepts of a 3-phase UPS PSR, and describe the typical carbon profile of a 3-phase UPS. Life is On | Schneider Electric Environmental declarations Program operators like the P.E.P. Association administer programs in compliance with ISO 14025 so that EPDs report the same type of information. They develop, approve, and publish product category rules (PCR) and product-specific rules (PSR) for Type III environmental declarations. All EPDs must be independently verified by internal2 or external experts and provide information need to track Scope 1, 2, and 3 3 emissions. For this e-guide, the PCR related to a UPS covers electrical, electronic, and HVAC-R products and defines how vendors should perform the LCA. When the PCR isn't detailed enough to develop EPDs for specific products, program operators develop PSRs. P.E.P. Association 11/17, rue de l'Amiral Hamelin - 75016 Paris Non-profit association (Law of 1901) – SIRET No.: 789 180 320 00010 PEP ecopassport® PROGRAM PCR Product Category Rules for Electrical, Electronic and HVAC-R Products PCR-ed4-EN-2021 09 06 © 2021 P.E.P. Association Copyright of PCR Product Category Rules are © PEP Ecopassport® Program property, if nothing else has been specified (e.g. the cross-publication of PCR from other programs). The use of the PCR for any other purpose than to develop PSRs and register PEPs in the International PEP Ecopassport® Program are subject to approval by the General Secretariat, which may be contacted at: contact@pep-ecopassport.org Reporting environmental data for a UPS 2 This applies to business-to-business products only. 3 See Appendix of White Paper 67, Guide to Environmental Sustainability Metrics for Data Centers, for information on Scope 1, 2, and 3. Life is On | Schneider Electric What is a PEP and how to read it PEP stands for Product Environmental Profile. The PEP Ecopassport association defines which mandatory information a PEP must provide. While the templates change from vendor to vendor, the key information needed for a UPS comparison is usually presented in the following order: 6 Verification information 5 Environmental impacts 4 Additional environmental information 3 Constituent materials 2 The "function" or "functional unit" 1 The "reference product" or "representative product" All values in the PEP are expressed in scientific notation using a decimal value with an exponential (E) of 10. In this example: 1.97E06 = 1.97 x 10E6 = 1.97 x 1,000,000 = 1,970,000 PEP contains the CO2 emissions data of the product PEP Extract of a 3-phase UPS: Galaxy VX The 'Contribution to climate change' contains the CO2 Emissions of the product expressed in kg CO2 equivalent. Description of the different Life Stages of the product Life is On | Schneider Electric The PSRs define rules for specific products within the larger product category. Due to their unique function, such as multiple operating modes, UPSs are one of those products that require their own product specific rules. There are 3 key concepts in the UPS PSR that play a significant role in determining the life cycle carbon footprint of a UPS. 1. Reference Service Life (RSL) The RSL is the length of time the UPS is expected to remain in service. According to section 3.5.5.1 of the PSR, a 3-phase UPS over 10 kW has a service life of 15 years. This means that the life cycle assessment accounts for 15 years of UPS emissions. For example, if the electricity use emissions for the UPS is 100,000 kg CO2 e per year, its lifetime electricity emissions would be 100,000 kg CO2 e x 15 years or 1,500,000 kg CO2 e. 2. Typical load profile A load profile is meant to ensure that all manufacturers use the same assumptions to calculate electricity use. A load profile includes % load, length of time a UPS operates during its lifetime, and UPS operating mode. For 3-phase UPSs greater than 10 kW, the electricity use is based on operating at: • 25% load for 25% of the UPS life (3.75 years) • 50% load for 50% of the UPS life (7.5 years) • 75% load for 25% of the UPS life (3.75 years) • 100% load at 0% of the UPS life (0 years) Product specific rules (PSR) for 3-phase UPS Reference Service Life (RSL) of a UPS Typical load profile of a UPS Life is On | Schneider Electric 3. Energy efficiency calculation The percent load and operating mode are important because they determine the UPS's efficiency at a specific load percentage. If a UPS has two operating modes, it will have two different efficiency values that characterize each mode. However, according to UPS PSR section 3.5.5.3, the electricity use calculation must be based on the UPS's operating mode with the worst case weighted efficiency; which in most cases is double conversion. The weighted efficiency for a 3-phase UPS (>10 kW) is calculated according to the formula: Weighted efficiency = 25% x Eff25% + 50% x Eff50% + 25% x Eff75% + 0% x Eff100% Product specific rules (PSR) for 3-phase UPS (continued) Efficiency figures at different load percentages for two operating modes (example: Galaxy VX 1250 kW) Weighted efficiency in double conversion = 25% x 95.6% + 50% X 96% + 25% x 95.7% + 0% x 95.2% = 95.8% Weighted efficiency in eConversion = 25% x 97.9% + 50% X 98.8% + 25% x 98.9% + 0% x 99% = 98.6% Life is On | Schneider Electric Because a UPS operates continuously over its lifetime, the largest contribution to its carbon emissions comes from the "use" stage. While there are significant differences among UPS models in terms of efficiency and the associated electrical losses, electricity consumption is by far the largest contributor of CO2 e life cycle emissions. Here is an example of how each stage of the lifecycle contributes to the CO2 e emissions of a 3-phase UPS taken from the Galaxy VX PEP. The use stage emissions represent about 93% of the UPS's carbon footprint. Carbon profile of a typical 3-phase UPS Manufacturing 6.2% Distribution 0.1% Installation 0.0% Use 93.3% End of life 0.4% Galaxy VX UPS 1250 - CO2e emissions per life stage Manufacturing Distribution Installation Use End of life Use 93.3% Breakdown of total carbon footprint for a 3-phase UPS (example: Galaxy VX). Life is On | Schneider Electric UPS carbon footprint comparisons Life is On | Schneider Electric • A sustainability comparison makes sense only after developing a list of UPS models that meet your functional requirements. • In the case of a UPS, requirements may include kW capacity, physical footprint, efficiency, modularity, etc. Once you have a list of UPSs, then you can quantitatively compare their environmental characteristics. • The most effective way to do this is to compare their PEPs. • A comprehensive UPS carbon footprint comparison should consider all five of its life cycle stages. This section first explains common errors to avoid when comparing UPSs and then provides step by step guidance on comparing each of the five life cycle stages. • We use two UPSs to demonstrate the comparison. A key theme in this section is the concept of comparing "apples to apples." UPS carbon footprint comparisons Common errors to avoid when comparing products While the ISO standards provide the basis for LCAs and PEPs, they don't eliminate vendor mistakes or ensure valid comparisons. Therefore, end users must be vigilant when comparing PEPs for two or more UPSs, especially if they're from different vendors. This section covers the major errors people make when comparing the carbon footprint of two or more UPS. Life is On | Schneider Electric An emission factor is the ratio of greenhouse gas emitted for every kWh of electricity a utility generates. The emission factor is multiplied by the energy (kWh) the UPS uses in its lifetime to arrive at the use stage emissions from electrical losses. Because a UPS operates continuously over its lifetime, the largest contribution to its carbon emissions comes from the use stage. Even a small difference in emission factors has a major impact on a comparison. This is why you can't compare UPSs with different grid emission factors. An example of this frequent error is illustrated here. As shown in the table below, it's quite possible for a PEP of an inefficient UPS (e.g., UPS X at 94%) to show lower total emissions than a more efficient UPS (e.g., Galaxy VX at 95.8%) with an (erroneously calculated) 980,000 kg CO2 e vs. 2,000,000 kg CO2 e. In reality, only the second and the third line can be used for an apples-to-apples comparison, which shows that UPS X emissions are much higher than Galaxy VX. How different grid emission factors impact CO2 e emissions declaration. Example: 1250kW UPS Efficiency % Grid Emissions Factor (kgCO2/kWH) Grid geography CO2 emissions declared in PeP (Use phase) in kgCO2 UPS X 94% 0,2 FR 980 000 94% 0,41 EU-27 2 000 000 Galaxy VX 95,8% 0,41 EU-27 1 400 000 2 22kW UPS Comparing "use stage" carbon emissions based on different utility grid emission factorsError #1 When the emission factors are set equal (0.41 kg CO2 e/kWh), the total CO2 e footprint for the low-efficiency UPS is 1.4 times higher than the high-efficiency UPS. This example was calculated assuming an overall emission factor for the 27 European countries (0.41 kg CO2 e/kWh) compared to that of France (0.2 kg CO2 e/kWh) 6 . 6 This is an older (and higher) value than today's EU-27 and France values. The program operator, P.E.P. Association, tries to keep this value consistent over the years to avoid publishing PEP documents based on different emission factors. Life is On | Schneider Electric Example of CO2 footprint comparison between UPS with different emission factors. Because PEPs use codes that can be difficult to understand, an easier way to assess the use stage emissions between two or more UPSs is to compare their efficiencies with the same grid emission factor. The 3-phase UPS Efficiency Comparison Calculator simplifies this task. 0 500,000 1,000,000 1,500,000 2,000,000 2,500,000 Manufacturing Distribution Installation Use End of life UPS CO2e footprint UPS X - 94% eff using French EF (0.2 kg CO2e/kWh UPS X - 94% eff using European EF (0.4 kg CO2e/kWh GVX - 96% eff using European EF (0.4 kg CO2e/kWh Incorrect comparison Correct comparison since both UPS use the same emission factor (EF) 2 2 2 Common errors to avoid when comparing products Life is On | Schneider Electric If a UPS has two operating modes, it will have two efficiency curves characterizing each mode. An example of this is illustrated using the Three Phase UPS Efficiency Comparison Calculator. Example of UPS efficiency curves for two different operating modes. • UPS with two operating modes will have two efficiency curves • Generally cannot compare values from different operating modes • If operator uses high-efficiency for one UPS but double conversion with another, values cannot be compared Comparing "use stage" carbon emissions with different operating modesError #2 Life is On | Schneider Electric Common errors to avoid when comparing products Declaring a winning attribute that is within the margin of errorError #7 Granting recycling credit without evidence of recycling programError #6 Assuming a PEP includes expected componentsError #5 Comparing UPS PEPs with different PSR and PCR versionsError #4 Comparing UPSs with different capacitiesError #3 Life is On | Schneider Electric Calculate the weighted UPS efficiency for the operating mode that will actually be used (e.g., double conversion or high-efficiency mode). The typical operating mode is double conversion. Do this for each UPS you're comparing using the formula provided below: This step requires: • The total energy consumption (kWh) – sum of all reference test loads from Step 2 • The grid emission factor (kg CO2 e/kWh) – Ideally, the emission factor is the same as that of the electric grid supplying the UPS. This final step sums the emissions from all five life cycle stages (i.e., manufacturing, distribution, installation, use, and end of life) using the UPS PEP document. If the UPSs have different rated capacities, then you should compare the total carbon footprint using the 'K- factor' described above, or use the data from the nearest UPS rating provided in the PEP. This will allow you to see which UPS has the lowest total carbon footprint. This step requires the following for each UPS you're comparing: • The efficiencies from Step 1 • The grid emission factor (kg CO2 e/kWh) – Ideally, the emission factor is the same as that of the electric grid supplying the UPS. • The rated capacity of the UPS (kW) • The UPS reference service life (RSL) (15 years) Step 1: Calculate the weighted efficiency. Step 3: Calculate UPS electricity CO2 emissions. Step 4: Add CO2 emissions from the other life stages. Step 2: Calculate UPS electricity consumption. Four steps for accurate UPS comparisons This section describes the steps required to accurately compare two or more UPSs. UPS life cycle electricity emissions (kg CO2 e) Weighted efficiency Total energy consumption kWh Emission factor (kg CO2 e/kWh) = = x 25% x Eff25% + 50% x Eff50% + 25% x Eff75% + 0% x Eff100% Life is On | Schneider Electric UPS carbon calculation tool This section describes the excel worksheet that facilitates UPS carbon footprint comparisons using the four steps described in the previous section. We describe each input that the worksheet uses to calculate the carbon footprint for the UPS models you're comparing. All input cells are highlighted in yellow. Main input cells: UPS carbon footprint comparison tool In Step 1, the set of inputs describe the efficiency of the UPSs you're comparing. The UPS model and operating mode inputs are used only to label the efficiency data. The efficiency data should have at least one decimal of precision. Note, you must choose the operating mode that will actually be used at the site (typically double conversion). With the data provided by the Three Phase UPS Efficiency Comparison Calculator, you can enter the efficiencies in the yellow cells for most Schneider Electric UPSs. Table used to calculate weighted UPS efficiency: In Step 2 & 3, with the data entered thus far, the tool calculates the electricity consumption (kWh) and electricity-based emissions (kg CO2 e) in the green rows. Table used to calculate electricity consumption and emissions (kg CO2 e): Per Step 4, the last part of the worksheet sums the emissions from the remaining life cycle stages (i.e., manufacturing, distribution, installation, and end of life) using the values in the UPS PEP document. The worksheet also calculates the emissions per unit kW of rated UPS capacity in case the UPSs have different rated capacities. Table used to calculate the total UPS life cycle carbon emissions (kg CO2 e): Life is On | Schneider Electric Conclusion Life is On | Schneider Electric As more companies and consumers seek to reduce their environmental footprint, vendors are responding with claims of environmentally sustainable UPSs. Assessing the environmental sustainability of a UPS is complex and claims are difficult to ascertain without knowing the underlying assumptions and standards upon which they are made. By understanding the calculations behind the sustainability claims of the UPS you are considering, you can confidently choose a UPS that is better for your operations and the planet. This e-guide defined and covered five life cycle stages that encompass a UPS's environmental sustainability performance. We provided explanations for how to calculate the electricity-based UPS emissions. Finally, we offered guidance for how to accurately assess the sustainability of similar UPSs and a tool to help with UPS comparisons. Conclusion © 2024 Schneider Electric. All Rights Reserved. Schneider Electric, APC, EcoStruxure, and Smart-UPS are trademarks and the property of Schneider Electric SE, its subsidiaries and affiliated companies. All other trademarks are the property of their respective owners. 998-23218491_GMA To learn more about addressing your UPS's environmental sustainability, visit: se.com Schneider Electric 35 rue Joseph Monier 92500 Rueil-Malmaison, France Tel : +33 (0)1 41 29 70 00 General 05/2024 EcoStruxure™ Power for EV Battery Manufacturing Plants Utilizing a Digital Twin for Electrical Distribution to Drive Efficient Facilities Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Purpose of the Document Target Audience This document is intended to address End User Engineering, Operations and Maintenance, Consultants, EPCs (Engineering, Procurement, and Construction) and Service teams and other qualified personnel. Objective To understand the challenges of designing and operating an EV battery manufacturing plant with an efficient and sustainable electrical distribution strategy. Table of Contents Overview of capabilities Previous Next Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Table of Contents SECTION 1: Introduction to the Electrical Vehicle Battery Manufacturing Plants Introduces the context and the challenges of EV battery manufacturing plants. SECTION 2: How Schneider Electric Can Support Electrical Vehicle Battery Manufacturing Plants Describes the solutions that Schneider Electric, and more specifically EcoStruxure Power provides for EV battery manufacturing plants, with typical electrical and digital architecture. BIBLIOGRAPHY Contains useful documents to find out more about capabilities. Provides details about Green Premium. SECTION 3: Digital Solutions and Services Gives information about EcoStruxure Power capabilities for EV Battery Manufacturing plants, sorted by value proposition: • Transverse Lifecycle Capabilities • Capabilities to Improve Time To Market • Capabilities to Improve Your Process • Capabilities to Improve Quality • Capabilities to Grow Sustainability Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General WHY READ THIS SECTION? SECTION 1 SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY EV Battery Market EV Battery Manufacturing Plant Challenges The objective of this section is to: • Introduce the growth, trends and challenges of the EV battery market • Present the 4 pillars to meet the EV battery manufacturing plant challenges. Introduction to the Electrical Vehicle Battery Manufacturing Industry Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY EV Battery Manufacturing Industry EV Battery Market EV Battery Manufacturing Plant Challenges EV Battery Market An industry driven by the electrical vehicle market 8 EV models Launched by Nissan by the end of 2023. Goal is to be on pace to sell 1M hybrid or electric vehicles per year globally. 15-25% sales of hybrid & EV for BMW by 2025. 20 EV models Launched by Audi by the end of 2025. 27 B$ investment By General Motors in EV infrastructure through 2025 with the aim of releasing 30 EV vehicles onto the market with the same timeframe 1 M hybrid & electrical vehicles On the road pledged by Volvo by end of 2025. Expectation of 50% of global sales from EVs. 10 EV models Introduced by Mercedes by the end of 2023. Ban of diesel- and gas-powered cars In the UK expected to go into effect by 2030. Sources https://www.caranddriver.com/news/g35562831/ev-plans-automakers-timeline/ Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY EV Battery Manufacturing Industry EV Battery Market EV Battery Manufacturing Plant Challenges EV Battery Market The market trends: a changing landscape Significant investment in Greenfield and expansions A growing focus on efficiency and sustainability High demand for energy and power to meet battery production capacity Cybersecurity Expertise Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY SECTION 1 – Introduction to the EV Battery Manufacturing Industry EV Battery Market EV Battery Manufacturing Plant Challenges How can we minimize downtime to increase yield rates and improve production quality? How can we be best-in- class for CO2 emissions per kWh? How to improve the overall energy efficiency of the plant and process? How can we accelerate the design & build of new EV battery plants? EV Battery Manufacturing Plant Challenges Four pillars to drive efficiency, reliability and sustainability KPIs The strong growth of the EV market leads to an increasing need for battery manufacturing plants. Creating or expanding EV battery manufacturing plants is not without its challenges. Four pillars must be addressed: Grow Sustainability Improve Quality Improve Your Process Improve Time to Market How can we reduce the cost of finished battery cells? Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General WHY READ THIS SECTION? SECTION 2 SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Solutions to Address the Four Pillars Schneider Electric Value Propositions Example of Electrical and Digital Architecture The objective of this section is to: • Present the solutions to address the four pillars to meet the EV battery manufacturing plant challenges • Explain how Schneider Electric EcoStruxure™ Power can support this industry • Give an example of electrical and digital architectures. How Schneider Electric Can Support Electrical Vehicle Battery Manufacturing Plants Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General Schneider Electric Value Propositions Example of Electrical and Digital Architecture Solutions to Address the Four Pillars SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Solutions to Address the Four Pillars of EV Battery Manufacturing Plants The four pillars can be addressed by the following solutions: Increase Production Efficiency Reduce Production Hazards Track Sustainability KPIs Use Standardized Architectures Use standardized electrical distribution and IT infrastructures in order to speed up the "design, build and commission" phase of new plants. Digitize and modernize your operations and turn data into useful business intelligence to empower your workforce, understand the profitability of your production assets and make smart business decisions for your entire ecosystem. Reduce downtimes and manage end-to-end quality to reduce production scrap. Utilize control tower and IoT platforms to collect analytics on processes, settings and maintenance. Monitor sustainability criteria to accelerate environmental transition and be compliant with sustainability standards and customer expectations. Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Example of Electrical and Digital Architecture Solutions to Address the Four Pillars Schneider Electric Value Propositions SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Schneider Electric Value Propositions At company level Through its entire organization, Schneider Electric has developed value propositions to address the four pillars for the different parts of EV battery manufacturing plants: Infrastructure / Facility Manufacturing Process Manufacturing Machine Design and Modeling Digital Automation & IOT Framework EcoStruxure Machine Architecture Energy Efficiency Process Efficiency Machine Performance & Flexibility Power Availability Predictive Quality Machine Tracking & Monitoring Green House Gas and Energy Compliance Energy Optimization Sustainable Sourcing Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Transverse Lifecycle Capabilities (Cybersecurity, Green Premium, Digital Twin) Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Example of Electrical and Digital Architecture Solutions to Address the Four Pillars Schneider Electric Value Propositions SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Schneider Electric Value Propositions At EcoStruxure Power level This guide focuses more specifically on value propositions provided by EcoStruxure Power: Manufacturing Process Manufacturing Machine Digital Automation & IOT Framework EcoStruxure Machine Architecture Process Efficiency Machine Performance & Flexibility Predictive Quality

Machine Tracking & Monitoring Energy Optimization Sustainable Sourcing Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Transverse Lifecycle Capabilities (Cybersecurity, Green Premium, Electrical Digital Twin) Infrastructure / Facility Design and Modeling Energy Efficiency Power Availability Green House Gas and Energy Compliance Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Example of Electrical and Digital Architecture Solutions to Address the Four Pillars Schneider Electric Value Propositions SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Schneider Electric Value Propositions At EcoStruxure Power level EcoStruxure Power helps deliver an end-to-end digital solution for efficient, reliable and sustainable EV Battery Plants. From electrode production to cell finishing, From electrical design to operations and maintenance, Our collaborative environments, enhanced by the Electrical Distribution Digital Twin of your Plant, enable high productivity operations. Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Solutions to Address the Four Pillars Schneider Electric Value Propositions Example of Electrical and Digital Architecture SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Example of Electrical and Digital Architecture Typical EV battery manufacturing plant Energy is key, whether for processes or for utilities: specific attention must be given to the design of the electrical architecture and associated digital architecture which will enable digital solutions and services. EV battery manufacturing plant PROCESS Energy consumption 60 % UTILITY Energy consumption 40 % Cell assembly Utilities – Clean and dry room Ageing/Formation Utilities Infrastructure 3%Mixing Coating and drying Vacuum drying Calendering Slitting 23 % 2% 2% 2% 2% 26 % 37 % 3% Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Solutions to Address the Four Pillars Schneider Electric Value Propositions Example of Electrical and Digital Architecture SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Example of Electrical and Digital Architecture Typical electrical architecture for an EV battery manufacturing plant Example of Electrical Architecture General Example of Electrical Architecture Expensive Process = Power Availability High Energy demand = Efficient Energy Management ELECTRODE PRODUCTION • Mixing • Coating & Drying • Calendering • Slitting • Vacuum Drying CELL ASSEMBLY • Electrode shaping • Stacking • Electric contacting • Case insertion • Case closure CELL FINISHING • Electrolyte filling Pre-charging • Filling hole closure • Ageing & formation INFRASTRUCTURE • Emergency Loads • IT and Control Room • Lightings and other UTILITIES • Dry Room MV Chillers and Dryers • Clean Room MV Chillers • Cooling Water • Waste Treatment • Inert gas (N2) PROCESS UTILITY 60 % 40 % Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Solutions to Address the Four Pillars Schneider Electric Value Propositions Example of Electrical and Digital Architecture SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Example of Electrical and Digital Architectures Suggested digital architecture (high-level view) for an EV battery manufacturing plant Example of Digital Architecture (High-Level View) General Example of Digital Architecture (High-Level View) Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Solutions to Address the Four Pillars Schneider Electric Value Propositions Example of Electrical and Digital Architecture SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry BIBLIOGRAPHY Example of Electrical and Digital Architectures Corresponding detailed digital architecture for an EV battery manufacturing plant Example of Digital Architecture (Detailed View) General Example Digital Architecture (Detailed View) Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General WHY READ THIS SECTION? SECTION 3 SECTION 3 – Digital Solutions and Services Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY This section gives information about EcoStruxure Power capabilities for EV battery manufacturing plants aligned to the industry challenges. Digital Solutions & Services Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Introduction SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Introduction EcoStruxure Power provides capabilities to support the challenges of EV battery manufacturing plant throughout the plant lifecycle: These capabilities provide standardized designs and digital architectures, and enable easy simulation, to reduce cost of design and ownership. These capabilities use digitization to provide intelligent information to the workforce, allowing them to make smart decisions that reduce operating costs and increase efficiency. These capabilities use digitization to reduce unplanned downtime, increase reliability, and thus reduce production waste. These capabilities help track energy consumption and carbon emissions to meet sustainability requirements. Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities Digital Solutions that support your project from the Design, Build, Commission to Operate & Maintain phases. Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Overview of Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities 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storage sizing simulation + + + + + + + Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry Capabilities to Grow Sustainability Electrical Digital Twin Maintain a Digital Twin of your electrical distribution Benefits • Intelligent user-interface for all levels of AC and DC networks • Enables users, from the design to operate phases, to model, simulate, analyze and validate electrical power systems to predict their electrical network behavior • Takes the day-to-day system modeling and design tasks to a new level of speed, accuracy and ease Electrical Digital Twin Transverse Lifecycle Capabilities Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry Capabilities to Grow Sustainability Green Premium Manage sustainability from design to end of life Benefits • Green Premium* products provide detailed information on their regulatory compliance, material content, environmental impact, and circularity attributes. Transverse Lifecycle Capabilities Compliance and transparency (compliance certificates, circularity profiles, environmental footprint, etc.)1 Circular performance Durability, upgradeability, re-manufacture, recycled content, recyclability Well-being performance E.g. free of PVC, mercury, silicone, SVHC, lead, toxic heavy metal and compliant with California Prop 65 4 Resource performance Optimized energy performance Lower carbon emissions 2 3 * The Green Premium label was created to provide Schneider Electric's customers with more sustainable products and to be transparent with environmental information. Supporting your efforts for a LEED certified building Helping you achieve Living Building Challenge certification Green Premium Value Proposition Learn more about: • Green Premium Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Transverse Lifecycle Capabilities SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry Capabilities to Grow Sustainability Cybersecurity Help secure the digital power distribution system Benefits • Provides a selection of cybersecurity certified products • Provides certified system architectures and solutions • Delivers lifecycle services Transverse Lifecycle Capabilities Learn more about: • Cybersecurity Certified products developed according to IEC 62443 functional requirements with Secure Development Lifecycle processes. Consulting services from design, implementation, operations and maintenance to tailor your security solutions to your strategy and budget. Lifecycle services Certified secure system architecture according to IEC 62443-3-3 with documented processes and solutions for a secure system. Cybersecurity system configuration software for consistent security policy deployment. Certified products Certified systems & solutions Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction Simulate before Operate Arc flash protection + + + + + + + + + Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability AC and DC Electrical Network Bus Design and Simulation Optimize bus design allocation and simulation Primary Department • Design • Construction Benefits • Single solution/environment - Unified AC & DC solution from HV to LV - One unique platform and one database • Efficient profile management - User-defined loading and generation profiles - External data profile based on field measurements • Scalability - Load growth study for future planning • Event simulations within the calculation period Capabilities to Improve Time to Market ETAP Electrical Network Model Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Electrical Network Short Circuit Simulation Design and simulate unbalanced short circuits Primary Department • Design • Construction Benefits • Expedite design studies with a wide range of calculation scenarios, including advanced fault analysis - IEC & ANSI duty calculation for balanced and unbalanced faults - Simultaneous fault at selected nodes - Inclusive 3-Phase and 1-Phase fault analysis - Pre-Fault system loading consideration Electrical Network Short Circuit Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Network Load Flow and Voltage Drop Simulation Perform power flow analysis and voltage drop calculations Primary Department • Design • Construction Benefits • Simulation of bus voltages, branch power factors, currents, system losses, power generation versus loading • Use of ETAP Electrical Digital Twin model with powerful calculation engines and user-friendly interface • Simulation using multiple loading and generation conditions Network Load Flow and Voltage Drop Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Device Coordination and Selectivity Automatically detect and evaluate the system protection and coordination/selectivity Primary Department • Design • Construction Benefits • Verified and validated libraries • Graphically adjustable device settings • Detailed device settings reporting • Continuous synchronization with one-line and integrated equipment database Device Coordination and Selectivity in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Arc Fault Protection and Coordination Perform sequence of operation for arc fault and bolted fault Primary Department • Design • Construction Benefits • Evaluate, verify, and confirm the operation and selectivity of the protective devices for various types of faults for any location directly from the single-line diagram • Animation displayed on the single-line diagram • 3-phase / 1-phase sequence of operation Arc Fault Protection and Coordination in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Power Quality Simulation and Modeling Evaluate and validate distortion due to harmonics Primary Department • Design • Construction Benefits • Simulate harmonic current and voltage sources: - To identify potential harmonic problems (report of harmonic voltage and current distortion limit violations) - To identify the need for a harmonics filter • Simulate and analyze the size of the harmonics filter your system will need to optimize performance and reduce nuisance trips Capabilities to Improve Time to Market Power Quality Simulation and Modeling in ETAP Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Time to Market SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Your Process Capabilities to Improve Quality Capabilities to Grow Sustainability Renewable and Microgrid Energy Storage Sizing Simulation Design and optimize the microgrid system Primary Department • Design • Construction Benefits • Build renewable energy models combined with full spectrum power system analysis calculations for: - Accurate simulation - Predictive analysis - Equipment sizing - Field verification of wind, solar farms and other DERs • Enable designers and engineers to conceptualize the collector systems, determine wind penetration and perform grid interconnection studies Microgrid Energy Storage Sizing Simulation in ETAP Capabilities to Improve Time to Market Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Your Process SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Quality Capabilities to Grow Sustainability Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities AC&DC electrical 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Improve Time to Market Capabilities to Improve Quality Capabilities to Grow Sustainability Operator Training Simulation Train new employees and build confidence on new systems Primary Department • Facility Operations & Maintenance Benefits • Practice operation within a simulated but highly realistic environment to enhance safety and operational efficiency • Track and review trainee actions to analyze and challenge them + Capabilities to Improve Your Process Learn more about: • Operator Training Simulation (IEC / NEMA) Principle of Operator Training Simulation Application Operator Training Simulation Reference Architecture General Operator Training Simulation Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Your Process SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Quality Capabilities to Grow Sustainability Energy Monitoring and Usage Analysis Determine where to focus energy conservation initiatives Primary Department • Facility Operations & Maintenance Benefits • Bring awareness to utility consumption - Turn data into easy-to-interpret graphical dashboards and reports to raise awareness amongst key stakeholders • Identify “quick-win” opportunities for energy savings - By comparing and visualizing energy usage and cost for different utilities over different time periods - By identifying and prioritizing which areas lend themselves to a high energy-saving return on investment Capabilities to Improve Your Process Energy Usage Analysis Dashboards in EcoStruxure Power Operation Learn more about: • Energy Monitoring (IEC / NEMA) Energy Monitoring and Usage Analysis Reference Architecture General Energy Monitoring and Usage Analysis Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Your Process SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Quality Capabilities to Grow Sustainability Energy Performance, Modeling and Verification Analyze the energy performance of a plant against a model baseline Primary Department • Facility Operations & Maintenance Benefits • Provide energy usage information based on equipment and processes • Compare model versus actual consumption • Compare pre-retrofit versus post-retrofit energy consumption to track improved performance and savings as a result of energy conservation initiatives Capabilities to Improve Your Process Energy Performance, Modeling and Verification Output in EcoStruxure Power Operation Learn more about: • Energy Performance (IEC / NEMA) • Energy Modeling and verification (IEC / NEMA) Energy Performance, Modeling and Verification Reference Architecture General Energy Performance Modeling and Verification Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Your Process SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Quality Capabilities to Grow Sustainability Capacity Management Monitor the capacity of electrical distribution Primary Department • Facility Operations & Maintenance Benefits • Monitor electrical network capacity • Track and review capacity efficiency • Minimize downtime by tracking the capacity of transformers, circuit breakers, UPSs, generators, etc. Capabilities to Improve Your Process Breaker Capacity Single-line Diagram in EcoStruxure Power Operation Learn more about: • Capacity Management (IEC / NEMA) Capacity Management Reference Architecture General Capacity Management Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Predictive Simulation Help employees make better decisions Primary Department • Facility Engineering • Design Engineering Benefits • Reduce safety risks by practicing emergencies and high-risk situations • Enhance operational efficiency by running “what-if” scenarios • Provide faster analysis response to incidents Capabilities to Improve Quality + Principle of Predictive Simulation Application Predictive Simulation Reference Architecture General Predictive Simulation Application Digital Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Simulate Before Operate Empower operators with predictive outcomes Primary Department • Facility Operations & Maintenance Benefits • Provide operators with a list of potential side effects, prior to executing a command • Empower employees to feel more confident when operating their facilities by providing real time guidance • Reduce human error that could lead to outages or safety concerns Capabilities to Improve Quality Learn more about: • Simulate Before Operate (IEC / NEMA) Principle of Simulate before Operate Application Simulate Before Operate Reference Architecture General Simulate Before Operate Application Digital Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Electrical Distribution Monitoring and Alarming Monitor and control electrical network Primary Department • Facility Operations & Maintenance Benefits • Show real-time status of the power distribution • Customized single-line diagram • 24/7 power monitoring and alarm notification Capabilities to Improve Quality Electrical Distribution Monitoring and Alarming Single-line Diagram in EcoStruxure Power Operation Learn more about: • Electrical distribution monitoring and alarming (IEC / NEMA) • Power Source and Load Control (IEC / NEMA) Electrical Distribution Monitoring and Alarming Reference Architecture General Electrical Distribution Monitoring and Alarming Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Power Event Analysis Analyze the root causes of electrical events Primary Department • Facility Operations & Maintenance Benefits • Automatically classifies and describes any electrical events • Uses system intelligence to determine root cause and location of events • Shows context and sequence of events using the timeline analysis interface Event and Alarm Status view in EcoStruxure Power Operation Event and Alarm Status Timeline in EcoStruxure Power Operation Capabilities to Improve Quality Learn more about: • Power Event Analysis (IEC / NEMA) Power Event Analysis Reference Architecture General Power Event Analysis Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Asset Performance Benefit from a strategic maintenance approach Primary Department • Facility Operations & Maintenance Benefits • Move from reactive or preventive to condition-based (predictive) maintenance strategies for critical assets like circuit breakers, gensets, transformers, etc. • Provide event details and notification to the operator if a protection setting has been changed • Receive notifications and diagnostics reports from expert service engineers with recommendations to optimize maintenance by asset or site Capabilities to Improve Quality Aging Diagram for Circuit Breakers in EcoStruxure Power Operation Gigafactory Learn more about: • Asset Performance (IEC / NEMA) Asset Performance Reference Architecture General Asset Performance Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Power Quality Monitoring and Compliance Gain insights to improve power quality and comply with standards Primary Department • Facility Operations & Maintenance Benefits • Bring awareness of power quality • Enhance operational efficiency by making sure clean power is fed to sensitive process equipment • Help protect sensitive equipment by tracking power quality problems before they arise Capabilities to Improve Quality Power Quality and Compliance Dashboards in EcoStruxure Power Operation Power Quality and Compliance Report in EcoStruxure Power Operation Learn more about: • Power Quality Monitoring and Compliance (IEC / NEMA) Power Quality Monitoring and Compliance Reference Architecture General Power Quality Monitoring and Compliance Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Power Quality and Power Factor Correction Help protect sensitive equipment from power quality issues Primary Department • Facility Operations & Maintenance Benefits • Monitor sensitive process lines and busbars • Provide clean power to sensitive process equipment • Track Power Quality problems to help avoid downtime • Reduce financial impact of power factor on energy bill Capabilities to Improve Quality Galaxy VM Power Quality Information in EcoStruxure Power Operation Before and After Power Quality and Power Factor Correction ImplementationLearn more about: • Power Quality Correction (IEC / NEMA) • Power Factor Correction (IEC / NEMA) Power Quality and Power Factor Correction Reference Architecture General Power Quality and Power Factor Correction Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Continuous Thermal Monitoring Help prevent electrical fires and help protect equipment Primary Department • Facility Operations & Maintenance Benefits • Bring early detection of temperature abnormalities • Help reduce the risk of equipment and electrical room damage and improve service continuity • Enable cost effective maintenance Continuous Thermal Monitoring in the Single-line Diagram of EcoStruxure Power Operation Continuous Thermal Monitoring Reference Architecture Capabilities to Improve Quality Learn more about: • Continuous Thermal monitoring (IEC / NEMA) General Continuous Thermal Monitoring Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Improve Quality SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Grow Sustainability Arc Flash Protection Help protect employees and equipment Primary Department • Facility Operations & Maintenance Benefits • Help prevent loss of life and reduce the risk of equipment and electrical room damage • Improve maintenance team awareness to help troubleshoot and identify the root cause of arc flash events Capabilities to Improve Quality Learn more about: • Arc Flash Protection (IEC / NEMA) Arc Flash in a Switchboard Arc Flash Alert and Location in EcoStruxure Power Operation Arc Flash Protection Reference Architecture General Arc Flash Protection Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Overview of Digital Solutions and Services Electrical Digital Twin Green Premium Operator training simulation Energy monitoring and usage analysis Energy performance, modeling and verification Capacity management + + + + Cybersecurity Carbon neutrality consulting services Energy efficiency compliance Greenhouse gas reporting + + + Grow Sustainability Improve Quality Improve Your Process Improve Time to Market Design, Build, Commission (Consultants & EPC) Operate & Maintain (Operators, maintenance team, service teams) Transverse Lifecycle Capabilities AC&DC electrical network bus design and simulation Electrical network short circuit simulation Network load flow and voltage drop simulation Device coordination and selectivity Arc fault protection and coordination Power quality simulation and modeling Renewable & microgrid energy storage sizing simulation + + + + + + + Asset performance Power quality monitoring and compliance Continuous thermal monitoring Electrical distribution monitoring and alarming Power event analysis Predictive simulation Power quality and power factor correction + + + + + + + Arc flash protection+ Simulate before Operate+ Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Carbon Neutrality Consulting Services Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Get support from our consulting services to define your strategy for achieving carbon neutrality Track and reduce carbon emissions to demonstrate the carbon neutrality of the company Capabilities to Grow Sustainability + Services Carbon neutrality Reduce Carbon Emissions Produce Renewable Energy Purchase Renewables/Offsets Energy Efficiency • Sustainable building design & operations – HVAC Efficiency – Lighting Efficiency – Operational Efficiency Behind-the-Meter Renewables • Solar Panels / Heating • Wind • Geothermal Purchase Renewables • Renewable Power Purchasing Agreements (PPA) • Renewable Energy Certificates (REC) • Biofuels Supporting Technologies • Microgrid with Smart Management • Battery Storage • Fuel Cells Purchase Offsets • Carbon Credits – Carbon Capture – Tree Planting 1 2 3 Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Energy Efficiency Compliance Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Report and show facility compliance to local sustainability requirements - To benefit from tax credits - To gain credibility to participate in new projects Comply with standards related to energy management systems Capabilities to Grow Sustainability EcoStruxure Power Operation Energy Star Compliance Dashboard EcoStruxure Resource Advisor Dashboard in EcoStruxure Power Operation Sustainable Organizations and Standards Learn more about: • Energy Efficiency Compliance (IEC / NEMA) Energy Efficiency Compliance Reference Architecture General Energy Efficiency Compliance Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services Capabilities to Grow Sustainability SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Introduction Overview of Digital Solutions and Services Transverse Lifecycle Capabilities Capabilities to Improve Time to Market Capabilities to Improve Your Process Capabilities to Improve Quality Greenhouse Gas Reporting Primary Department • Facility Operations & Maintenance • Sustainability Office Benefits • Track and report carbon emissions and waste (e.g., water) in one single place • Provide period-over-period usage comparison to detect a drift Track and report carbon emissions Greenhouse Gas Reporting and Dashboard Examples in EcoStruxure Power Operation Capabilities to Grow Sustainability Greenhouse Gas Reporting Reference Architecture Learn more about: • Greenhouse Gas Reporting (IEC / NEMA) General Greenhouse Gas Reporting Reference Architecture Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants BIBLIOGRAPHY Reference Documents Legal Information BIBLIOGRAPHY Reference Guide EcoStruxure™ Power for EV Battery Manufacturing Plants General BIBLIOGRAPHY Reference Documents SECTION 3 – Digital Solutions and Services SECTION 1 – Introduction to the EV Battery Manufacturing Industry SECTION 2 – How SE Can Support EV Battery Manufacturing Plants Legal Information Reference Documents Design Guide IEC EcoStruxure Power Design Guide Ref: ESXP2G001EN 02/2024 Digital Applications for Large Buildings and Critical Facilities The Digital Applications Design Guide provides comprehensive details on the building blocks of EcoStruxure Power: the IoT applications are driven by a software layer to control the traditional electrical distribution infrastructure. Developed to help engineering consultants and designers, this guide is an invaluable resource for specifying, designing and prescribing EcoStruxure Power architectures capable of performing one or more of the business-driven applications described within. 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All other brands are trademarks of their respective owners Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Status Data 40002 0x0001 1 UPS Status 1 0 UPS operation mode - Battery BOOLEAN 1=UPS operation mode - Battery 1 Battery is below minimum acceptable runtime BOOLEAN 1=Battery is below minimum acceptable runtime 2 Bypass BOOLEAN 1=UPS is in Bypass 3 UPS operation mode - Battery Test BOOLEAN 1=UPS operation mode - Battery Test 4 Reserved BOOLEAN 5 High Efficiency Mode disable by system BOOLEAN 1=High Efficiency Mode (ECO, ECOnversion) disable by system 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Battery fault BOOLEAN 1=Battery fault 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Informational alarm present BOOLEAN 1=Informational alarm present 14 Warning alarm present BOOLEAN 1=Warning alarm present 15 Critical alarm present BOOLEAN 1=Critical alarm present 40003 0x0002 2 Alarm Register 1 0 Lost local network management interface - to - UPS communication BOOLEAN 1=Lost local network management interface - to - UPS communication 1 Display communication is lost BOOLEAN 1=Main Controller is unable to communicate with the display 2 Parallel communication incorrect on PBUS cable 1 BOOLEAN 1=Parallel communication incorrect on PBUS cable 1 3 Parallel communication incorrect on PBUS cable 2 BOOLEAN 1=Parallel communication incorrect on PBUS cable 2 4 MegaTie activation alarm BOOLEAN 1=MegaTie activation is present 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Communication cable termination fault BOOLEAN 1=Communication cable termination fault 13 General parallel system incorrect BOOLEAN 1=General parallel system incorrect 14 Lost parallel redundancy BOOLEAN 1=Lost parallel redundancy 15 Reserved BOOLEAN 40004 0x0003 3 Alarm Register 0 Reserved BOOLEAN 1 UPS operation mode - Requested Static Bypass BOOLEAN 1=UPS operation mode - Requested Static Bypass 2 UPS operation mode - Forced Static Bypass BOOLEAN 1=UPS operation mode - Forced Static Bypass Modbus Register Map:Galaxy VX (3:3 250kW-1500kW) Scale Notes: 1. 16-bit registers are transmitted MSB first (i.e. big-endian). 2. INT32 and UINT32 are most-significant word in n+0, least significant word in n+1 (i.e. big-endian). 3. Function codes 3 and 4 are supported 4. Modbus serial RTU and Modbus over TCP is supported. 5. Signed numbers are twos-compliment 6. Status bits are atomic within a single Modbus register. User should not look for consistency across multiple registers, only within a single register. 7. For ASCII strings less than the maximum length, the unused characters are filled with nulls. 8. Single-register reads of reserved or undefined registers will return an error. Block reads which begin with a valid register will not return an error but will return zeros for undefined registers. 9. Strings are two characters per register, first character in high-order byte, second character in low-order byte. Printable ASCII only. 10. Bit #0 is least significant bit. 11. Data Type column: "INT16"=signed 16-bit integer, "UINT16" = unsigned 16-bit integer, "INT32" = signed 32-bit integer, "UINT32" = unsigned 32-bit integer, "ENUM" is a UINT16 value which maps to a defined list of states, "ASCII" = the printable ASCII subset from 0x20 - 0x7E. BOOLEAN= a single bit, 0 or 1. 12. "Absolute Starting Register Address" = 0 (the column heading used in this table) is equivalent to "Register 40001" in Modicon terminology, which is address zero when transmitted over the wire. For detailed modbus configuration settings, please refer to the Display or AP9635 User's Guide. 990-5915E May/ 2024 Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 3 UPS operation mode - Maintenance Bypass BOOLEAN 1=UPS operation mode - Maintenance Bypass 4 Reserved BOOLEAN 5 UPS operation mode - Off BOOLEAN 1=UPS operation mode - Off 6 UPS operation mode - Initialize BOOLEAN 1=UPS operation mode - Initialize 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Input phase sequence incorrect BOOLEAN 1=Input phase sequence incorrect 12 Input frequency out of range BOOLEAN 1=Input frequency out of range 13 Input voltage out of range BOOLEAN 1=Input voltage is out of range 14 Selftest - Failed BOOLEAN 1=Self test has failed 15 Power cabinet mixed operation mode (Battery and Normal) BOOLEAN 1=Power Cabinet in mixed operation mode (Battery and Normal) 40005 0x0004 4 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Bypass frequency out of range BOOLEAN 1=Bypass frequency out of range 4 Bypass phase sequence incorrect BOOLEAN 1=Bypass phase sequence incorrect 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Overload on UPS BOOLEAN 1=Overload on UPS 9 Overload on Static bypass switch BOOLEAN 1=Overload on Static bypass switch 10 Ambient temperature out of range BOOLEAN 1=Ambient temperature out of range 11 EPO Switch Activated BOOLEAN 1=EPO Switch activated 12 Ground fault detected BOOLEAN 1=Ground fault detected 13 Reserved BOOLEAN 14 Bypass voltage out of range BOOLEAN 1=Bypass voltage is out of range 15 High Efficiency mode is disable due to bypass UTHD BOOLEAN 1=Bypass UTHD is out of range for High Efficiency Mode 40006 0x0005 5 Alarm Register 1 0 System locked in bypass operation BOOLEAN 1=System locked in bypass operation 1 Batteries are discharging BOOLEAN 1=Batteries are discharging 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Continuous Overload on UPS BOOLEAN 1=Overload on UPS present. Load below Continuous Overload Threshold. 5 Charge power is reduced BOOLEAN 1=Charge power is reduced 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Distributed Energy Reserved Mode activated BOOLEAN 1= Distributed Energy Reserved mode activated 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Battery condition is weak BOOLEAN 1=Battery condition is weak 13 Battery condition is poor BOOLEAN 1=Battery condition is poor 14 Reserved BOOLEAN 15 Battery capacity is below minimum acceptable level BOOLEAN 1=Battery capacity is below minimum acceptable level 40007 0x0006 6 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Power cabinet redundancy lost BOOLEAN 1=Power cabinet redundancy lost 40008 0x0007 7 Alarm Register 1 0 Reserved BOOLEAN 1 Bypass transfert inhibited by relay input activated BOOLEAN 1= transfert to bypass is inhibited by input relay activated 2 DC ground fault BOOLEAN 1= DC ground fault is present Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 3 Ambient temperature high BOOLEAN 1 = Ambient temperature is high 4 Overload on UPS due to high ambient temperature BOOLEAN 1 = Overload on UPS due to high ambient temperature 5 Output frequency out of range BOOLEAN 1=Output frequency out of range 6 Output voltage out of range BOOLEAN 1=Output voltage is out of range 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Overload on installation BOOLEAN 1=Overload on installation 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40009 0x0008 8 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 UOB Auxiliary wiring not correct BOOLEAN 1= UOB Aux wiring is not correct 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40010 0x0009 9 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Load bank breaker closed, parallel test mode enabled BOOLEAN 1=Load bank breaker closed, parallel test mode enabled 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Unit Unit Breaker (UIB) open BOOLEAN 1=Unit Unit Breaker (UIB) open 10 Unit Ouput Breaker (UOB) open BOOLEAN 1=Unit Ouput Breaker (UOB) open 11 Maintenance Bypass Breaker (MBB) closed BOOLEAN 1=Maintenance Bypass Breaker (MBB) closed 12 System Isolation Breaker (SIB) open BOOLEAN 1=System Isolation Breaker (SIB) open 13 Static Switch Input Breaker (SSIB) open BOOLEAN 1=Static Switch Input Breaker (SSIB) open 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40011 0x000A 10 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Static bypass switch inoperable BOOLEAN 1=Static bypass switch has a critical alarm that prevents it from operating 9 Static bypass switch warning BOOLEAN 1=Static bypass switch has an alarm with severity level warning 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40012 0x000B 11 RESERVED 2 40014 0x000D 13 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 3 Reserved BOOLEAN 4 Battery room ventilation inoperable BOOLEAN 1=Battery room ventilation inoperable 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 External battery monitoring alarm BOOLEAN 1=External battery monitoring alarm 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40015 0x000E 14 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 High Battery Temperature Level BOOLEAN 1=Battery temperature above alarm setting 4 Low Battery Temperature Level BOOLEAN 1=Battery temperature below alarm setting 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Battery breaker BB1 open BOOLEAN 1=Battery breaker BB1 open 12 Battery breaker BB2 open BOOLEAN 1=Battery breaker BB2 open 13 Battery breaker BB3 open BOOLEAN 1=Battery breaker BB3 open 14 Battery breaker BB4 open BOOLEAN 1=Battery breaker BB4 open 15 Delayed transfer from Battery to Normal Operation BOOLEAN 1=The delayed transfer from Battery to Normal Operation is active. 40016 0x000F 15 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Breaker BF2 open BOOLEAN 1= breaker BF2 open 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12

Reserved BOOLEAN 13 Reserved BOOLEAN 14 Li-Ion AC Supply Breaker BMS:B1/BMS:B2 open BOOLEAN 1=Li-Ion AC Supply Breaker BMS:B1/BMS:B2 open 15 Reserved BOOLEAN 40017 0x0010 16 Alarm Register 1 0 UPS operation mode - Static bypass standby BOOLEAN 1=UPS operation mode - Static bypass standby 1 UPS operation mode - Inverter standby BOOLEAN 1=UPS operation mode - Inverter standby 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 General UPS settings incorrect BOOLEAN 1=General UPS settings incorrect 5 UPS configuration incorrect BOOLEAN 1=UPS general configuration is incorrect 6 Synchronization unavailable BOOLEAN 1=Synchronization unavaliable - system is free running 7 Fan inoperable BOOLEAN 1=UPS has one or more inoperable fans. Fan redundancy is lost. 8 Inverter is Off due to a request by the user BOOLEAN 1= Inverter is Off due to a request by the user 9 Restricted air flow BOOLEAN 1=Restricted air flow 10 Surveillance detected a fault BOOLEAN 1=Surveillance detected a fault 11 Charger status BOOLEAN 1=Inoperable 12 Inverter status BOOLEAN 1=Inoperable 13 PFC status BOOLEAN 1=Inoperable 14 Battery status BOOLEAN 1=Inoperable 15 Reserved BOOLEAN 40018 0x0011 17 Alarm Register 1 0 Technical check recommended BOOLEAN 1=Technical check recommended 1 Start-up recommended BOOLEAN 1= Secure start-up recommended 2 Warranty expiring soon BOOLEAN 1=Warranty expiring soon 3 Reserved BOOLEAN Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 4 Air filter check recommened BOOLEAN 1=Air filter check recommened 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40019 0x0012 18 RESERVED 1 40020 0x0013 19 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Not enough UPSs ready to turn on inverter BOOLEAN 1=Not enough UPSs ready to turn on inverter 6 Parallel UPS 1 not present BOOLEAN 1=Parallel UPS 1 not present 7 Parallel UPS 2 not present BOOLEAN 1=Parallel UPS 2 not present 8 Parallel UPS 3 not present BOOLEAN 1=Parallel UPS 3 not present 9 Parallel UPS 4 not present BOOLEAN 1=Parallel UPS 4 not present 10 Parallel UPS 5 not present BOOLEAN 1=Parallel UPS 5 not present 11 Parallel mixed operation mode BOOLEAN 1=Parallel mixed operation mode 12 Firmware versions in parallel UPS units are not identical BOOLEAN 1=Firmware versions in parallel UPS units are not identical 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40021 0x0014 20 RESERVED 1 40022 0x0015 21 Alarm Register 1 0 System operation mode - Off BOOLEAN 1 = System operation mode - Off 1 System operation mode - Forced static bypass BOOLEAN 1 = System operation mode - Forced static bypass 2 System operation mode - Requested static bypass BOOLEAN 1 = System operation mode - Requested static bypass 3 System operation mode - Maintenance bypass BOOLEAN 1 = System operation mode - Maintenance bypass 4 System operation mode - Static Bypass Standby BOOLEAN 1 = System operation mode - Static Bypass Standby 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40023 0x0016 22 Alarm Register 1 0 Input missing phase BOOLEAN 1=Input is missing a phase 1 Bypass missing phase BOOLEAN 1=Bypass input is missing a phase 2 External sync voltage out of range BOOLEAN 1=External sync voltage is out of range 3 External sync phase sequence incorrect BOOLEAN 1=The phase rotation on external sync is wrong 4 External sync frequency out of range BOOLEAN 1=External sync frequency is out of range 5 External sync missing phase BOOLEAN 1=External sync is missing a phase 6 External sync temporarily disabled BOOLEAN 1=External sync temporarily disabled 7 Flywheel inoperable BOOLEAN 1=Flywheel inoperable 8 Display firmware incompatibility detected BOOLEAN 1=Display firmware incompatibility detected 9 NMC 1 firmware incompatibility detected BOOLEAN 1=NMC 1 firmware incompatibility detected 10 NMC 2 firmware incompatibility detected BOOLEAN 1=NMC 2 firmware incompatibility detected 11 10-Inch display incompatibility detected BOOLEAN 1=10 inch Display firmware incompatibility detected 12 Inverter output is not in phase with bypass input BOOLEAN 1=Inverter output is not in phase with bypass input 13 Engineering Firmware Version detected BOOLEAN 1=Alarm Engineering Firmware Version detected 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40024 0x0017 23 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40025 0x0018 24 Alarm Register 1 0 Reserved BOOLEAN 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40026 0x0019 25 Alarm Register 1 0 Sensor AP9810 - Input contact A in sensor 1 BOOLEAN 1 = Alarm from sensor 1 / contact A 1 Sensor AP9810 - Input contact B in sensor 1 BOOLEAN 1 = Alarm from sensor 1 / contact B 2 Sensor AP9810 - Input contact A in sensor 2 BOOLEAN 1 = Alarm from sensor 2 / contact A 3 Sensor AP9810 - Input contact B in sensor 2 BOOLEAN 1 = Alarm from sensor 2 / contact B 4 Sensor AP9335T or AP9335TH - temperature alarm in sensor 1 BOOLEAN 1 = temperature alarm in sensor 1 5 Sensor AP9335T or AP9335TH - temperature alarm in sensor 2 BOOLEAN 1 = temperature alarm in sensor 2 6 Sensor AP9335TH - humidity alarm in sensor 1 BOOLEAN 1 = humidity alarm in sensor 1 7 Sensor AP9335TH - humidity alarm in sensor 2 BOOLEAN 1 = humidity alarm in sensor 2 8 Sensor Communication Lost with sensor 1 BOOLEAN 1 = communication lost with sensor 1 9 Sensor Communication Lost with sensor 2 BOOLEAN 1= communication lost with sensor 2 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 40027 0x0020 26 Alarm Register 1 0 Power Cabinet 1 surveillance detected a fault BOOLEAN 1 = Power Cabinet 1 surveillance detected a fault 1 Power Cabinet 2 surveillance detected a fault BOOLEAN 1 = Power Cabinet 2 surveillance detected a fault 2 Power Cabinet 3 surveillance detected a fault BOOLEAN 1 = Power Cabinet 3 surveillance detected a fault 3 Power Cabinet 4 surveillance detected a fault BOOLEAN 1 = Power Cabinet 4 surveillance detected a fault 4 Power Cabinet 5 surveillance detected a fault BOOLEAN 1 = Power Cabinet 5 surveillance detected a fault 5 Power Cabinet 6 surveillance detected a fault BOOLEAN 1 = Power Cabinet 6 surveillance detected a fault 6 Power Cabinet 7 surveillance detected a fault BOOLEAN 1 = Power Cabinet 7 surveillance detected a fault 7 Reserved BOOLEAN 8 Power Cabinet 1 inoperable BOOLEAN 1 = Power cabinet inoperable 9 Power Cabinet 2 inoperable BOOLEAN 1 = Power cabinet inoperable 10 Power Cabinet 3 inoperable BOOLEAN 1 = Power cabinet inoperable 11 Power Cabinet 4 inoperable BOOLEAN 1 = Power cabinet inoperable 12 Power Cabinet 5 inoperable BOOLEAN 1 = Power cabinet inoperable 13 Power Cabinet 6 inoperable BOOLEAN 1 = Power cabinet inoperable 14 Power Cabinet 7 inoperable BOOLEAN 1 = Power cabinet inoperable 15 Reserved BOOLEAN 40028 0x0021 27 Alarm Register 1 0 Input dry contact: Genset supplying UPS BOOLEAN 1= a Genset supply the UPS 1 Input dry contact: Battery room ventilation inoperable BOOLEAN 1= Battery room ventilation inoperable 2 Input dry contact: External battery monitoring inoperable BOOLEAN 1= External battery monitoring inoperable Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 3 Input dry contact: Ground fault detected BOOLEAN 1= Ground fault detected 4 Input dry contact: UPS locked in static bypass mode is actived BOOLEAN 1= UPS locked in static bypass mode is actived 5 Input dry contact: User-defined input dry contacts 1 BOOLEAN 1= User-defined input dry contacts 1, in alarm position 6 Input dry contact: User-defined input dry contacts 2 BOOLEAN 1= User-defined input dry contacts 2, in alarm position 7 Input dry contact: Flywheel inoperable BOOLEAN 1= Flywheel inoperable 8 Input dry contact: External energy storage monitoring major alarm BOOLEAN 1= External energy storage monitoring major alarm 9 Input dry contact: External energy storage monitoring minor alarm BOOLEAN 1= External energy storage monitoring minor alarm 10 Input dry contact: Force Charger Off BOOLEAN 1= Force Charger Off 11 Input dry contact: Disable High Efficiency Mode BOOLEAN 1= Disable High Efficiency Mode 12 Input dry contact: Transfer from Battery to Normal Operation delay BOOLEAN 1=Transfer from Battery to Normal Operation delay 13 Input dry contact: Force Battery Operation BOOLEAN 1=Force Battery Operation 14 Input dry contact: Request Bypass operation BOOLEAN 1=Requested Bypass command from input relay activated 15 Reserved BOOLEAN 40029 0x0022 28 Alarm Register 1 0 Power Cabinet 1 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 1 Power Cabinet 1 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 2 Power Cabinet 1 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 3 Power Cabinet 1 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 4 Power Cabinet 1 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 5 Power Cabinet 1 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 6 Power Cabinet 1 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 7 Power Cabinet 1 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 8 Power Cabinet 2 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 9 Power Cabinet 2 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 10 Power Cabinet 2 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 11 Power Cabinet 2 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 12 Power Cabinet 2 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 13 Power Cabinet 2 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 14 Power Cabinet 2 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 15 Power Cabinet 2 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 40030 0x0023 29 Alarm Register 1 0 Power Cabinet 3 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 1 Power Cabinet 3 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 2 Power Cabinet 3 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 3 Power Cabinet 3 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 4 Power Cabinet 3 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 5 Power Cabinet 3 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 6 Power Cabinet 3 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 7 Power Cabinet 3 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 8 Power Cabinet 4 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 9 Power Cabinet 4 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 10 Power Cabinet 4 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 11 Power Cabinet 4 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 12 Power Cabinet 4 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 13 Power Cabinet 4 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 14 Power Cabinet 4 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 15 Power Cabinet 4 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 40031 0x0024 30 Alarm Register 1 0 Power Cabinet 5 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 1 Power Cabinet 5 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 2 Power Cabinet 5 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 3 Power Cabinet 5 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 4 Power Cabinet 5 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 5 Power Cabinet 5 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 6 Power Cabinet 5 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 7 Power Cabinet 5 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 8 Power Cabinet 6 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 9 Power Cabinet 6 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 10 Power Cabinet 6 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 11 Power Cabinet 6 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 12 Power Cabinet 6 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 13 Power Cabinet 6 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 14 Power Cabinet 6 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 15 Power Cabinet 6 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 40032 0x0025 31 Alarm Register 1 Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 0 Power Cabinet 7 surveillance fault BOOLEAN 1 = Temporized Power Cabinet surveillance fault 1 Power Cabinet 7 inoperable BOOLEAN 1 = Temporized Power Cabinet inoperable 2 Power Cabinet 7 - Power Bloc L1A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 3 Power Cabinet 7 - Power Bloc L2A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 4 Power Cabinet 7 - Power Bloc L3A - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 5 Power Cabinet 7 - Power Bloc L1B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 6 Power Cabinet 7 - Power Bloc L2B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 7 Power Cabinet 7 - Power Bloc L3B - Surveillance fault BOOLEAN 1 = Power Bloc from Power Cabinet Surveillance fault 8 Reserved BOOLEAN 9 Surveillance Limit Detected on Power Cabinet 1 BOOLEAN 1= SurvLimitDetected on Power Cabinet 1 10 Surveillance Limit Detected on Power Cabinet 2 BOOLEAN 1= SurvLimitDetected on Power Cabinet 2 11 Surveillance Limit Detected on Power Cabinet 3 BOOLEAN 1= SurvLimitDetected on Power Cabinet 3 12 Surveillance Limit Detected on Power Cabinet 4 BOOLEAN 1= SurvLimitDetected on Power Cabinet 4 13 Surveillance Limit Detected on Power Cabinet 5 BOOLEAN 1= SurvLimitDetected on Power Cabinet 5 14 Surveillance Limit Detected on Power Cabinet 6 BOOLEAN 1= SurvLimitDetected on Power Cabinet 6 15 Surveillance Limit Detected on Power Cabinet 7 BOOLEAN 1= SurvLimitDetected on Power Cabinet 7 Static Data 44097 0x1000 4096 Display/NMC Model Number 9 ASCII 44106 0x1009 4105 Display/NMC Serial Number 8 ASCII 44114 0x1011 4113 Display/NMC Firmware Revision APP 9 ASCII 44123 0x101A 4122 Display/NMC Hardware Revision 9 ASCII 44132 0x1023 4131 Display/NMC Date of Manufacture 6 ASCII 44138 0x1029 4137 RESERVED 8 44146 0x1031 4145 UPS Serial Number 6 ASCII 44152 0x1037 4151 UPS Firmware Version 12 ASCII 44164 0x1043 4163 Product Name 40 ASCII 44204 0x106B 4203 UPS Serial Number for 14 characters 8 ASCII for new 3-phases UPS, using 14 characters Dynamic Data 44353 0x1100 4352 RESERVED 2 44355 0x1102 4354 Runtime remaining 2 UINT32 1 1 Seconds 44357 0x1104 4356 Estimated charge time 2 UINT32 1 1 Seconds 44359 0x1106 4358 Estimated charge % 1 UINT16 1 1 % 44360 0x1107 4359 RESERVED 8 44368 0x110F 4367 Battery Temperature (for classic battery solution) 1 UINT16 1 1 °C or °F 44369 0x1110 4368 Charger Mode 1 0 Float Charging BOOLEAN 1=Charger mode is float charging 1 Boost Charging BOOLEAN 1=Charger mode is boost charging 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Equalization Charging BOOLEAN 1=Charger mode is eqalization charging 6 Not Charging BOOLEAN 1=Charger mode is Off 7 Test In Progress BOOLEAN 1=Test is in progress 8 Cyclic Charging BOOLEAN 1=Charge mode is cyclic charging 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 44370 0x1111 4369 Battery Power 1 UNIT16 0.1 10 kW 44371 0x1112 4370 RESERVED 1 44372 0x1113 4371 Battery Voltage 1 UINT16 0.1 10 Vdc 44373 0x1114 4372 Battery Current, for GVX up to 1000kVA 1 UNIT16 0.1 10 Amps - Caution overflow possible. There is a current limitation [– 3276A, 3276A]. That register can be use for GVX up to 1000KVA. When GVX power rating exceed 1000 kVA (1250KVA and 1500kVA) used register 0x111D 44374 0x1115 4373 RESERVED 1 UINT16 1 1 44375 0x1116 4374 RESERVED 1 UINT16 1 1 44376 0x1117 4375 RESERVED 1 UINT16 1 1 44377 0x1118 4376 RESERVED 1 UINT16 1 1 44378 0x1119 4377 RESERVED 1 UINT16 1 1 44379 0x111A 4378 RESERVED 1 UINT16 1 1 44380 0x111B 4379 RESERVED 1 UINT16 1 1 44381 0x111C 4380 RESERVED 1 UINT16 1 1 Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 44382 0x111D 4381 Battery Current, for all GVX power rating (from 250kVA up to 1500kVA) 1 UNT16 1 1 Amps - Recommended register for GVX. To be used when UPS power rating exceed 1000 kVA. This register supports all GVX power rating (from 250KVA up to 1500kVA). 44383 0x111E 4382 Battery Test Process Status ENUM 0= Inactive 1= Battery Calibration is In Progress 2= Battery Calibration is Passed 5= Battery Calibration is Aborted 44384 0x111F 4383 Battery Calibration Process Status ENUM 0= Inactive 1= Battery Calibration is In Progress 2= Battery Calibration is Passed 5= Battery Calibration is Aborted 44385 0x1120 4384 Battery Test Status ENUM 0= Unknown 1= Battery OK 2= Battery CapacityReduced 3= Battery Defect 44609 0x1200 4608 Frequency (input) 1 UINT16 0.1 10 Hz 44610 0x1201 4609 Voltage L1-2 (input) 1 UINT16 1 1 Volts 44611 0x1202 4610 Voltage L2-3 (input) 1 UINT16 1 1 Volts 44612 0x1203 4611 Voltage L3-1 (input) 1 UINT16 1 1 Volts 44613 0x1204 4612 Current L1 (input) 1 UINT16 1 1 amps 44614 0x1205 4613 Current L2 (input) 1 UINT16 1 1 amps 44615 0x1206 4614 Current L3 (input) 1 UINT16 1 1 amps 44616 0x1207 4615 Active power L1 (input) 1 UINT16 1 1 kW 44617 0x1208 4616 Active power L2 (input) 1 UINT16 1 1 kW 44618 0x1209 4617 Active power L3 (input) 1 UINT16 1 1 kW 44619 0x120A 4618 Apparent power L1 (input) 1 UINT16 1 1 kVA 44620 0x120B 4619 Apparent power L2 (input) 1 UINT16 1 1 kVA 44621 0x120C 4620 Apparent power L3 (input) 1 UINT16 1 1 kVA 44622 0x120D 4621 Total active power (input) 1 UINT16 1 1 kW 44623 0x120E 4622 Total apparent power (input) 1 UINT16 1 1 kVA 44624 0x120F 4623 Voltage L1-N (input) 1 UINT16 1 1 Volts 44625 0x1210 4624 Voltage L2-N (input) 1 UINT16 1 1 Volts 44626 0x1211 4625 Voltage L3-N (input) 1 UINT16 1 1 Volts 44627 0x1212 4626 Maximum RMS Current L1 (input) 2 UINT32 1 1 amps 44629 0x1214 4628 Maximum RMS Current L2 (input) 2 UINT32 1 1 amps 44631 0x1216 4630 Maximum RMS Current L3 (input) 2 UINT32 1 1 amps 44633 0x1218 4632 Power factor L1 (input) 1 UINT16 0.01 100 Unitless 44634 0x1219 4633 Power factor L2 (input) 1 UINT16 0.01 100 Unitless 44635 0x121A 4634 Power factor L3 (input) 1 UINT16 0.01 100 Unitless 44865 0x1300 4864 Frequency (bypass) 1 UINT16 0.1 10 Hz 44866 0x1301 4865 Voltage L1-2 (bypass) 1 UINT16 1 1 Volts 44867 0x1302 4866 Voltage L2-3 (bypass) 1 UINT16 1 1 Volts 44868 0x1303 4867 Voltage L3-1 (bypass) 1 UINT16 1 1 Volts 44869 0x1304 4868 Current L1 (bypass) 1 UINT16 1 1 amps 44870 0x1305 4869 Current L2 (bypass) 1 UINT16 1 1 amps 44871 0x1306 4870 Current L3 (bypass) 1 UINT16 1 1 amps 44872 0x1307 4871 Active power L1 (bypass) 1 UINT16 1 1 kW 44873 0x1308 4872 Active power L2 (bypass) 1 UINT16 1 1 kW 44874 0x1309 4873 Active power L3 (bypass) 1 UINT16 1 1 kW 44875 0x130A 4874 Apparent power L1 (bypass) 1 UINT16 1 1 kVA 44876 0x130B 4875 Apparent power L2 (bypass) 1 UINT16 1 1 kVA 44877 0x130C 4876 Apparent power L3 (bypass) 1 UINT16 1 1 kVA 44878 0x130D 4877 Total active power (bypass) 1 UINT16 1 1 kW 44879 0x130E 4878 Total apparent power (bypass) 1 UINT16 1 1 kVA 44880 0x130F 4879 Voltage L1-N (bypass) 1 UINT16 1 1 Volts 44881 0x1310 4880 Voltage L2-N (bypass) 1 UINT16 1 1 Volts 44882 0x1311 4881 Voltage L3-N (bypass) 1 UINT16 1 1 Volts 44883 0x1312 4882 Maximum RMS Current L1 (bypass) 2 UINT32 1 1 amps 44885 0x1314 4884 Maximum RMS Current L2 (bypass) 2 UINT32 1 1 amps 44887 0x1316 4886 Maximum RMS Current L3 (bypass) 2 UINT32 1 1 amps 44889 0x1318 4888 Power factor L1 (bypass) 1 UINT16 0.01 100 Unitless 44890 0x1319 4889 Power factor L2 (bypass) 1 UINT16 0.01 100 Unitless 44891 0x131A 4890 Power factor L3 (bypass) 1 UINT16 0.01 100 Unitless 44892 0x131B 4891 UTHD - Voltage THD L1 (bypass) 1 UINT16 0.1 10 % 44893 0x131C 4892 UTHD - Voltage THD L2 (bypass) 1 UINT16 0.1 10 % 44894 0x131D 4893 UTHD - Voltage THD L3 (bypass) 1 UINT16 0.1 10 % 45121 0x1400 5120 UPS Power Rating 1 UINT16 1 1 kVA 45122 0x1401 5121 Frequency (output) 1 UINT16 0.1 10 Hz 45123 0x1402 5122 Voltage L1-2 (output) 1 UINT16 1 1 Volts Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 45124 0x1403 5123 Voltage L2-3 (output) 1 UINT16 1 1 Volts 45125 0x1404 5124 Voltage L3-1 (output) 1 UINT16 1 1 Volts 45126 0x1405 5125 Current L1 (output) 1 UINT16 1 1 amps 45127 0x1406 5126 Current L2 (output) 1 UINT16 1 1 amps 45128 0x1407 5127 Current L3 (output) 1 UINT16 1 1 amps 45129 0x1408 5128 Maximum RMS current L1 (output) 2 UINT32 1 1 amps 45131 0x140A 5130 Maximum RMS current L2 (output) 2 UINT32 1 1 amps 45133 0x140C 5132 Maximum RMS current L3 (output) 2 UINT32 1 1 amps 45135 0x140E 5134 Active power L1 (output) 1 UINT16 1 1 kW 45136 0x140F 5135 Active power L2 (output) 1 UINT16 1 1 kW 45137 0x1410 5136 Active power L3 (output) 1 UINT16 1 1 kW 45138 0x1411 5137 Apparent power L1 (output) 1 UINT16 1 1 kVA 45139 0x1412 5138 Apparent power L2 (output) 1 UINT16 1 1 kVA 45140 0x1413 5139 Apparent power L3 (output) 1 UINT16 1 1 kVA 45141 0x1414 5140 Apparent power percent L1 (output) 1 UINT16 0.1 10 % 45142 0x1415 5141 Apparent power percent L2 (output) 1 UINT16 0.1 10 % 45143 0x1416 5142 Apparent power percent L3 (output) 1 UINT16 0.1 10 % 45144 0x1417 5143 Total active power (output) 1 UINT16 1 1 kW 45145 0x1418 5144 Total apparent power (output) 1 UINT16 1 1 kVA 45146 0x1419 5145 Total Output Percent load 1 UINT16 0.1 10 % 45147 0x141A 5146 Power factor L1 (output) 1 UINT16 0.01 100 power factor 45148 0x141B 5147 Power factor L2 (output) 1 UINT16 0.01 100 power factor 45149 0x141C 5148 Power factor L3 (output) 1 UINT16 0.01 100 power factor 45150 0x141D 5149 Current crest factor L1 (output) 1 UINT16 0.1 10 crest factor 45151 0x141E 5150 Current crest factor L2 (output) 1 UINT16 0.1 10 crest factor 45152 0x141F 5151 Current crest factor L3 (output) 1 UINT16 0.1 10 crest factor 45153 0x1420 5152 Voltage L1-N (output) 1 UINT16 1 1 Volts 45154 0x1421 5153 Voltage L2-N (output) 1 UINT16 1 1 Volts 45155 0x1422 5154 Voltage L3-N (output) 1 UINT16 1 1 Volts 45156 0x1423 5155 Neutral current (output) 1 UINT16 1 1 amps 45157 0x1424 5156 Current THD L1 (output) 1 UINT16 0.1 10 % 45158 0x1425 5157 Current THD L2 (output) 1 UINT16 0.1 10 % 45159 0x1426 5158 Current THD L3 (output) 1 UINT16 0.1 10 % 45160 0x1427 5159 IOC Power Rating 1 UINT16 1 1 kVA 45161 0x1428 5160 Available UPS Power Rating 1 UINT16 1 1 kVA 45376 0x14FF 5375 RESERVED 1 UINT16 1 1 45377 0x1500 5376 IOC Ambient temperature 1 UINT16 1 1 °C or °F 45378 0x1501 5377 Switch gear status 1 Bit mask For each bit, 0 = open, 1 =closed 0 Unit Input Breaker (UIB) BOOLEAN 1 Unit Output Breaker (UOB) BOOLEAN 2 Maintenance Bypass Breaker (MBB) BOOLEAN 3 System Isolation Breaker (SIB) BOOLEAN 4 Static Switch Input Breaker (SSIB) BOOLEAN 5 Battery Breaker 1 (for classic battery solution) BOOLEAN 6 Battery Breaker 2 (for classic battery solution) BOOLEAN 7 Battery Breaker 3 (for classic battery solution) BOOLEAN 8 Battery Breaker 4 (for classic battery solution) BOOLEAN 9 BF2 BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 45379 0x1502 5378 UPS Operation Mode 1 ENUM 1 = Normal operation 2 = Battery Operation 3 = Battery Test 4 = Requested Static Bypass 5 = Forced Static Bypass 6 = Maintenance Bypass 7 = Off 8 = Emergency Static Bypass 9 = Static Bypass Standby 10 = Inverter Standby 11 = Power Saving Mode 12 = Inverter SPoT Mode 13 = ECO Mode 14 = ECOnversion 45380 0x1503 5379 Number of Active Alarms 1 UINT16 1 1 Number of active alarms in the system 45381 0x1504 5380 Highest alarm severity 1 UINT16 1 1 0 = none 1 = informational 2 = warning 3 = critical 45382 0x1505 5381 System Mode 1 ENUM 1 = Inverter 2 = Requested Static Bypass 3 = Forced Static Bypass 4 = Off 5 = Reserved 6 = Maintenance Bypass 7 = ECO Mode 45383 0x1506 5382 RESERVED 3 45385 0x1508 5384 UPS Redundancy Status 1 UINT16 1 1 45386 0x1509 5385 NMC/UPS Time 4 ASCII hh:mm:ss format 45390 0x150D 5389 NMC/UPS Date 5 ASCII mm/dd/yyyy format 45395 0x1512 5394 Input kWh 2 UINT32 1 1 kWh 45397 0x1514 5396 Output kWh 2 UINT32 1 1 kWh 45399 0x1516 5398 IOC Exhaust Air Temperature 1 UINT16 1 1 °C or °F 45400 0x1517 5399 Ambient Temperature from Power Cabinet [1] 1 UINT16 1 1 °C or °F 45401 0x1518 5400 Exhaust Temperature from Power Cabinet [1] 1 UINT16 1 1 °C or °F 45402 0x1519 5401 Ambient Temperature from Power Cabinet [2] 1 UINT16 1 1 °C or °F 45403 0x151A 5402 Exhaust Temperature from Power Cabinet [2] 1 UINT16 1 1 °C or °F 45404 0x151B 5403 Ambient Temperature from Power Cabinet [3] 1 UINT16 1 1 °C or °F 45405 0x151C 5404 Exhaust Temperature from Power Cabinet [3] 1 UINT16 1 1 °C or °F 45406 0x151D 5405 Ambient Temperature from Power Cabinet [4] 1 UINT16 1 1 °C or °F 45407 0x151E 5406 Exhaust Temperature from Power Cabinet [4] 1 UINT16 1 1 °C or °F 45408 0x151F 5407 Ambient Temperature from Power Cabinet [5] 1 UINT16 1 1 °C or °F 45409 0x1520 5408 Exhaust Temperature from Power Cabinet [5] 1 UINT16 1 1 °C or °F 45410 0x1521 5409 Ambient Temperature from Power Cabinet [6] 1 UINT16 1 1 °C or °F 45411 0x1522 5410 Exhaust Temperature from Power Cabinet [6] 1 UINT16 1 1 °C or °F 45412 0x1523 5411 Ambient Temperature from Power Cabinet [7] 1 UINT16 1 1 °C or °F 45413 0x1524 5412 Exhaust Temperature from Power Cabinet [7] 1 UINT16 1 1 °C or °F 45414 0x1525 5413 Power Cabinet Redundancy Status 1 UINT16 1 1 0 - 7 46401 0x1900 6400 Current L1 (parallel system mains input) 1 UINT16 1 1 amps 46402 0x1901 6401 Current L2 (parallel system mains input) 1 UINT16 1 1 amps 46403 0x1902 6402 Current L3 (parallel system mains input) 1 UINT16 1 1 amps 46404 0x1903 6403 Current L1 (parallel system bypass input) 1 UINT16 1 1 amps 46405 0x1904 6404 Current L2 (parallel system bypass input) 1 UINT16 1 1 amps 46406 0x1905 6405 Current L3 (parallel system bypass input) 1 UINT16 1 1 amps 46407 0x1906 6406 Current L1 (parallel system output) 1 UINT16 1 1 amps 46408 0x1907 6407 Current L2 (parallel system output) 1 UINT16 1 1 amps 46409 0x1908 6408 Current L3 (parallel system output) 1 UINT16 1 1 amps 46410 0x1909 6409 Total apparent power (parallel system output) 1 UINT16 1 1 kVA 46411 0x190A 6410 Total Percent load (parallel system output) 1 UINT16 0.1 10 % 46412 0x190B 6411 Total active power (parallel system output) 1 UINT16 1 1 kW 46413 0x190C 6412 Apparent power percent L1 (parallel system output) 1 UINT16 0.1 10 % 46414 0x190D 6413 Apparent power percent L2 (parallel system output) 1 UINT16 0.1 10 % 46415 0x190E 6414 Apparent power percent L3 (parallel system output) 1 UINT16 0.1 10 % 46416 0x190F 6415 Reserved 46417 0x1910 6416 Reserved 46418 0x1911 6417 Reserved 46419 0x1912 6418 Reserved 46420 0x1913 6419 UPS Operation Modes 1 bit = 1, define current UPS operation mode Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 0 Initialize BOOLEAN 1 Normal Operation BOOLEAN 2 Battery Operation BOOLEAN 3 Battery test or Battery Discharge in Spot Mode BOOLEAN 4 Requested Static Bypass BOOLEAN 5 Forced Static Bypass BOOLEAN 6 Maintenance Bypass BOOLEAN 7 Off BOOLEAN 8 Emergency Static Bypass BOOLEAN 9 Static Bypass Standby BOOLEAN 10 Inverter standby BOOLEAN 11 Power Saving mode BOOLEAN 12 Inverter SPoT Mode BOOLEAN 13 ECO mode BOOLEAN 14 ECOnvertion Mode mode BOOLEAN 15 Charger SPoT Mode BOOLEAN 46421 0x1914 6420 System Mode 1 bit = 1, define current System mode 0 Inverter BOOLEAN 1 Requested Static Bypass BOOLEAN 2 Forced Static Bypass BOOLEAN 3 Off BOOLEAN 4 Maintenance Bypass BOOLEAN 5 ECO mode BOOLEAN 6 ECOnversion mode BOOLEAN 7 Static Bypass Standby Operation BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 46422 0x1915 6421 Reserved 1 UINT16 1 1 46423 0x1916 6422 Reserved 1 UINT16 1 1 46424 0x1917 6423 Reserved 1 UINT16 1 1 46425 0x1918 6424 Reserved 1 UINT16 1 1 46426 0x1919 6425 Reserved 1 UINT16 1 1 46427 0x191A 6426 Reserved 1 UINT16 1 1 46428 0x191B 6427 Reserved 1 UINT16 1 1 46429 0x191C 6428 Reserved 1 UINT16 1 1 46430 0x191D 6429 Reserved 1 UINT16 1 1 46431 0x191E 6430 Sensor temperature in sensor 1 1 UINT16 0.1 10 °C or °F 46432 0x191F 6431 Sensor temperature in sensor 2 1 UINT16 0.1 10 °C or °F 46433 0x1920 6432 Sensor humidity in sensor 1 1 UINT16 0.1 10 % 46434 0x1921 6433 Sensor humidity in sensor 2 1 UINT16 0.1 10 % 46435 0x1922 6434 Sensor (AP9810) input contact status 1 Bit mask For each bit, 0 = open, 1 =closed 0 Sensor dry contact A in sensor 1 BOOLEAN 1 Sensor dry contact B in sensor 1 BOOLEAN 2 Sensor dry contact A in sensor 2 BOOLEAN 3 Sensor dry contact B in sensor 2 BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 46449 0x1930 6448 User interface - Input Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 46450 0x1931 6449 User interface - PFC Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46451 0x1932 6450 User interface - Battery Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46452 0x1933 6451 User interface - Inverter Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46453 0x1934 6452 User interface - Output Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46454 0x1935 6453 User interface - Bypass Input Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46455 0x1936 6454 User interface - Static Bypass Pictogram 1 UINT16 1 1 Inoperable (Red) = 4 Ok and operating (Green) = 2 None of the above (Black) = 0 46456 0x1937 6455 Status for mimic animation 1 UINT16 1 1 0 Aggregated Battery circuit breaker status BOOLEAN 0 = open, 1 =closed 1 Reserved BOOLEAN 2 Reserved BOOLEAN 3 Reserved BOOLEAN 4 Reserved BOOLEAN 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 46457 0x1938 6456 Power Cabinet status for UPS detailled view animation 1 UINT16 1 1 0 Warning alarm present in Power Cabinet 1 BOOLEAN 1 = warning alarm present in Power Cabinet 1 (Orange) 1 Critical alarm present in Power Cabinet 1 BOOLEAN 1 = critical alarm present Power Cabinet 1 (Red) 2 Warning alarm present in Power Cabinet 2 BOOLEAN 1 = warning alarm present in Power Cabinet 2 (Orange) 3 Critical alarm present in Power Cabinet 2 BOOLEAN 1 = critical alarm present Power Cabinet 2 (Red) 4 Warning alarm present in Power Cabinet 3 BOOLEAN 1 = warning alarm present in Power Cabinet 3 (Orange) 5 Critical alarm present in Power Cabinet 3 BOOLEAN 1 = critical alarm present Power Cabinet 3 (Red) 6 Warning alarm present in Power Cabinet 4 BOOLEAN 1 = warning alarm present in Power Cabinet 4 (Orange) 7 Critical alarm present in Power Cabinet 4 BOOLEAN 1 = critical alarm present Power Cabinet 4 (Red) 8 Warning alarm present in Power Cabinet 5 BOOLEAN 1 = warning alarm present in Power Cabinet 5 (Orange) 9 Critical alarm present in Power Cabinet 5 BOOLEAN 1 = critical alarm present Power Cabinet 5 (Red) 10 Warning alarm present in Power Cabinet 6 BOOLEAN 1 = warning alarm present in Power Cabinet 6 (Orange) 11 Critical alarm present in Power Cabinet 6 BOOLEAN 1 = critical alarm present Power Cabinet 6 (Red) 12 Warning alarm present in Power Cabinet 7 BOOLEAN 1 = warning alarm present in Power Cabinet 7 (Orange) 13 Critical alarm present in Power Cabinet 7 BOOLEAN 1 = critical alarm present Power Cabinet 7 (Red) 14 Reserved BOOLEAN 15 Reserved BOOLEAN 46458 0x1939 6457 Power Cabinet status for UPS detailled view animation 1 UINT16 1 1 0 informational alarm present in Power Cabinet 1 BOOLEAN 1 = informational alarm present in Power Cabinet 1 1 informational alarm present in Power Cabinet 2 BOOLEAN 2 = informational alarm present in Power Cabinet 2 2 informational alarm present in Power Cabinet 3 BOOLEAN 3 = informational alarm present in Power Cabinet 3 3 informational alarm present in Power Cabinet 4 BOOLEAN 4 = informational alarm present in Power Cabinet 4 4 informational alarm present in Power Cabinet 5 BOOLEAN 5 = informational alarm present in Power Cabinet 5 5 informational alarm present in Power Cabinet 6 BOOLEAN 6 = informational alarm present in Power Cabinet 6 6 informational alarm present in Power Cabinet 7 BOOLEAN 7 = informational alarm present in Power Cabinet 7 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 14 Reserved BOOLEAN 15 Reserved BOOLEAN Configuratio n Data 48193 0x2000 8192 RESERVED 3 48196 0x2003 8195 RESERVED 1 48198 0x2005 8197 RESERVED 48199 0x2006 8198 RESERVED 48200 0x2007 8199 Breaker settings 1 bit = 1, breaker is present 0 breaker Q1 (UIB) BOOLEAN 1 breaker Q2 (UOB) BOOLEAN 2 Q3 (MBB) BOOLEAN 3 Q4 (SIB) BOOLEAN 4 Q5 (SSIB) BOOLEAN 5 BB1 BOOLEAN 6 BB2 BOOLEAN 7 BB3 BOOLEAN 8 BB4 BOOLEAN 9 BF2 BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 48201 0x2008 8200 Temperature unity 1 ENUM 0 = Celcius 1 = Fahrenheit 48202 0x2009 8201 UPS environment settings 1 0 Input transformer presence BOOLEAN bit = 1, transformer is present 1 Output transformer presence BOOLEAN bit = 1, transformer is present 2 AC wiring configuration BOOLEAN bit = 0, input cabling 3 wires bit = 1, input cabling 4 wires 3 UPS mains supply by single input BOOLEAN bit = 1, mains supply input is single 4 UPS mains supply by dual input BOOLEAN bit = 1, mains supply input is dual 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 48203 0x200A 8202 SIB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "SIB " 48205 0x200C 8204 UIB breaker label 2 ASCII 4 bytes string = 2 registers, Default value UIB " 48207 0x200E 8206 SSIB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "SSIB" 48209 0x2010 8208 MBB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "MBB " 48211 0x2012 8210 UOB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "UOB " 48213 0x2014 8212 BF2 breaker label 2 ASCII 4 bytes string = 2 registers, Default value "BF2 " 48215 0x2016 8214 BB breaker label 2 ASCII 4 bytes string = 2 registers, Default value "BB " 48217 0x2018 8216 UPS Name 9 ASCII 18 bytes string = 8 registers 48449 0x2100 8448 Low Battery Alarm Threshold 1 UINT16 1 1 Seconds 48450 0x2101 8449 Battery Type 1 ENUM 1 1 0=VRLA 1=Open Cell 2=Lithium-Ion 3=NiCd 6=NiZn 48451 0x2102 8450 Battery Solution 1 ENUM 1 1 0=None 1=Classic 2=NA 3=Unknown 48452 0x2103 8451 Deep Discharge Allowed 1 ENUM 1 1 0=No 1=Yes 48453 0x2104 8452 Total Battery Capacity 1 UINT16 1 1 Ah 48454 0x2105 8453 Reserved 1 UINT16 1 1 48455 0x2106 8454 Number of battery bank for Classical battery 1 UINT16 1 1 Unitless Modicon Standard Register Number Absolute Starting Register Address, (Hexa-decimal) Absolute Starting Register Address, (Decimal) Bit Data Point Length # register s Data Type Multiply Reading By: Divide Reading By: Valid Response Scale 48705 0x2200 8704 Nominal Output Voltage 1 ENUM 1 1 0=380V 1=400V 2=415V 3=480V 4=440V 48706 0x2201 8705 Transfer to Static Bypass Disable 1 ENUM 1 1 0=Disable 1=Enable 48707 0x2202 8706 Reserved 1 UINT16 1 1 48708 0x2203 8707 Automatic Battery Disconnect 1 ENUM 1 1 0=No 1=Yes 48709 0x2204 8708 High Efficiency Mode 1 ENUM 1 1 0=Disable 1=ECO mode 2=ECOnversion 3=ECOnversion Harmonics Compensator 48710 0x2205 8709 Reserved 1 1 1 48711 0x2206 8710 Number of UPS installed in a parallel installation 1 UINT16 1 1 48712 0x2207 8711 Number of redundant UPS installed in a parallel installatio 1 UINT16 1 1 48713 0x2208 8712 Number of redundant Power Cabinet installed in a UPS 1 UINT16 1 1 48714 0x2209 8713 UPSs presence in parallel installation 1 0 UPS 1 presence BOOLEAN bit = 0, UPS 1 not present bit = 1, UPS 1 is present 1 UPS 2 presence BOOLEAN bit = 0, UPS 2 not present bit = 1, UPS 2 is present 2 UPS 3 presence BOOLEAN bit = 0, UPS 3 not present bit = 1, UPS 3 is present 3 UPS 4 presence BOOLEAN bit = 0, UPS 4 not present bit = 1, UPS 4 is present 4 UPS 5 presence BOOLEAN bit = 0, UPS 5 not present bit = 1, UPS 5 is present 5 Reserved BOOLEAN 6 Reserved BOOLEAN 7 Reserved BOOLEAN 8 Reserved BOOLEAN 9 Reserved BOOLEAN 10 Reserved BOOLEAN 11 Reserved BOOLEAN 12 Reserved BOOLEAN 13 Reserved BOOLEAN 14 Reserved BOOLEAN 15 Reserved BOOLEAN 48715 0x220A 8714 Frequency Converter Mode 1 ENUM 1 1 0=Disable 1=Enable 48716 0x220B 8715 Energy Storage Type 1 ENUM 1 1 0=None 1=Battery 2=Flywheel48717 0x220C 8716 Number Power Cabinet on the left of IO Cabinet 1 UINT16 1 1 48718 0x220D 8717 Continuous Overload Mode Setting 1 UINT16 1 1 % Worldwide Customer Support Customer support for this or any other product is available at no charge in any of the following ways: * Visit the Schneider Electric Web site to access documents in the Schneider Electric Knowledge Base and to submit customer support requests. – www.schneider-electric.com (Corporate Headquarters) Connect to localized Schneider Electric Web sites for specific countries, each of which provides customer support information. – www.schneider-electric.com/support/ Global support searching Schneider Electric Knowledge Base and using e-support. * Contact the Schneider Electric Customer Support Center by telephone or e-mail. – Local, country-specific centers: go to www.schneider-electric.com > Support > Operations around the world for contact information. SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System Product Environmental Profile Galaxy VX UPS System #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System 3600 kg Plastics Metals Others 22.70% General information Reference product Galaxy VX 1250kVA, 400V, Start up 5x8 - GVX1250K1250NHS Constituent materials This document provides environmental impact and performance of the product based on Life Cycle Assessment (LCA), from cradle to grave (materials, manufacturing, distribution, installation, use and end of life). Reference product mass including the product, its packaging and additional elements and accessories 4.80% 72.50% Description of the product The Galaxy VX is a scalable, highly efficient 500 - 1500KVA 3 phase Uninterruptible Power Supply (UPS) system that provides seamless power protection for large sized data centers, industrial and facilities applications. Description of the range Galaxy VX UPS System The representative product is 1250 kW rating (5 Power Cabinets) with 1250 kW I/O Cabinet (GVX1250K1250NHS). The environmental impacts of this referenced product are representative of the impacts of the other products of the range which are developed with a similar technology. Meanwhile, environmental details of other kVA ratings are available in supplementary information at the end of this document. Functional unit To protect the load of 1250 kW against input power failure during 15 years and switch to the energy storage system to avoid power outage. Steel - 42% Copper - 16.6% Aluminium - 12.8% Tin - 0.5% Ferrous alloys - 0.3% Brass - 0.3% Electronic components - 16.6% Wood - 3.6% Cardboard - 1.3% Miscellaneous - 0.4% Various - 0.8% PC Polycarbonate - 2.6% UP Polyester - 0.5% PE Polyethylene - 0.5% PA Polyamide - 0.4% Diverse Thermosetting Plastics - 0.4% ABS Acrylonitrile Butadiene Styrene - 0.4% #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System RoHS compliance REACH compliance Battery Directive compliance End Of Life 76% Use scenario Power consumption conforms to the requirements in PSR0010-ed1.1-EN-2015_10_16_UPS: The referent UPS can operate in 2 modes. It has an average energy efficiency of 95.8% in Double Conversion mode and 98.6% in eConversion mode. Total energy losses are calculated to be 3418454 kWh in Double Conversion and 1047094 kWh in eConversion after 15 years. Geographical representativeness Europe Energy model used [A1 - A3] [A5] [B6] [C1 - C4] Electricity Mix; Production mix; Low voltage; IN Electricity Mix; Production mix; Low voltage; UE-27 Electricity Mix; Production mix; Low voltage; UE-27 Electricity Mix; Production mix; Low voltage; UE-27 Technological representativeness The Modules of Technologies such as material production, manufacturing process and transport technology used in this PEP analysis (LCA- EIME in this case) are Similar and representative of the actual type of technologies used to make the product in production. Environmental impacts Reference service life time 15 years Installation elements The disposal of the packaging materials is accounted for 6% during the installation phase (including transport to disposal). Substance assessment Details of ROHS and REACH substances information are available on the Schneider-Electric Green Premium website https://www.se.com/ww/en/work/support/green-premium/ Additional environmental information Recyclability potential: Recyclability rate has been calculated based on REEECY'LAB tool developed by Ecosystem, for components/materials not covered by the tool, data from the "ECO'DEEE recyclability and recoverability calculation method" was taken. If no data was found a conservative assumption was used (0% recyclability). Products of this range are designed in conformity with the requirements of the RoHS directive (European Directive 2011/65/EU of 8 June 2011) on restriction of lead, mercury, cadmium, hexavalent chromium or flame retardants -PBB&PBDE or phthalates-DEHP, BBP, DBP, DIBP. Products of this range are designed in conformity with the requirements of the REACH 1907/2006 regulation and its latest updates. The battery within this product range are designed in conformity with the requirements of the Battery and Accumulator Directive (European Directive 2006/66/EC of 26 September 2006).Average energy efficiency Electricity consumption (kWh over 15 years) Average energy efficiency Electricity consumption (kWh over 15 years) 500 kW with 1250 kW I/O Cabinet 95.6% 1.45E+06 98.6% 4.52E+05 625 kW with 1250 kW I/O Cabinet 95.6% 1.81E+06 98.2% 6.78E+05 750 kW with 1250 kW I/O Cabinet 95.6% 2.17E+06 98.4% 7.51E+05 800 kW with 1250 kW I/O Cabinet 95.7% 2.23E+06 98.3% 8.02E+05 1000 kW with 1250 kW I/O Cabinet 95.8% 2.76E+06 98.6% 8.71E+05 1100 kW with 1250 kW I/O Cabinet 95.9% 2.98E+06 98.6% 9.58E+05 1250 kW with 1250 kW I/O Cabinet 95.8% 3.42E+06 98.6% 1.05E+06 500 kW with 1500 kW I/O Cabinet 96.4% 1.19E+06 99.0% 3.20E+05 750 kW with 1500 kW I/O Cabinet 96.2% 1.90E+06 98.9% 5.05E+05 1000 kW with 1500 kW I/O Cabinet 96.0% 2.65E+06 98.9% 6.73E+05 1250 kW with 1500 kW I/O Cabinet 96.2% 3.20E+06 99.0% 7.60E+05 1500 kW with 1500 kW I/O Cabinet 96.2% 3.84E+06 99.0% 9.12E+05 Type (400V UPS system) Double conversion eConversionAverage energy efficiency Electricity consumption (kWh over 15 years) Average energy efficiency Electricity consumption (kWh over 15 years) 500 kW with 1250 kW I/O Cabinet 95.7% 1.38E+06 98.0% 5.83E+05 625 kW with 1250 kW I/O Cabinet 95.9% 1.61E+06 98.2% 6.78E+05 750 kW with 1250 kW I/O Cabinet 95.9% 1.98E+06 98.4% 7.51E+05 800 kW with 1250 kW I/O Cabinet 95.9% 2.08E+06 98.3% 8.02E+05 1000 kW with 1250 kW I/O Cabinet 96.1% 2.51E+06 98.6% 8.46E+05 1100 kW with 1250 kW I/O Cabinet 96.2% 2.68E+06 98.5% 9.67E+05 1250 kW with 1250 kW I/O Cabinet 96.2% 3.08E+06 98.6% 1.06E+06 500 kW with 1500 kW I/O Cabinet 96.2% 1.23E+06 98.9% 3.20E+05 750 kW with 1500 kW I/O Cabinet 96.3% 1.80E+06 98.9% 5.05E+05 1000 kW with 1500 kW I/O Cabinet 96.3% 2.37E+06 98.9% 6.73E+05 1250 kW with 1500 kW I/O Cabinet 96.4% 2.92E+06 99.0% 7.60E+05 1500 kW with 1500 kW I/O Cabinet 96.3% 3.58E+06 99.0% 9.12E+05 Type (480V UPS system) Double conversion eConversionLoad rate 25% 50% 75% 100% Proportion of time at specified load 0.25 0.5 0.25 0 #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System Detailed results, including all the optional indicators mentioned in PCRed4, and the split of the Use Phase (B1 to B7), are available in the LCA report and on demand in a digital format - Country Customer Care Center - http://www.schneider-electric.com/contact kg CO2 eq kg CO2 eq kg CO2 eq kg CO2 eq kg CFC-11 eq mol H+ eq kg (PO4)³⁻eq kg N eq mol N eq kg COVNM eq kg Sb eq MJ m3 eq Additional indicators for the French regulation are available as well MJ MJ MJ MJ MJ kg MJ MJ m³ Contribution to use of non renewable secondary fuels Contribution to net use of freshwater 0.00E+00 2.56E+03 3.77E+02 1.22E+00 1.76E+00 1.15E+03 1.03E+03 -6.12E+03 0.00E+00 0* 0* 0* 0* 0* Contribution to total use of renewable primary energy resources 6.88E+06 2.29E+04 0* 0* 6.85E+06 0* -9.45E+03 3.68E+07 7.30E+05 1.26E+04 0* 3.57E+07 3.52E+05 -8.62E+06 0.00E+00 0.00E+00 0* 0* 0* 0* 0.00E+00 1.27E+00 1.27E+00 0* 0* 0* 0*Contribution to use of secondary material Contribution to total use of non-renewable primary energy resources Contribution to use of renewable secondary fuels 3.17E+03 -1.91E+05 Contribution to use of renewable primary energy resources used as raw material 3.89E+03 3.89E+03 0* 0* 0* 0* -7.67E+03 Contribution to use of renewable primary energy excluding renewable primary energy used as raw material 6.88E+06 1.90E+04 0* 0* 6.85E+06 Contribution to use of non renewable primary energy resources used as raw material 1.19E+04 1.19E+04 0* 0* 0* 3.17E+03 -1.99E+05 Contribution to use of non renewable primary energy excluding non renewable primary energy used as raw material 3.68E+07 7.18E+05 1.26E+04 0* 3.57E+07 3.52E+05 -8.61E+06 Inventory flows Indicators Galaxy VX UPS System - GVX1250K1250NHS Inventory flows Unit Total Manufact. Distribution Installation Contribution to water use 1.06E+05 1.62E+04 5.26E+01 7.58E+01 4.96E+04 Use End of Life Benefits [A1 - A3] [A4] [A5] [B1 - B7] [C1 - C4] [D] 1.26E-01 -1.07E+02 Contribution to resource use, fossils 3.68E+07 7.30E+05 1.26E+04 0* 3.57E+07 3.52E+05 -8.62E+06 Contribution to resource use, minerals and metals 7.93E+00 7.70E+00 0* 0* 1.02E-01 3.99E+04 -2.63E+05 Contribution to eutrophication marine 1.01E+03 9.22E+01 2.07E+00 1.66E-01 9.08E+02 7.38E+00 -2.70E+02 Contribution to eutrophication, freshwater 8.49E+00 1.77E-01 0* 2.19E-03 3.84E+00 6.43E+01 -3.10E+03 Contribution to photochemical ozone formation - human health 3.26E+03 3.15E+02 7.36E+00 4.29E-01 2.92E+03 1.94E+01 -1.20E+03 Contribution to eutrophication, terrestrial 1.49E+04 1.18E+03 2.25E+01 0* 1.36E+04 1.08E-04 -7.02E-02 Contribution to acidification 8.89E+03 8.50E+02 4.51E+00 0* 8.00E+03 3.55E+01 -5.07E+03 Contribution to ozone depletion 1.99E-02 1.29E-02 9.16E-04 8.90E-06 5.99E-03 4.48E+00 -9.84E-01 Contribution to climate change-fossil 1.50E+06 9.24E+04 1.04E+03 2.89E+02 1.40E+06 6.12E+03 -4.38E+05 Contribution to climate change 1.50E+06 9.31E+04 1.04E+03 2.18E+02 1.40E+06 1.31E+02 -7.38E+03 Contribution to climate change-land use and land use change 2.27E-03 5.00E-05 0* 1.20E-04 0* 2.10E-03 0.00E+00 Contribution to climate change-biogenic 2.60E+03 6.69E+02 0* 0* 1.87E+03 Impact indicators Unit Total Manufacturing Distribution Installation Use End of Life Benefits [A1 - A3] [A4] [A5] [B1 - B7] [C1 - C4] [D] 6.25E+03 -4.46E+05 Mandatory Indicators Galaxy VX UPS System - GVX1250K1250NHS *Net benefits and loads beyond the system boundaries stage (module D): potential for reuse, recovery and/or recycling, expressed as net benefits and impacts. #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System kg kg kg kg kg kg MJ kg de C kg de C Referent product 500 625 750 800 1000 1100 1250 500 750 1000 1250 1500 1 1 1 1 1 1 1 1 1 1 1 1 2 3 3 4 4 5 5 2 3 4 5 6 1920 2480 2480 3040 3040 3600 3600 2180 2740 3300 3860 4420 6.37E+05 8.00E+05 9.48E+05 9.86E+05 1.20E+06 1.31E+06 1.50E+06 5.42E+05 8.46E+05 1.17E+06 1.41E+06 1.68E+06 8.86E-03 1.15E-02 1.21E-02 1.42E-02 1.52E-02 1.76E-02 1.99E-02 9.37E-03 1.26E-02 1.59E-02 1.89E-02 2.21E-02 3.79E+03 4.76E+03 5.61E+03 5.87E+03 7.12E+03 7.76E+03 8.89E+03 3.26E+03 5.05E+03 6.93E+03 8.34E+03 9.97E+03 3.74E+00 4.82E+00 5.23E+00 5.96E+00 6.56E+00 7.48E+00 8.49E+00 3.78E+00 5.25E+00 6.76E+00 8.05E+00 9.44E+00 4.30E+02 5.41E+02 6.37E+02 6.68E+02 8.09E+02 8.83E+02 1.01E+03 3.71E+02 5.74E+02 7.88E+02 9.49E+02 1.13E+03 6.35E+03 7.98E+03 9.42E+03 9.84E+03 1.20E+04 1.30E+04 1.49E+04 5.44E+03 8.45E+03 1.16E+04 1.40E+04 1.67E+04 1.39E+03 1.75E+03 2.05E+03 2.15E+03 2.61E+03 2.85E+03 3.26E+03 1.20E+03 1.85E+03 2.54E+03 3.06E+03 3.66E+03 3.61E+00 4.75E+00 4.76E+00 5.90E+00 5.91E+00 7.05E+00 7.93E+00 4.14E+00 5.29E+00 6.44E+00 7.59E+00 8.74E+00 1.85E+07 2.32E+07 2.77E+07 2.86E+07 3.52E+07 3.81E+07 3.68E+07 1.55E+07 2.44E+07 3.39E+07 4.09E+07 4.91E+07 4.66E+04 6.00E+04 6.52E+04 7.42E+04 8.19E+04 9.33E+04 1.06E+05 4.68E+04 6.52E+04 8.42E+04 1.00E+05 1.18E+05 2.29E+05 3.36E+05 3.66E+05 4.01E+05 4.29E+05 4.79E+05 5.26E+05 1.83E+05 2.72E+05 3.55E+05 4.04E+05 4.80E+05 500 625 750 800 1000 1100 1250 500 750 1000 1250 1500 1 1 1 1 1 1 1 1 1 1 1 1 2 3 3 4 4 5 5 2 3 4 5 6 1920 2480 2480 3040 3040 3600 3600 2180 2740 3300 3860 4420 6.09E+05 7.18E+05 8.72E+05 9.27E+05 1.10E+06 1.19E+06 1.35E+06 5.57E+05 8.03E+05 1.05E+06 1.29E+06 1.58E+06 8.74E-03 1.12E-02 1.18E-02 1.40E-02 1.47E-02 1.71E-02 1.78E-02 9.44E-03 1.24E-02 1.55E-02 1.84E-02 2.16E-02 3.62E+03 4.29E+03 5.17E+03 5.53E+03 6.54E+03 7.07E+03 7.99E+03 3.35E+03 4.80E+03 6.28E+03 7.67E+03 9.37E+03 3.66E+00 4.60E+00 5.02E+00 5.80E+00 6.29E+00 7.15E+00 7.59E+00 3.82E+00 5.13E+00 6.45E+00 7.73E+00 9.15E+00 4.12E+02 4.88E+02 5.88E+02 6.29E+02 7.44E+02 8.03E+02 9.09E+02 3.81E+02 5.46E+02 7.13E+02 8.72E+02 1.06E+03 6.07E+03 7.18E+03 8.68E+03 9.26E+03 1.10E+04 1.18E+04 1.34E+04 5.58E+03 8.03E+03 1.05E+04 1.29E+04 1.57E+04 1.33E+03 1.58E+03 1.90E+03 2.03E+03 2.40E+03 2.59E+03 2.93E+03 1.23E+03 1.76E+03 2.30E+03 2.81E+03 3.43E+03 Contribution to hazardous waste disposed Contribution to radioactive waste disposed Contribution to non hazardous waste disposed 0* 0.00E+00 * represents less than 0.01% of the total life cycle of the reference flow Life cycle assessment performed with EIME version v5.9.4, database version 2022-01 in compliance with ISO14044. Detailed results, including all the optional indicators mentioned in PCRed4, and the split of the Use Phase (B1 to B7), are available in the LCA report and on demand in a digital format - Country Customer Care Center - http://www.schneider-electric.com/contact ** Net benefits and loads beyond the system boundaries stage (module D): potential for reuse, recovery and/or recycling, expressed as net benefits and impacts. Not accounted in the Total. Environmental indicators- 'Total' of Life Cycle Phases (UPS in eConversion mode) Contribution to climate change (kg CO2 eq) 480V UPS system Galaxy VX UPS (kVA) with 1250 kW I/O Cabinet Galaxy VX UPS (kVA) with 1500 kW I/O Cabinet Product type Product information I/O Cabinet Power Cabinets (250 kW/3U) Weight with Packaging (kg) Compulsory environmental indicators - 'Total' of Life Cycle Phases (UPS in Double conversion mode) Contribution to materials for energy recovery 4.30E-07 4.30E-07 0* 0* 0* 0* 0.00E+00 Please note that the values given above are only valid within the context specified and cannot be used directly to draw up the environmental assessment of an installation. Extrapolated data 400V UPS system Galaxy VX UPS (kVA) with 1250 kW I/O Cabinet Galaxy VX UPS (kVA) with 1500 kW I/O Cabinet Product type Product information I/O Cabinet Power Cabinets (250 kW/3U) Weight with Packaging (kg) 0* 0.00E+00 Contribution to biogenic carbon content of the product 0.00E+00 0* 0* 0* 0* 0.00E+00 Contribution to exported energy 9.26E+01 8.71E+00 0* 8.39E+01 0* Contribution to biogenic carbon content of the associated packaging 0.00E+00 0* 0* 0* -2.72E+02 Contribution to components for reuse 0.00E+00 0* 0* 0* 0* 0.00E+00 8.72E+01 4.47E+01 2.06E-01 4.74E-02 4.22E+01 3.11E-02 2.66E+03 0.00E+00Contribution to materials for recycling 2.78E+03 2.87E+00 0* 1.18E+02 0* -8.73E+06 2.33E+05 3.07E+04 0* 4.30E+02 2.02E+05 1.86E+02 -4.45E+05 3.04E+05 2.75E+05 0* 0* 2.62E+04 3.11E+03 Contribution to climate change (kg CO2 eq) Contribution to Ozone depletion (kg CFC11 eq) Contribution to Acidification (mol H+ eq) Contribution to eutrophication, freshwater (kg PO43- eq) Contribution to eutrophication marine (kg N eq) Contribution to eutrophication, terrestrial (mol N eq) Contribution to photochemical ozone formation - human health (kg COVNM eq) Contribution to resource use, minerals and metals (kgSbeq) Total use of primary energy (MJ) Contribution to water use (m3 eq) Compulsory environmental indicators - 'Total' of Life Cycle Phases (UPS in Double conversion mode) Contribution to climate change (kg CO2 eq) Contribution to Ozone depletion (kg CFC11 eq) Contribution to Acidification (mol H+ eq) Contribution to eutrophication, freshwater (kg PO43- eq) Contribution to eutrophication marine (kg N eq) Contribution to eutrophication, terrestrial (mol N eq) Contribution to photochemical ozone formation - human health (kg COVNM eq) #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 SCHN-01185-V01.01-EN - PEP ECOPASSPORT®- Galaxy VX UPS System 3.61E+00 4.74E+00 4.76E+00 5.89E+00 5.90E+00 7.04E+00 7.05E+00 4.14E+00 5.29E+00 6.44E+00 7.58E+00 8.74E+00 1.76E+07 2.07E+07 2.54E+07 2.68E+07 3.21E+07 3.44E+07 3.93E+07 1.59E+07 2.31E+07 3.05E+07 3.74E+07 4.59E+07 4.56E+04 5.71E+04 6.25E+04 7.21E+04 7.83E+04 8.90E+04 9.47E+04 4.73E+04 6.37E+04 8.02E+04 9.62E+04 1.14E+05 2.83E+05 3.36E+05 3.66E+05 4.01E+05 4.19E+05 4.83E+05 5.20E+05 1.83E+05 2.72E+05 3.55E+05 4.05E+05 4.81E+05 Internal External 5 years 2024/4/23 CS 30323 F- 92500 Rueil Malmaison Cedex RCS Nanterre 954 503 439 Capital social 896 313 776 € www.se.com Published by Schneider Electric Schneider Electric Industries SAS Country Customer Care Center http://www.schneider-electric.com/contact 35, rue Joseph Monier ©2023 - Schneider Electric – All rights reserved Independent verification of the declaration and data, in compliance with ISO 14025 : 2010 X The PCR review was conducted by a panel of experts chaired by Julie ORGELET (DDemain) PEP are compliant with XP C08-100-1 :2016 or EN 50693:2019 The elements of the present PEP cannot be compared with elements from another program. Document in compliance with ISO 14025 : 2010 « Environmental labels and declarations. Type III environmental declarations » Date of issue 2024/4/23 Information and reference documents Registration number : SCHN-01185-V01.01-EN Drafting rules PEP-PCR-ed4-2021 09 06 Verifier accreditation N° VH08 Supplemented by www.pep-ecopassport.org Validity period PSR-0010-ed1.1-2015 10 16 Environmental indicators- 'Total' of Life Cycle Phases (UPS in eConversion mode) Contribution to climate change (kg CO2 eq) Other Additional information Operating the Galaxy VX in eConversion mode results in significantly reduced environmental impact, in particular Carbon emissions (up to 65% reduction) compared to operation in Double Conversion mode. This is mainly due to an improved energy efficiency in eConversion of 98.6% (average) compared to an efficiency of 95.8% (average) in Double Conversion mode. For details about eConversion, consult the Schneider-Electric eConversion page: https://www.se.com/ww/en/work/products/product-launch/econversion-high-efficiency-ups- mode/ Compulsory environmental indicators - 'Total' of Life Cycle Phases (UPS in Double conversion mode) Contribution to resource use, minerals and metals (kgSbeq) Total use of primary energy (MJ) Contribution to water use (m3 eq) #Internal ENVPEP2311001_V2 - SCHN-01185-V01.01-EN 2024/4/23 No reply 12:32 PM (7 minutes ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: 08b93f14-4d65-41cf-9f4a-a8d9670e17e7 Bill of Material Build No Reference Description Quantity 1 EALBTP23 licence, Ecostruxure Automation Expert, standard engineering buildtime, v23 1 2 EALBFP23 license, EcoStruxure Automation Expert, professional engineering, buildtime, v23 1 Run No Reference Description Quantity 3 EALDSP license, EcoStruxure Automation Expert, standard device runtime, add on, v23 6 4 EALDHP license, EcoStruxure Automation Expert, high availability option, runtime, add on, v23 7 5 EALADP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for ATV dPac 1 6 EALAMP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M251, M262 dPAC 2 7 EALASP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M580 dPAC 1 8 EALALP license, EcoStruxure Automation Expert, run time, application, permannet, 1 user, for M580 dPAC with extensions 1 Run Add-on No Reference Description Quantity 9 EALH1P license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony ST6 1 10 EALH2P license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony iPC 1 Service plan No Reference Description Quantity 11 ECAUTESEAE Service plan for EcoStruxure Automation Expert - Essential 294 ... Software license configurator • Software selectionDone • • License selectorDone • Finalize and shareDone Bill of materials My Configuration Verification No Reference Description Quantity 1 CEGVER01AN license, EcoStruxure Control Engineering, verification, basic, node locked, 1 shot 1 Documentation No Reference Description Quantity 2 CEGDOC01AN license, EcoStruxure Control Engineering, documentation, basic, node locked, 1 shot 1 Software license configurator • Software selectionDone • • License selectorDone • • Service plansDone • Finalize and shareDone Bill of materials My Configuration Regular No Reference Description Quantity 1 CEXSPUCZSSPAZZ Control Expert S single e-licence 1 2 CEXSPMCZXTPAZZ License, EcoStruxure Control Expert, Topology Manager & M580 safety add-on for XL, team floating (10 users), digital 1 Service plan No Reference Description Service plan size 3 ECAUTESECE Service plan for EcoStruxure Control Expert - Essential 283 Your configuration has been saved! Copy the configuration ID to your clipboard Send by email Add to my project Export (1) Export the bill of material in XLS .xls Documentation (2) Product Data Sheet .zip Catalog Configuration Name : My Configuration Configuration ID : f9d295b2-90b2-4164-b665-04551a1f2f54 Date : Sun Mar 09 10:52:15 UTC 2025 Operation Server No Reference Description Quantity 1 EUSOPECZZSPEZZ SW PE OPER SERVER LIC 6 Operation Client No Reference Description Quantity 2 EUSLCCCZZSPEZZ SW PE CTRL CLIENT LIC 1 3 EUSVCCCZZSPEZZ SW PE VIEW CLIENT LIC 1 4 EUSLRCCZZSPEZZ SW PE RED CTRL CLIENT LIC 1 5 EUSVRCCZZSPEZZ SW PE RED VIEW CLIENT LIC 1 Service plan No Reference Description Quantity 6 ECAUTESEPE Service plan for EPE - Essential 608 Product Selector Tool This tool is designed to assist you through the product selection process. Try our Product Selector Content Training Installed Base Programs Overview Product Configurators PLC Your products have been added to a New Project/BOM View BOM Select your location Tshingombe fiston Software license configurator • Software selectionDone • • License selectorDone • • Service plansDone • Finalize and shareDone Bill of materials Perpetual My Configuration Design & Build No Reference Description Quantity 1 EALBTP23 licence, Ecostruxure Automation Expert, standard engineering buildtime, v23 1 2 EALBFP23 license, EcoStruxure Automation Expert, professional engineering, buildtime, v23 1 Operate & Maintain No Reference Description Quantity 3 EALDSP license, EcoStruxure Automation Expert, standard device runtime, add on, v23 6 4 EALDHP license, EcoStruxure Automation Expert, high availability option, runtime, add on, v23 7 5 EALADP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for ATV dPac 1 6 EALAMP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M251, M262 dPAC 2 7 EALASP license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M580 dPAC 1 8 EALALP license, EcoStruxure Automation Expert, run time, application, permannet, 1 user, for M580 dPAC with extensions 1 Run Add-on No Reference Description Quantity 9 EALH1P license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony ST6 1 10 EALH2P license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony iPC 1 Service plan No Reference Description Service plan size 11 ECAUTESEAE Service plan for EcoStruxure Automation Expert - Essential 294 Your configuration has been saved! Copy the configuration ID to your clipboard Send by email Add to my project Export (1) Export the bill of material in XLS .xls Documentation (2) Product Data Sheet .zip Catalog pdf Feedback Back Go to start page Back Go to start page mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric mySchneider Design & Build;;; No;Reference;Description;Quantity 1;EALBTP23;licence Ecostruxure Automation Expert standard engineering buildtime v23;1 2;EALBFP23;license EcoStruxure Automation Expert professional engineering buildtime v23;1 Operate & Maintain;;; No;Reference;Description;Quantity 3;EALDSP;license EcoStruxure Automation Expert standard device runtime add on v23;6 4;EALDHP;license EcoStruxure Automation Expert high availability option runtime add on v23;7 5;EALADP;license EcoStruxure Automation Expert run time application permanent 1 user for ATV dPac;1 6;EALAMP;license EcoStruxure Automation Expert run time application permanent 1 user for M251 M262 dPAC;2 7;EALASP;license EcoStruxure Automation Expert run time application permanent 1 user for M580 dPAC;1 8;EALALP;license EcoStruxure Automation Expert run time application permannet 1 user for M580 dPAC with extensions;1 Run Add-on;;; No;Reference;Description;Quantity 9;EALH1P;license EcoStruxure Automation Expert run time HMI permanent 1 user for Harmony ST6;1 10;EALH2P;license EcoStruxure Automation Expert run time HMI permanent 1 user for Harmony iPC;1 Service plan;;; No;Reference;Description;Quantity 11;ECAUTESEAE;Service plan for EcoStruxure Automation Expert - Essential;294 Direct Starter EcoStruxure™ Motor Control Configurator • Voltage440 V • • Motor detailsIE3-55 kW • • AdjustDone • • OptionsDone • Save & ShareDone My Configuration Technology: direct starter Supply Voltage: 440 V Standard: IEC (kW) Motor power: 55 kW Coordination type: Coordination type 1 Number of product: 2 products Range: 664 Starter type: Direct Online PLC Control: no Breaking performance Iq: 50 kA Coil Type: Standard Coil voltage: 230 V AC - 50/60 Hz Power terminal connection: Screw Clamp Motor efficiency class: IE3 Breaker GV4P115N Motor circuit breaker, TeSys GV4, 3P, 115A, Icu 50kA, thermal magnetic, Everlink terminals Accessories GV4AE11 Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC GV4AE11 Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC Contactor LC1D115P7 Contactor, TeSys Deca, 3P(3NO), AC-3/AC-3e, Show options (2) Contactor LC1D115P7 Contactor, TeSys Deca, 3P(3NO), AC-3/AC-3e, Show options (1) Your configuration has been saved! Copy the configuration ID to your clipboard dc5b40a4-bb0a-4e45-b277-b7fa55863d6a Please find a summary of Energy Savings delivered for Drive instead of a fixed speed solution This data is to be considered with assemption Export (2) Print Export Bill of Material (.xls) .xls Documentation (6) Product Data Sheet Bill of Material - My Configuration - 6b546e9d-8a2e-424f-af3c-939ea886fdcd - Schneider Electric Inbox No reply 12:45 PM (14 minutes ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: 6b546e9d-8a2e-424f-af3c-939ea886fdcd Bill of Material Verification No Reference Description Quantity 1 CEGVER01AN license, EcoStruxure Control Engineering, verification, basic, node locked, 1 shot 1 Documentation No Reference Description Quantity 2 CEGDOC01AN license, EcoStruxure Control Engineering, documentation, basic, node locked, 1 shot 1 Service plan No Reference Description Quantity ... [Message clipped] View entire message Bill of Material - My Configuration - 577e9790-a49e-4c0c-9307-f56f18a5ab60 - Schneider Electric Inbox No reply 12:50 PM (10 minutes ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: 577e9790-a49e-4c0c-9307-f56f18a5ab60 Bill of Material Regular No Reference Description Quantity 1 CEXSPUCZSSPAZZ License, EcoStruxure Control Expert, service pack base, small S, 1 user, node locked, digital license 1 2 CEXSPMCZXTPAZZ License, EcoStruxure Control Expert, with Topology Manager and M580 safety, for XL, node locked, 10 users, digital 1 Service plan No Reference Description Quantity 3 ECAUTESECE Service plan for EcoStruxure Control Expert - Essential 283 ... [Message clipped] View entire message Bill of Material - My Configuration - f9d295b2-90b2-4164-b665-04551a1f2f54 - Schneider Electric Inbox No reply 12:54 PM (6 minutes ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: f9d295b2-90b2-4164-b665-04551a1f2f54 Bill of Material Operation Server No Reference Description Quantity 1 EUSOPECZZSPEZZ SW PE OPER SERVER LIC 6 Operation Client No Reference Description Quantity 2 EUSLCCCZZSPEZZ SW PE CTRL CLIENT LIC 1 3 EUSVCCCZZSPEZZ SW PE VIEW CLIENT LIC 1 4 EUSLRCCZZSPEZZ SW PE RED CTRL CLIENT LIC 1 5 EUSVRCCZZSPEZZ SW PE RED VIEW CLIENT LIC 1 Service plan No Reference Description Quantity 6 ECAUTESEPE Service plan for EPE - Essential 608 ... Bill of Material - My Configuration - dc5b40a4-bb0a-4e45-b277-b7fa55863d6a - Schneider Electric Inbox tshingombe tshitadi 12:58 PM (2 minutes ago) to me Dear tshingombe tshitadi, Please find your configuration created from: EcoStruxureTM Motor Control Configurator Configuration link: My Configuration Your configuration ID: dc5b40a4-bb0a-4e45-b277-b7fa55863d6a Motor Starter parameters selected Technology: Direct Start Standard: IEC Supply Voltage: 440 V V Motor Power: 55 kW Motor efficiency class: IE3 Breaker Breaking performance Iq: 50 kA Contactor Coil voltage: 230 V AC - 50/60 Hz Power terminal connection: Screw Clamp Coil Type: Standard Bill of Material Devices Options Description Quantity: Breaker GV4P115N Motor circuit breaker, TeSys GV4, 3P, 115A, Icu 50kA, thermal magnetic, Everlink terminals 1 GV4AE11 Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC Auxiliary Contact Block > Front Function Sd > 1 NO + 1 NC - SD function 1 GV4AE11 Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC Auxiliary Contact Block > Front Function On/off > 1 NO + 1 NC - OF function 1 Contactor LC1D115P7 Contactor, TeSys Deca, 3P(3NO), AC-3/AC-3e, Front Clip Position 1 > 10180 s - 1 NO + 1 NC 1 LX1D8P7 Spareparts • Voltage440 V • • Motor detailsIE3-55 kW • • AdjustDone • • OptionsDone • Save & ShareDone My Configuration Technology: soft starter Supply Voltage: 440 V Standard: IEC (kW) Motor power: 132 kW Segment and process: Machine Manufacturing Application: Standard Machines Service duty: Normal duty Coordination type: Coordination type 1 Range: 5745 Communication module: Modbus SL (embedded) Motor Softstarter connection: In line Integrated bypass: yes With trip unit: yes Breaking capacity: 50 kA Coil Type: without coil Breaker C40H31M320 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, <=440V 265A without coil Accessories LADN01 Auxiliary contact block, TeSys Deca, 1NC, front mounting, screw clamp terminals LADN11 Auxiliary contact block, TeSys Deca, 1NO+1NC, front mounting, screw clamp terminals LADN13 Auxiliary contact block, TeSys Deca, 1NO+3NC, front mounting, screw clamp terminals Soft starter ATS22C25Q soft starter for asynchronous motor, Altistart 22, control 230V, 230 to 440V, 75 to 132kW My Configuration ZA Add to My Products Technology: soft starter Supply Voltage: 440 V Standard: IEC (kW) Motor power: 132 kW Segment and process: Machine Manufacturing Application: Standard Machines Service duty: Normal duty Coordination type: Coordination type 1 Range: 5745 Communication module: Modbus SL (embedded) Motor Softstarter connection: In line Integrated bypass: yes With trip unit: yes Breaking capacity: 50 kA Coil Type: without coil Breaker C40H31M320 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, Show options (3) Soft starter ATS22C25Q soft starter for asynchronous motor, Altistart 22, control 230V, 230 to 440V, 75 to 132kW Your configuration has been saved! Copy the configuration ID to your clipboard 98d8730c-cef0-4fd3-8fbe-b6f8b3c1d66b Please find a summary of Energy Savings delivered for Drive instead of a fixed speed solution This data is to be considered with assemption Export (2) Print Export Bill of Material (.xls) .xls Documentation (6) Product Data Sheet .zip Variable Speed Drive EcoStruxure™ Motor Control Configurator My Configuration Technology: variable speed drive Supply Voltage: 480 V Standard: IEC (kW) Motor power: 132 kW Segment and process: Machine Manufacturing Application: Standard Machines Service duty: Heavy duty Range: 63124 Communication module: Modbus SL Installation type: wall mounted Protection level: IP21 With braking unit: yes With trip unit: yes Breaking capacity: 50 kA Coil Type: without coil Breaker C40H31M320 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A Accessories 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, Show options (3) Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, Show options (3) Drive ATV930C16N4 variable speed drive, Altivar Process ATV900, ATV930, 160kW, 380 to 480V, with braking unit, IP20 Your configuration has been saved! Copy the configuration ID to your clipboard 96d5a340-770b-4927-bab7-5c538288d832 This data is to be considered with assemption Export (2) Print Export Bill of Material (.xls) .xls Documentation (6) Product Data Sheet .zip CAD files Modicon PLC • HomeDone • • PLC selectionDone • • Graphical editorDone • • Power supplyDone • • AccessorizeSkipped • Finalize and shareDone My Configuration Range Pacdrive LMC Power supply 24 Vdc Field bus protocols EtherNet/IP; Sercos Bill of materials Add to Favorites Controller + I/O No Reference Description Quantity 1 LMC216CAA10000 Motion controller LMC216 16 axis - Acc kit - Basic 1 2 ABL8WPS24200 Regulated switch power supply, modicon power supply, 3 phases, 380 to 500V AC, 24V, 20A 1 3 GV2ME06 Motor circuit breaker, TeSys Deca, 3P, 1 to 1.6A, thermal magnetic, screw clamp terminals, button control 1 4 ABL8BBU24200 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 20A, for regulated SMPS 1 5 ABL8BBU24400 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 40A, for regulated SMPS 1 6 BVS480XDPDR Easy UPS control module, 24V DC-DC, DIN Rail, Industrial, 20A 1 7 XB005XPDR Easy UPS battery module, 24V DC-DC, DIN Rail, Industrial, 4.5Ah 1 Your configuration has been saved! Copy the configuration ID to your clipboard Send by email Add to my project Export (5) Export to EcoStruxure Machine Expert .py Export PNG picture .zip Export the bill of material in XLS .xls Export project in PDF .pdf Export architecture in PDF .pdf Documentation (6) Product Data Sheet .zip CAD .zip Instruction Sheet .zip User guide .zip Certificate .zip Catalog .zip Feedback Bill of Material - My Configuration - 98d8730c-cef0-4fd3-8fbe-b6f8b3c1d66b - Schneider Electric Inbox tshingombe 1:09 PM (12 minutes ago) to me Dear tshingombe, Please find your configuration created from: EcoStruxureTM Motor Control Configurator Configuration link: My Configuration Your configuration ID: 98d8730c-cef0-4fd3-8fbe-b6f8b3c1d66b Motor Starter parameters selected Technology: Soft Starter Standard: IEC Supply Voltage: 440 V V Motor Power: 132 kW Segment and Process: Machine Manufacturing Application: Standard machines Heavy Duty selection: no Breaker Breaking capacity: 50 kA With trip unit: yes Contactor Coil voltage: n/a Coil Type: without coil Soft Starter Integrated bypass: yes Bill of Material Devices Options Description Quantity: Breaker C40H31M320 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A 1 LV432513 Spareparts 1 Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, Right > 1 NC 1 LADN11 Auxiliary contact block, TeSys Deca, 1NO+1NC, front mounting, screw clamp terminals Auxiliary Contact For Standard Environment > Front Clip Position 1 > 1 NO + 1 NC 1 LADN13 Auxiliary contact block, TeSys Deca, 1NO+3NC, front mounting, screw clamp terminals Auxiliary Contact For Standard Environment > Front Clip Position 1 > 1 NO + 3 NC 1 Soft Starter ATS22C25Q soft starter for asynchronous motor, Altistart 22, control 230V, 230 to 440V, 75 to 132kW 1 Bill of Material - My Configuration - 96d5a340-770b-4927-bab7-5c538288d832 - Schneider Electric Inbox tshingombefiston 1:12 PM (9 minutes ago) to me Dear tshingombefiston, Please find your configuration created from: EcoStruxureTM Motor Control Configurator Configuration link: My Configuration Your configuration ID: 96d5a340-770b-4927-bab7-5c538288d832 Motor Starter parameters selected Technology: Variable Speed Drive Standard: IEC Supply Voltage: 480 V V Motor Power: 132 kW Segment and Process: Machine Manufacturing Application: Standard machines Heavy Duty selection: no Breaker Breaking capacity: 50 kA With trip unit: yes Contactor Coil voltage: n/a Coil Type: without coil Drive Installation type: wall mounted With braking unit: yes Protection level: IP21 Bill of Material Devices Options Description Quantity: Breaker C40H31M320 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A 1 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type Add-on Auxiliary Contact-low Level > Front Function Sde > SDE function 1 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type Add-on Auxiliary Contact-low Level > Front Function Sd > SD function 1 29452 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type Add-on Auxiliary Contact-low Level > Front Function On/off > ON/OFF 1 LV432513 Spareparts 1 Contactor LC1F265 Contactor body,TeSys F,3P(3NO)-AC-3, Clip On Rail Mounting > 127240 V AC 1 LADT0 Time delay auxiliary contact block, TeSys Deca, 1NO+1NC, on delay 0.3-3s, front, screw clamp terminals Time On Delay > Front Clip Position 1 > 0.13 s - 1 NO + 1 NC 1 LADT2 Time delay contact block,TeSys Deca,1NO+1NC,on-delay 1-30s,front Time On Delay > Front Clip Position 1 > 0.130 s - 1 NO + 1 NC 1 LA5FH431 Spareparts 1 Drive ATV930C16N4 variable speed drive, Altivar Process ATV900, ATV930, 160kW, 380 to 480V, with braking unit, IP20 1 Bill of Material - My Configuration - 36455ef8-f6c2-460a-91c3-15d69cf9452f - Schneider Electric Inbox No reply 1:16 PM (6 minutes ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: 36455ef8-f6c2-460a-91c3-15d69cf9452f Bill of Material Bom level Position Reference Description Quantity My Configuration 1 LMC216CAA10000 Motion controller LMC216 16 axis - Acc kit - Basic 1 My Configuration 2 ABL8WPS24200 Regulated switch power supply, modicon power supply, 3 phases, 380 to 500V AC, 24V, 20A 1 My Configuration 3 GV2ME06 Motor circuit breaker, TeSys Deca, 3P, 1 to 1.6A, thermal magnetic, screw clamp terminals, button control 1 My Configuration 4 ABL8BBU24200 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 20A, for regulated SMPS 1 My Configuration 5 ABL8BBU24400 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 40A, for regulated SMPS 1 My Configuration 6 BVS480XDPDR Easy UPS control module, 24V DC-DC, DIN Rail, Industrial, 20A 1 My Configuration 7 XB005XPDR Easy UPS battery module, 24V DC-DC, DIN Rail, Industrial, 4.5Ah 1 ... Bill of Material - My Configuration - 9988cbd9-4fe8-473c-927f-c3473aaf67af - Schneider Electric Inbox No reply 1:21 PM (1 minute ago) to me Dear Tshingombe fiston, Please find your configuration My Configuration created with the Modicon PLC Configurator application. Your configuration ID: 9988cbd9-4fe8-473c-927f-c3473aaf67af Bill of Material Bom level Position Reference Description Quantity My Configuration 1 TM171ODM22R Controller, Modicon M171/M172/M173, optimized display 22 IO, Modbus 1 My Configuration 2 TM171ACB4OI1M Modicon M171 Optimized LV Connector 1m cable 2 My Configuration 3 TM171ACB4OAO1M Modicon M171 Optimized AO Connector 1m cable 1 My Configuration 4 TM171ACB4OAO2M Modicon M171 Optimized AO Connector 2m cable 1 My Configuration 5 TM171DLED Modicon M171 Optimized Display LED 1 My Configuration 6 TM171DLCD2U Modicon M171 Optimized Display LCD 1 My Configuration 7 TM171DWAL2U Modicon M171 Optimized Wall thermostat without backlight 1 My Configuration 8 TM1STNTCRN52015 NTC 1,5m IP68 5x20 -50+110°C Grey 1 My Configuration 9 TM1STNTCRN5201P NTC 1,5m IP68 5x20 -50+110°C Grey 1 My Configuration 10 TM1STNTCRN52030 NTC 3,0m IP68 5x20 -50+110°C Grey 1 My Configuration 11 TM171VEVA2 EEV Driver, Actuator 1 My Configuration 12 TM171VEVD4 EEV Driver, Autonomous & Hardwired 1 My Configuration 13 TM171VEVM4 EEV Driver, Autonomous & Modbus 1 ... [Message clipped] View entire message www.se.com Catalog | July 2024 Software-defined Automation Software version v24.0 EcoStruxure™ Automation Expert Industrial Automation systems Find your catalog > With just 3 clicks, you can access the Industrial Automation and Control catalogs, in both English and French > Consult digital automation catalogs at Digi-Cat Online Select your training > Find the right Training for your needs on our Global website > Locate the training center with the selector tool, using this link Quick access to product information Get technical information about your product Each commercial reference presented in a catalog contains a hyperlink. Click on it to obtain the technical information of the product: – Characteristics, Dimensions and drawings, Mounting and clearance, Connections and schemas, Performance curves – Product image, Instruction sheet, User guide, Product certifications, End of life manual • Up-to-date catalogs • Embedded product selectors, 360° pictures • Optimized search by commercial references General contents EcoStruxure™ Automation Expert b General presentation v EcoStruxure Automation Expert........................ page 2 v Feature overview .... page 3 b Presentation v Software - EcoStruxure Automation Expert engineering .... page 4 - EcoStruxure Automation Expert - HMI .... page 5 - EcoStruxure Automation Expert - Archive .... page 5 - EcoStruxure Automation Expert - AVEVA System Platform integration........................ page 5 - EcoStruxure Automation Expert - Libraries .... page 5 - System requirements........................ page 9 v Hardware - Software dPAC .... page 10 - Edge Controller........................page 11 - Altivar and Modicon dPAC .... page 11 - Selection Guide .... page 14 - Architecture .... page 17 v Licenses - EcoStruxure Automation Expert – Perpetual licensing .... page 20 - EcoStruxure Automation Expert – Subscription-based licensing .... page 21 - EcoStruxure Automation Expert Licensing – Architecture .... page 21 b Compatibility v List of X80 hardware compatible with Modicon M580 dPAC .... page 28 v List of TM3 hardware compatible with ModiconM251 dPAC and M262 dPAC .... page 30 v Altivar hardware and Altivar ATV dPAC compatibility .... page 31 b References v Modicon M580 dPAC .... page 32 v Modicon M251 dPAC .... page 36 v Modicon M262 dPAC .... page 37 v Altivar ATV dPAC .... page 38 b Services........................ page 40 b Product reference index........................ page 42 1 2 EcoStruxure™ Automation Expert Industrial automation systems EcoStruxure Automation Expert General presentation Libraries Operator Station Automation Expert HMI Runtime Modicon dPAC Engineering Automation Expert Communications X80 TM3 I/O & Enc M580 dPAC M2xx dPAC ATV dPAC Soft dPAC Linux/HA Soft dPAC Windows Automation ExpertHistorization Automation Expert Archive Control Room AVEVA System Platform CRD + X80 EcoStruxure Automation Expert consists of a suite of integrated hardware and software solutions: > EcoStruxure Automation Expert build time - engineering, monitoring, and management environment > Distributed Programmable Automation Controller (dPAC) platforms with the Universalautomation.org Shared Source Runtime engine: b ATV dPAC for Altivar b Modicon M251 dPAC/TM3 I/O b Modicon M262 dPAC/TM3 I/O b Modicon M580 dPAC/X80 I/O > Plus, innovative new software-based controllers: b Soft dPAC for Linux™, for standalone and high availability configurations b Soft dPAC for Windows™ , for standalone configurations > EcoStruxure Automation Expert - HMI, a fully integrated, object-oriented industrial visualization solution > EcoStruxure Automation Expert - Archive, a centralized solution for the historization of process data, alarms, and trends > Schneider Electric Libraries, a comprehensive set of hardware-independent libraries, ranging from basic functions up to segment solutions > Asset Link for Bulk Engineering to extract data from engineering tools for automated application generation > Asset Link for AVEVA OMI to create application objects (AppObjects) in the AVEVA System Platform in an automated workflow Note: UniversalAutomation.org is an independent, non-for-profit association managing the implementation of an industrial automation shared source runtime execution engine, based on the IEC 61499 standard that is an object-oriented further development of IEC 61131 with the cyclical execution model of IEC 61131 replaced by an event-based model. This new level of shared technology provides the basis for an ecosystem of portable, interoperable, “plug and produce” solutions and creates an entirely new category within industrial automation. EcoStruxure Automation Expert is a software-defined industrial automation system, a new category of industrial automation that leverages innovative technology to enable industrial operators to realize a step-change improvement over traditional process control systems and deliver significant advancement in productivity, quality, flexibility, and security throughout the entire lifecycle of industrial assets. 3 Feature overview EcoStruxure Automation Expert represents a new approach to designing, building, operating, and maintaining industrial automation systems that offers a unique technology mix to define a new category of integrated automation systems. Complexity mastered Systems, devices, services, and assets are natively represented as ready-to-use software objects called composite automation types (CATs) that encapsulate internal behaviour and simplify functional interfaces. An object-oriented approach promotes code reuse, standardization on best practice, and helps manage complexity while providing the fundamental building blocks for the creation of state-of-the-art cyber-physical systems. CAT objects follow a type/instance relation and can be combined to create new objects that encapsulate: b Control logic b HMI/SCADA visualization b I/O and device communications b Simulation and test rigging b Documentation Decoupling the application from implementation EcoStruxure Automation Expert addresses full automation system engineering and extends the best features of classic PLC and DCS control approaches to a new generation of automation system that completely decouples the application design from runtime deployment, enabling automation professionals to focus on these tasks independently in their project lifecycle. Applications are portable, reusable, and interoperable across runtime platforms, meaning deployment decisions are made just in time and on the fly, enabling exceptional system agility. Efficient engineering EcoStruxure Automation Expert build time provides a single, modular engineering environment for all tasks for engineering, monitoring, and managing the complete automation system including hardware and software, control, and visualization. It automates low value engineering and integration tasks, reducing engineering effort and sources of error by Asset Link to perform digital engineering. Complex functions can be encapsulated into manageable objects, enabling non-technical users to understand and manage complex systems. Cross communications are transparent and implicit regardless of physical location, requiring zero engineering consideration. Common runtime environment Through the implementation of the shared source Runtime engine provided by universalautomation.org across hardware and software platforms, exceptional re-usability, scalability, and architectural flexibility are now available. Application portability provides cost savings through the decoupling of the lifecycles of software and hardware systems. Simple system orchestration EcoStruxure Automation Expert was designed with the complete lifecycle of an automation system in mind, with functions to facilitate management and monitoring of multiple assets and devices at scale. With a single user environment covering the entire system scope including third-party devices, orchestration of complex, heterogenous systems becomes simpler. Native IT integration Modern automation systems generate increased value when coupled with business information and hence wider IT ecosystems. EcoStruxure Automation Expert provides an expandable platform for Industry 4.0 solutions with support for high-level programming, modular systems design, and open standards. Thanks to event-driven execution and object-oriented design, EcoStruxure Automation Expert applies to IT programming language standards. Cybersecurity EcoStruxure Automation Expert includes robust support for cybersecurity including credential management and secure communications. User and device credentials are managed by the EcoStruxure Automation Expert build time environment, and secure communications are available between controllers, HMI, SCADA, and third-party devices. Industrial automation systems EcoStruxure Automation Expert General presentation (continued) 4 EcoStruxure Automation Expert Software The EcoStruxure Automation Expert software offer includes: b The EcoStruxure Automation Expert engineering environment, with add-ons for integration of AVEVA Engineering and AVEVA System Platform software b EcoStruxure Automation Expert HMI Runtime b EcoStruxure Automation Expert Archive b Asset-oriented application libraries EcoStruxure Automation Expert engineering EcoStruxure Automation Expert is an asset-based, fully-integrated engineering environment that allows portable, IEC 61499-standard-based automation systems to be managed within a single environment. EcoStruxure Automation Expert provides the capability to: b Design and manage asset-based applications using object libraries based on multifaceted models (asset logic, operating modes, HMI symbols and faceplates (including alarms and trends), I/O interface, and asset documentation) b Design the process based on asset-oriented objects with single line connections b Create rich process displays to monitor and control the process from the control room or line terminal by dragging and dropping asset-based objects b Manage a single solution independently of the number of controllers and HMI stations b Design the application solution independently of the hardware configuration b Test and simulate the control and HMI for the whole solution b Create and modify procedural automation CATs based on S88 state model with graphical editor b Support multi-user change management through SVN client integration b Design, configure, and manage network and device topologies b Flexibly deploy applications to multiple hardware or software platforms based on a common runtime b Automatically discover and diagnose compatible runtime devices b Automate bulk generation of asset instances from AVEVA Engineering or DEXPI files b Automate bulk generation of asset instances for AVEVA System Platform b Embedded AVEVA industrial graphic editor in EcoStruxure Automation Expert build time to create new AVEVA industrial graphics or to reuse graphics from existing applications b Secure the automation system by managing authentication with encrypted communication and security certificates at solution and devices level EcoStruxure Automation Expert V24.0 build time Industrial automation systems EcoStruxure Automation Expert Software Presentation 5 EcoStruxure Automation Expert Software EcoStruxure Automation Expert – HMI EcoStruxure Automation Expert HMI is a tightly integrated human-machine interface designed for EcoStruxure Automation Expert applications. Its features include: b Compatibility with WindowsTM OS/LinuxTM OS hardware or Schneider Electric Harmony ST6 b Seamless management of controller and HMI communication b Support for single/multi operator stations with cloning b User management for access control b Multi-language application b Monitoring of runtime connections The EcoStruxure Automation Expert HMI Client for WindowTM/LinuxTM operating system can be installed on various hardware such as Workstations, Industrial PCs, and Edge Boxes, provided they meet the minimum system requirements. It ensures high-performance, seamless management of controller and HMI communication. Furthermore, the EcoStruxure Automation Expert HMI Client for Harmony ST6 is compatible with HMIST6200, HMIST6400, HMIST6500, HMIST6600, HMIST6700, HMISTM6400, and HMISTM6200 touch panel screens. It offers seamless management of controller and automatic HMI communication, particularly ideal for a small number of assets. EcoStruxure Automation Expert – Archive EcoStruxure Automation Expert Archive operates as a highly integrated local data historian, providing minimal engineering effort historization and retrieval of live process data, alarms, and events within Automation Expert HMI and the capability to integrate with larger enterprise data storage systems by Structured Query Language (SQL). It is compatible with Windows 10, Windows 11, and Linux operating system. EcoStruxure Automation Expert – AVEVA System Platform integration EcoStruxure Automation Expert includes native support for System Platform - AVEVA’s real-time operations control platform for supervisory, HMI, SCADA, and IIoT applications. EcoStruxure Automation Expert is capable of auto-generating OPC UA-based secure communications between platforms and generate AVEVA System Platform-compatible graphics for clean integration. Furthermore, it now embeds the AVEVA Industrial Graphics editor so that users no longer need to move from EcoStruxure Automation Expert buildtime to AVEVA buildtime, providing unpreceeded integration. Automation Expert version Library compatibile version Platform version for Asset Link Version for Asset Link and AVEVA Industrial Graphics V23.0 AVEVA System Platform 2020 R2 SP1 AVEVA System Platform 2020 R2 SP1 or later No AVEVA Industrial Graphics support V23.1 AVEVA System Platform 2023 AVEVA System Platform 2020 R2 SP1 or later (New Galaxy creation is possible only with Library compatible version)* AVEVA System Platform 2023 or later V24.0 AVEVA System Platform 2023 or R2 SP1 AVEVA System Platform 2020 R2 SP1 or later (New Galaxy creation is possible only with AVEVA System Platform 2023 R2 SP1)* AVEVA System Platform 2023 or later (New Galaxy creation is possible only with AVEVA System Platform 2023 R2 SP1)* *Only Select Existing Galaxy from the configurator is possible if Library compatible version is not available with the user. Embedded AVEVA industrial graphic editor in EcoStruxure Automation Expert build time Industrial automation systems EcoStruxure Automation Expert Software Presentation (continued) 6 EcoStruxure Automation Expert Software (continued) EcoStruxure Automation Expert – Libraries EcoStruxure Automation Expert includes a set of application libraries with generic process and control modules such as motors / valves and segment-based libraries with equipment modules that include multiple facets – logic, Automation Expert HMI, AVEVA System Platform template, and documentation within a single package to minimize the engineering time. EcoStruxure Automation Expert also includes a hardware library for easier integration of the most common Schneider Electric and Technical Partner’s field devices through Modbus TCP / Ethernet IP that provides the mapping, HMI, and documentation to be used in the application. With version 24.0 release, the free libraries included are: b Field Device b Base and common process b Sequence management and Phase Management b Liquid food b Water & Wastewater (including desalination) b Single line power monitoring b Conveying These libraries include HMI objects that are compatible with Windows and Linux Ubuntu native HMI runtime, including the Harmony HMIST6xxx and HMISTM6xxx panels. Additionally, Universal Automation vendors provide specific hardware libraries to deploy EcoStruxure Automation Expert applications to their offer. Industrial automation systems EcoStruxure Automation Expert Software Presentation (continued) With this release the library updates include: b Elementary blocks with easier customization covering basic application functions like alarms, conditions, owners, and signal conditioning that are used by other application CATs – SE.App2Base. b Library of application CATs with easier customization to address common process assets or functions like digital I/O, analog I/O, motors, valves, and flowcontrol. There are multiple layers of each object available which can be used and customized for various application purposes – SE.App2CommonProcess. b State management functionality for generic application (State Manager) as well as ISA-88 based application (Phase Manager). Phase Manager also includes a phase logical interface that accepts commands from external batching interfaces such as AVEVA Batch Management and returns the phase manager status – SE.App2StateManagement. Example of HWCAT symbol and faceplate on EcoStruxure Automation Expert HMI Example of Application CAT symbol and faceplate on AVEVA OMI Application – Common Process Setpoint, Signal Processing, Motors, Valves, Process Control, Flow Control, Pump Set M580 dPAC CPU, X80 I/O Modules M251 dPAC CPU, TM3 I/O Modules M262 dPAC CPU, TM3 I/O Modules ATV dPAC Soft dPAC I/O Modbus Read/Write registers Field Device Modbus/TCP ATV, ATS, Lexium, PowerMeter Gateways Modbus Gateway, UDP Gateway HARDWARE SPECIALIZED APPLICATION GENERAL APPLICATION Application – Base Deviation Alarm, Limit Alarm, Range of Change Alarm, State Alarm Conditions, Owner Application 2 – Base Deviation Alarm, Limit Alarm, Range of Change Alarm, State Alarm Conditions, Owner Application – Sequence Sequence Step, Sequence Action Application 2 – Common Process Setpoint, Signal Processing, Motors, Valves, Process Control, Flow Control, Pump Set Segment Applications WWW, Single Line Power Monitoring, Conveying, Liquid Food, State Management Segment Applications 2 State Management 7 Industrial automation systems EcoStruxure Automation Expert Software Presentation (continued) EcoStruxure Automation Expert Software (continued) EcoStruxure Automation Expert – Libraries (continued) EcoStruxure Automation Expert libraries Library name Short description Extended description Runtime.Base Standard blocks This library contains the basic function blocks to be used for: b Runtime management b Arithmetic functions b Logic functions b Format conversion b Event management b etc. SE.AppBase Elementary block of the application Library of application CATs covering basic application functions like alarms, conditions, owners, and signal conditioning that are used by other application CATs like the ones from SE.AppCommonProcess SE.App2Base Elementary blocks of the application SE.AppBase objects are redesigned to make customization easier. These objects will be used by other redesigned libraries. SE.AppSequence Sequence control This library has a set of application CATs that allows you to create sequential control algorithms with steps and transitions to command control modules. This library works with both SE.AppCommonProcess and SE.App2CommonProcess. SE.AppCommonProcess Common process applications Library of application CATs to address common process assets or functions like digital I/O, analog I/O, motors, valves, flow control, etc. These types of object can be used in any industrial application as well as in process control in manufacturing applications SE.App2CommonProcess Common process application SE.AppCommonProcess objects are redesigned to make customization easier. There are multiple layers of each object available, which can be used and customized for various application purposes. SE.AppConveying Conveying Library of application CATs to address common equipment such as conveyors, sorters, transfer tables, and turntables, typically used in logistic hubs and distribution centers SE.AppLiquidFood Liquid and Food This library has an application CAT to control the seats of mixproof valves used in Liquid and Food applications SE.SingleLinePowerMonitoring Low and medium power monitoring This library includes templates with common functions for electrical objects such as busbars, sources, infeeds, and loads that can be connected to energy management hardware CATs SE.AppStateManagement State management This library is used to monitor and manage interface states of the machine: b receiving control commands and providing machine information b managing acting state sequence and transitions SE.App2StateManagement State management This library is used to provide state management functionality for generic application (State Manager) as well as ISA-88 based application (Phase Manager). Phase Manager also includes a phase logical interface that accepts commands from external batching interfaces such as AVEVA Batch Management and returns the Phase Manager status. SE.AppProcedure Procedure control This library is used to monitor and manage phases based on ISA-88 associated with sequences in coordination with sequence control blocks from SE.AppSequence. It also includes a phase logical interface that accepts commands from external batching interfaces such as AVEVA Batch Management and returns the phase manager status. SE.AppWWW Waste and wastewater This library contains blocks used to monitor and manage control sequences like aeration and dual media filter for Water and Wastewater applications SE.DPAC dPAC hardware controllers Library containing the dPAC device types AVEVA.IndustrialGraphicsLibrary Industrial graphics library Industrial Graphics are vector-based graphics that can be scaled, animated, embedded into application objects, and deployed. The library contains common industrial equipment. You can modify graphics or add graphics to the library by creating new graphics using the Industrial Graphic Editor. SE.EAEPortal AVEVA System Platform Device type The AVEVA System Platform device type is required by Asset Link for establishing communication and creating the application objects automatically in AVEVA System Platform SE.FieldDevice Field device hardware CATs This library has ready-to-use hardware CATs for motor control, energy management, machine safety, and weighing from Schneider Electric, allowing dPAC communication with these devices by Modbus TCP or Ethernet IP depending on the device SE.HwCommon Common hardware CAT functions Library of functions used by the various hardware CAT libraries SE.IoATV Variable speed drive I/O services for ATV dPAC Library of hardware CATs for Altivar I/O (local and modules) used for the Altivar dPAC module hardware configuration 8 Industrial automation systems EcoStruxure Automation Expert Software Presentation (continued) EcoStruxure Automation Expert Software (continued) EcoStruxure Automation Expert – Libraries (continued) EcoStruxure Automation Expert libraries Library name Short description Extended description Standard.IoNet UDP gateway Library of hardware CATs to enable UDP communication SE.IoTMx TM I/O services for M251d/M262d Library of hardware CATs for TMx I/O modules used for M251d and M262d hardware configuration SE.IoX80 X80 I/O services for M580d Library of hardware CATs for X80 I/O modules used for M580d hardware configuration SE.ModbusGateway Standard Modbus gateway Library of hardware CATs to enable Modbus TCP communication with import of data description file SE.Standard EcoStruxure Automation Expert HMI device type Standard.IoEtherNetIP Standard Ethernet IP scanner functions Library of hardware CATs used for EIP scanner configuration (Implicit use by the EcoStruxure Automation Expert system when using the EIP scanner and also to add custom EIP connections) Standard.IoModbus Standard Modbus functions Library of hardware CATs to enable Modbus client communication Standard.IoModbusSlave Standard Modbus server functions Library of hardware CATs to enable Modbus server communication Standard.OPCUAClient Standard OPC UA client functions Functions to enable OPC UA client connection, monitor, read, and write data Definitions: b CAT object: A composite automation type (CAT) function block includes objects with multiple facets: v Logic to define its operating modes v I/O interfaces to exchange data/events with its environment v Symbols/faceplates for control and monitoring in the HMI v Documentation that is implicitly part of the project online help b Application CAT: representing application assets or functions b Hardware CAT: representing hardware devices that can be added to the hardware configuration, for device monitoring and control 9 Industrial automation systems EcoStruxure Automation Expert Software Presentation (continued) EcoStruxure Automation Expert Software (continued) System requirements Windows – Engineering, HMI, and Archive System requirements Minimum Performance Engineering HMI Archive Processor 1 GHz 2 GHz or higher RAM (1) 2 GB 2 GB 2 GB 4 GB 4 GB 4 GB Hard disk free space (1) 1 GB 1 GB 1 GB 10 GB 10 GB 10 GB Display resolution 1280x1024 1920x1080 or higher Pointing device Mouse or compatible Network access One Ethernet interface Operating system Microsoft Windows 10 Professional (64-bit) Version 1903 and later, Microsoft Windows 11 Professional Version 21H2 and later, and Microsoft Server Version 2019 (1809 and later) .NET framework .NET 4.8 .NET 4.8 or higher (1) Requirement is indicated for each software package. More than one software package can be installed on the same device. In this case, you need to add the respective RAM and hard disk free space requirements together. For example, if you install the HMI and Archive software packages on the same device, the minimum RAM required is 4 GB (2 GB + 2 GB). 10 Industrial automation systems EcoStruxure Automation Expert Software Presentation (continued) EcoStruxure Automation Expert Distributed Programmable Automation Controller (dPAC) Platforms EcoStruxure Automation Expert consists of several hardware components working together to create a complete automation system. Soft dPAC Soft dPAC is an edge computing controller designed to execute an application and interact with field devices. This hardware-agnostic controller is versatile, capable of installation on various hardware such as servers, workstations, industrial PCs, or microcomputers, provided they meet the necessary hardware and software requirements. Soft dPAC supports both LinuxTM and WindowsTM operating systems: v The Linux SoftdPAC is ideal for real-time control when installed in conjunction with a Linux real-time patch. v The Windows SoftdPAC is best suited for non-critical applications that do not demand real-time control. In a Linux environment, multiple instances of Soft dPAC can be seamlessly installed on a single host machine, allowing tasks like line expansions to be completed without disrupting ongoing processes. This capability minimizes downtime, thereby enhancing productivity and profitability. For Windows, one Soft dPAC instance can be installed per host machine. High Availability Soft dPAC High Availability Soft dPAC (HA Soft dPAC) represents a software-based high availability industrial automation system specifically engineered to operate in a redundant configuration, offering resilience against hardware failures and ensuring continuous operations. This capability effectively minimizes process downtime, making it ideal for demanding applications where uninterrupted process flows are critical. The integration of the high-availability system with EcoStruxure Automation Expert software plays a pivotal role in enhancing productivity by significantly reducing process downtime. High Availability Soft dPAC is compatible with the following hardware: v Schneider Electric Harmony P6 iPC v ASRockTM iEP-5000G Series Industrial IoT Controller v For compatibility with other OS, please contact your Schneider Electric representative for additional information. Moreover, High Availability Soft dPAC seamlessly integrates with Modicon X80 IOs using the BMECRD0100 Remote I/O module, ensuring comprehensive compatibility and functionality within industrial automation setups. Essential Edge Controller Essential Edge Controller is part of the Harmony iPC range and runs at the Edge of Ecostruxure. Essential Edge Controller provides customers the flexibility and versatility in products to be used in control and compute applications and helps to enhance the customer's experience by reducing the time to market and improving the cybersecurity of the solution. Product reference: HMIBX1A0NDA Essential Edge Controller is a versatile and open-to-application edge terminal running Linux Operating software. It is a simple edge device, capable of bringing solid values for and beyond industrial use cases. v Pre-installed EcoStruxure Automation Expert Soft dPAC, HMI for immediate deployment v Capability to run third-party applications on the same hardware. Essential Edge Controller has no embedded I/O; it supports Remote I/O on Modicon TM3, X80 expansion modules with up to 32 devices connected via Modbus TCP/IP or Ethernet IP communication. Performance Edge Controller Performance Edge Controller is part of the Harmony iPC range and is positioned at the Edge of EcoStruxure. A cutting-edge iPC-based Edge controller with more performance, designed to revolutionize industrial automation. Equipped with pre-installed Soft dPAC, HMI, and Archive, this powerhouse of a controller offers seamless integration and unparalleled flexibility. With the ability to install third-party applications on the same hardware, it empowers you to customize and expand functionality to suit your specific needs. Performance Edge Controller operates on the robust and secure Linux operating system, helps to provide a stable and efficient platform for industrial automation. Linux OS contributes to maintaining consistent performance, enhanced security, and seamless integration with a wide range of industrial applications. Product Reference: HMIP6CTO It is a configure-to-order product, where the user can choose the processor type (Celeron / i3), Memory size, and accessories. The Performance Edge controller has no embedded I/O; it supports Remote I/O on Modicon TM3, X80 expansion modules with up to 200 devices connected via Modbus TCP/IP or Ethernet IP communication. This innovative Performance Edge controller is an all-in-one solution, streamlining operations and maximizing efficiency. NOTE: Please contact your Schneider Electric representative for additional information. HMIBX1A0NDA HMIP6CTO 11 Industrial automation systems EcoStruxure Automation Expert Hardware Presentation (continued) EcoStruxure Automation Expert Distributed Programmable Automation Controller (dPAC) Platforms (continued) HA Edge Controller Designed for high availability applications, this HA Edge controller running on Linux OS helps to maintain a continuous operation, offering a platform for critical industrial processes. Whether in manufacturing, energy management, or process automation, the versatility of our controller combined with Linux OS opens a world of possibilities, improving seamless and efficient operations in demanding industrial environments. Product Reference: HMIP6CTO It is a configure-to-order product, where the user can choose the processor type (Celeron / i3), Memory size, and accessories. v Pre-installed EcoStruxure Automation Expert HA soft dPAC for immediate deployment v Robust performance for diverse industrial applications The HA Edge controller has no embedded I/O; it supports Remote I/O on Modicon X80 expansion modules with up to 200 devices connected via Modbus TCP/IP communication. NOTE: Please contact your Schneider Electric representative for additional information. Modicon M580 dPAC A high-performance, rugged distributed field controller based on the widely successful Modicon M580 ePAC platform with up to 64 MB ECC RAM for programs and data. The Modicon M580 dPAC supports the robust, high-performance Modicon X80 I/O catalog(1) and is available in standard and conformal coated versions. Product references: b BMED581020: Modicon M580 dPAC (standard) b BMED581020C: Modicon M580 dPAC (conformal coated) BMED581020 and BMED581020C controllers support: v Up to 1,024 discrete I/O channels(2) v Up to 256 analog I/O channels(2) v Up to 4 racks of local I/O Modicon M251 dPAC A cost-optimized, low-footprint distributed controller based on the machine-specialized Modicon M251 Logic Controller platform. The Modicon M251 dPAC provides a single Ethernet port for fieldbus, switched dual Ethernet ports for peer communications, and supports the field-proven TM3 I/O system(1). Product reference: b TM251MDESE: Modicon M251 dPAC The TM251MDESE controller has no embedded I/O; it supports Modicon TM3 I/O expansion modules: v Up to 448 discrete I/O channels(2) v Up to 112 analog I/O channels(2) v Up to 14 Modicon TM3 expansion modules (7 local modules + 7 remote modules) with Modicon TM3 bus expansion modules (transmitter module and receiver module) It is possible to control up to 4 TeSys U and TeSys D motor starters by connecting a TM3XTYS4 TM3 module to the Modicon M251 dPAC. Modicon M262 dPAC This is the controller for performance machines. It is powered with a non-isolated 24 V DC power supply, has a built-in overload protection, embeds a dual-core processor and a 256 MB memory capacity and supports RSTP protocol. Product reference: b TM262L01MDESE8T: Modicon M262 dPAC The TM262L01MDESE8T controller has no embedded I/O; it supports Modicon TM3 I/O expansion modules: v Up to 448 discrete I/O channels(2) v Up to 112 analog I/O channels(2) v Up to 14 Modicon TM3 expansion modules (7 local modules + 7 remote modules) with Modicon TM3 bus expansion modules (transmitter module and receiver module) It is possible to control up to 4 TeSys U and TeSys D motor starters by connecting a TM3XTYS4 TM3 module to the Modicon M262 dPAC. (1) Expert/specialist modules are not supported in this release. Please refer to the compatibility table on page 28. (2) These values are theoretical limits; the device limits are highly dependent on the event load of the user application. BMED581020 TM251MDESE TM262L01MDESE8T 12 Industrial automation systems EcoStruxure Automation Expert Hardware Presentation (continued) EcoStruxure Automation Expert Distributed Programmable Automation Controller (dPAC) Platforms (continued) Altivar ATV dPAC module The ATV dPAC module is part of the EcoStruxure Automation Expert distributed control solution platform, with 12 MB memory for programs and data. It is intended to be used as a slide-on option for ATV600, ATV900, and ATV340 variable speed drive (VSD) families(1). The Altivar ATV dPAC module is powered by the drive and provides dual Ethernet sockets for connection to peer controllers, distributed I/O, or remote secondary devices. Product references: b VW3A3530D: Altivar ATV dPAC module b VW3A1111: Graphic display terminal The VW3A3530D dedicated controller has no embedded I/O. However, all standard I/O on the respective Altivar Process and Altivar Machine drives can be used and extended with I/O modules: b Up to 23 discrete I/O b Up to 7 analog I/O b Encoder interfaces (ATV900 and ATV340) It is possible to control up to 8 Modbus TCP devices, such as Altivar drives and soft starters, TeSys motor starters, remote I/O using a TM3BCEIP bus coupler, PowerLogic meters, or Harmony Hub wireless sensors. For more information about the input/output capability, refer to Altivar dPAC Module VW3A3530D user guide. (1) For details, please refer to the compatibility table on page 31. VW3A3530D Altivar Process drives slots 13 Industrial automation systems EcoStruxure Automation Expert Hardware Presentation (continued) EcoStruxure Automation Expert Distributed Programmable Automation Controller (dPAC) Platforms (continued) Information Technology (IT)/Operational Technology (OT) Communication Protocols Platform Soft dPAC High Availability (Linux) Simplex Soft dPAC (Linux) Simplex Soft dPAC (Windows OS) M580 dPAC M262 dPAC M251 dPAC ATV dPAC OPCUA Client – – – – Server MQTT Pub/Sub – – – – Modbus TCP Client Server – Modbus RTU Client – – – – Server – – – – EtherNet/IP Scanner (Client) – – – PROFIBUS DP Client Through Modbus TCP third party gateway Through Modbus TCP third party gateway Through Modbus TCP third party gateway Through Modbus TCP third party gateway Through Modbus TCP third party gateway Through Modbus TCP third party gateway Through Modbus TCP third party gateway AsiS-5 / ASi-3 Through Modbus TCP third party gateway Through Modbus TCP third party gateway Through Modbus TCP third party gateway Through Modbus TCP third party gateway Through Modbus TCP third party gateway Through Modbus TCP third party gateway Through Modbus TCP third party gateway HART – – – – Open TCP/IP – 14 15 Presentation (continued) EcoStruxure Automation Expert Distributed Programmable Automation Controller (dPAC) Platforms Selection guide EcoStruxure Automation Expert consists of several hardware components working together to create a complete automation system. High Availability Soft dPAC Simplex Soft dPAC (Linux OS) Simplex Soft dPAC (Windows OS) Modicon M580 dPAC Modicon M262 dPAC Modicon M251 dPAC Altivar ATV dPAC Applications Type Virtualized device Virtualized device Virtualized device Embedded device Embedded device Embedded device Embedded device Specification For critical applications For real time applications For non-real time applications For robust process application For performance modular machines For small modular machines For distributed or Variable Speed Drive centric applications, including mini modular machines Max Application size (Mbytes) Scalable(10) Scalable(10) Scalable(10) 100MB 100MB 20MB 12MB Communication fieldbus and network performance Embedded OPCUA Server (20000 variables) Modbus TCP Client (60 devices)(1) OPCUA Server (20000 variables) OPCUA Client EtherNet/IP (32 devices @20ms RPI)(1) Modbus TCP Client (60 devices)(1) Modbus TCP Server (800 variables)(1) OPCUA Server (20000 variables) Modbus TCP Client (60 devices)(1) Modbus TCP Server (800 variables)(1) OPCUA Server (5000 variables) EtherNet/IP (16 devices @20ms RPI)(1) Modbus TCP Client (16 devices)(1) OPCUA Server (5000 variables) EtherNet/IP (16 devices @20ms RPI)(1) Modbus TCP Client (16 devices)(1) Modbus TCP Server (800 variables)(1) Modbus RTU 56kbps OPCUA Server (1000 variables) EtherNet/IP (8 devices @20ms RPI)(1) Modbus TCP Client (16 devices)(1) Modbus TCP Server (800 variables)(1) Modbus RTU 56kbps OPCUA Server (200 variables) OPCUA Client Modbus TCP Client (8 devices)(1) Modbus TCP Server (50 variables)(1) Optional Profibus DP through Modbus TCP third party gateway Asi-5/Asi-3 through Modbus TCP third party gateway Profibus DP through Modbus TCP third party gateway Asi-5/Asi-3 through Modbus TCP third party gateway Profibus DP through Modbus TCP third party gateway Asi-5/Asi-3 through Modbus TCP third party gateway Profibus DP through Modbus TCP third party gateway Asi-5/Asi-3 through Modbus TCP third party gateway Profibus DP through Modbus TCP third party gateway Asi-5/Asi-3 through Modbus TCP third party gateway – Connectivity services – MQTT Pub/Sub Open TCP/IP MQTT Pub/Sub Open TCP/IP Open TCP/IP Open TCP/IP Open TCP/IP I/O Discrete I/O channels 1750(3) 1750(3) – 352(2) 112(2) 112(2) Up to 23 (depending on drive reference) Analog I/O channels 1750(3) 1750(3) – 72 112 112 Up to 7 (depending on drive reference) Compatible expansion I/O module ranges(5) Extension I/O – – – 4 Modicon X80 backplane 14 Modicon TM3 14 Modicon TM3 – Remote I/O 16 Modicon X80 backplane(4) 16 Modicon X80 backplane(4) – – – – – References Hardware agnostic(8) Hardware agnostic(8) Hardware agnostic(9) BMED581020 / BMED581020C TM262L01MDESE8T TM251MDESE VW3A3530D(6) / VW3A1111(7) (1) Recommended limit (2) Typical architecture – I/O can increase or decrease depending on the I/O scan rate or change rate, and the auxiliary application load with connected devices, such as Modbus. (3) I/O count can increase or decrease depending on the CPU version used on the host iPC, I/O scan rate or change rate, and the auxiliary application load with connected devices, such as Modbus. The host iPC processor speed greatly affects the performance capabilities of the controller. The performance limits can be increased when using more powerful iPC processors, such as the Intel i5/i7 offerings. (4) BMECRD0100: Ethernet Remote I/O drop adapter for Automation Expert High Availability (5) Consult the DIA3ED2140109EN and DIA6ED2131203EN catalog for additional information on the I/O compatibility. (6) Altivar ATV dPAC module (7) Graphic display terminal for Altivar ATV340 (8) Reference value based on the Harmony P6 Celeron (2 cores) (9) Minimum requirements available in the section Windows – Software dPAC (page 13). (10) Maximum application size can increase or decrease depending on the CPU version on the host iPC. Industrial automation systems EcoStruxure Automation Expert Hardware 16 Presentation (continued) Industrial automation systems EcoStruxure Automation Expert Hardware EcoStruxure Automation Expert Distributed Programmable Automation Controller (dPAC) Platforms (continued) System requirements Linux – Software dPAC System requirements Minimum Performance Required for RT control OS Debian 10.3, Ubuntu 18.04 and 20.04, or Raspbian 32- or 64-bit Ubuntu 20.04 with low-latency patch or other distribution with PREEMPT-RT patch Docker Docker 19.03.8 and above CPU X86/ARM 1 GHz or higher Multi-core X86/ARM 1 GHz or higher Dedicated cores RAM 256 MB 1 GB HDD/SSD 16 GB 32 GB Network interface At least one Network Interface Card (NIC) Two NICs to isolate control and device networks One NIC per container for RT fieldbuses Time synchronization NTPv4 client NTPv4 client support with monotonic and drift compensation Linux – Software dPAC, High Availability(1) System requirements Description Note Processor PC Celeron 4305UE, 2 Core, 2 Threads Need Multi-core X86 processor. ARM is not supported for v24.0 RAM SO-DIMM RAM 4 GB Minimum 4GB. ECC support is optional. Memory M.2 SSD Standard Endurance 128 GB 128 GB is not required. However, it is the lowest that was tested. Network interface RJ45 GbE Ethernet NIC Three NICs are needed for redundant network configuration. • One 1 GB speed NIC for interlink connection • Two 100MB for device network Operating system Linux Ubuntu 20.04 (Harmony P6)/22.04 (ASRock) tested (1) A set of 2 manageable switches compatible with RSTP and having at least 6 physical ports is also needed. Windows – Software dPAC System requirements Minimum Performance Processor 1 GHz 2 GHz or higher RAM(1) 2 GB 4 GB Hard disk free space(1) 1 GB 10 GB Display resolution 1280x1024 1920x1080 or higher Pointing device Mouse or compatible Network interface One Ethernet interface Operating system Microsoft Windows 10 Professional (64-bit) Version 1903 and later, Microsoft Windows 11 Professional Version 21H2 and later, and Microsoft Server Version 2019 (1809 and later) .NET framework .NET 4.8 .NET 4.8 or higher (1) Requirement is indicated for each software package. More than one software package can be installed on the same device. In this case, you need to add the respective RAM and hard disk free space requirements together. For example, if you install the HMI and Archive software packages on the same device, the minimum RAM required is 4 GB (2 GB + 2 GB). 17 Industrial automation systems EcoStruxure Automation Expert Architecture Presentation (continued) Types of standard architectures EcoStruxure Automation Expert breaks the dependency between the application software and the hardware platform it runs. Together with its distribution capabilities, EcoStruxure Automation Expert is a unique automation solution to be used in any kind of architecture, from small machines up to complex process architecture. Example of Soft dPAC standard architecture The EcoStruxure Automation Expert architecture for small machines increases engineering efficiency by using the Automatically generated network transparent communications between controller and HMI objects with many-to-many connectivity and communication protocol for field devices. Example of distributed standard architecture The openness and scalability of the EcoStruxure Automation Expert makes it ready for IT/OT with connectivity AI model by HTTP and apps & analytics in an architecture with distributed controllers. EcoStruxure Automation Expert HMI Switch Field Device Soft dPAC Apps and Analytics Edge M251 dPAC Connected Devices M262 dPAC Distributed IO XPSMCM TM3 TM5 STB ATV320 ATV340 ATV320WS ATV320 (Flex center) TeSys Island 3rd party roller drives Vision system AS-i Gateway Weighing system Barcode reader Motor Control Sensors 3rd Party Products M580 dPAC AS-i Safety Safety Ethernet/IP Harmony P6 PacDrive M580 CIP safety CIP Safety IO 3rd Party PCHMIBSC HMIBMU EcoStruxure Automation Expert Orchestrated AVEVA Automation Expert HMI ATV dPACCRD 18 Industrial automation systems EcoStruxure Automation Expert Architecture Presentation (continued) Example of complex standard architecture The complex architecture below illustrates the extensive possibilities of distributed application for the EcoStruxure Automation Expert solution among the different dPACs. This example is focused on a combination of Modicon M580d and Altivar ATVd dPACs. Control Network ATVd Pumps (6) ATVd Motors (4) ATVd Pumps (2) ATVd Pumps (7) ATVd Motors (2) ATVd Pumps (7) Control Room Standard PC x 1 EAE Embedded HMI x 1 EcoStruxure Automation Expert 19 Industrial automation systems EcoStruxure Automation Expert Architecture Presentation (continued) Types of high-availability architectures The EcoStruxure Automation Expert high-availability system is used for more demanding applications in terms of the availability of the control/ command system where no interruption of the process can be tolerated. The high-availability system with EcoStruxure Automation Expert software helps increase productivity by minimizing process downtime. High-availability Soft dPAC based on Ethernet RIO architecture The high-availability configuration comprises two identical iPCs (industrial computers), each hosting a High-Availability Soft dPAC, and configured to run in a Pair where one instance (a Partner) is driving the process while the other Partner is ready to take over control, if the first one stops working. The two Partners check each other's availability by communicating over two links: • A dedicated cable (the HA Interlink), and • The device network, which also carries commands and diagnostics. In a high-availability Soft dPAC topology based on an Ethernet RIO architecture, devices are hardwired on remote I/O over Ethernet by BMECRD1020 (RIO drop adapter for Modicon X80 I/Os modules). This high-availability system is used for sensitive processes that require a bumpless I/O control takeover time. 1. Linux-based iPC pair, each hosting an instance of High Availability Soft dPAC 2. HA Interlink: 1GB/s Network Interface Card (NIC)/connection 3. Redundant network: 100MB/s with NIC bonding 4. Linux-based standalone iPC, hosting an instance of non-redundant Soft dPAC 5. Non-redundant Modicon X80 I/O drop with BMECRD0100 RIO drop adapter and redundant power supplies 6. Non-redundant Modicon X80 I/O drop with BMECRD0100 RIO drop adapter and redundant power supplies 7. Remote I/O RSTP - enabled ring network 8. Workstation running EcoStruxure Automation Expert build time, RSTP configuration software 9. Workstation running AVEVA System Platform (ASP), AVEVA Operation Management Interface (OMI), and AVEVA historian. Communication is over OPC UA 10. Workstation running EcoStruxure Automation Expert Runtime HMI 11. Managed switches, for example, Modicon switch 20 Industrial automation systems EcoStruxure Automation Expert Architecture Presentation (continued) Components of a high-availability system High-Availability Soft dPAC pair At the heart of a high-availability architecture are two iPCS - Preferred Primary and Non-Preferred Primary, with identical hardware configurations, based on Linux software connected via a high-speed (1 Gbps) communication link. The Preferred Primary device executes the application program and controls the I/Os located in Modicon X80 drops. The Non-Preferred Primary remains in the background. In the event of a detected error affecting the Primary device, the Standby system switches over automatically, changing over the execution of the application program and control of the I/O to the Standby device with an up-to-date data context. Once the changeover is complete, the Standby device becomes the Primary device while the former Primary device is being cleared from the detected error: when clearance is done, the device reconnects to the standby system and acts as the Standby device. The changeover from Primary to Standby is performed smoothly at the outputs and is completely transparent to the process. Modicon X80 Redundant power supplies and compatible backplanes For high-availability applications, two BMXCPS●●02 redundant power supplies can be used on the same rack to increase the availability of power supply. They are supported by 6-slot BMEXBP0602 backplane and 10-slot BMEXBP1002 backplane equipped with dual slots marked CPS1 and CPS2. On CPS1 slot, the power supply is initially set as Primary and on CPS2 slot, as Standby. When power stops being supplied in accordance with expected rate, they switch roles so that power can be continuously delivered. See Modicon X80 modules catalog for more details. Example of complex high-availability architecture The complex architecture illustrates the extensive possibilities of the High-Availability Soft dPAC in terms of cross-communication, RIO and DIO networks: 1. Linux-based iPC pair, each hosting an instance of High Availability Soft dPAC 2. HA Interlink: 1GB/s NIC/connection 3. Redundant network: 100MB/s with NIC bonding 4. Remote I/O RSTP enabled ring network 5. Non-redundant X80 I/O drop with: - BMECRD0100 RIO drop adapter - Redundant power supplies on the main backplane - Extended main backplane 6. Distributed I/O connected to field devices (sensors, actuators) 7. Non-redundant Modicon X80 I/O drop with BMECRD0100 RIO drop adapter 8. BMEAHI0812/BMEAHO0412 Hart I/O modules 9. Modbus TCP devices in an Intelligent power and motor control center (including PM5500 power meter series and MasterPact MTZ) connected to TeSysT motor controllers and Altivar processors 10. Managed switches 11. Workstation running AVEVA System Platform (ASP), AVEVA Operation Management Interface (OMI), and AVEVA historian Communication is over OPC UA 12. Workstation running EcoStruxure Automation Expert Runtime HMI 13. Cross-communication with Altivar ATVdPAC for motor control 21 Industrial automation systems EcoStruxure Automation Expert Licenses Presentation, references EcoStruxure Automation Expert – Perpetual licensing The EcoStruxure Automation Expert offer provides a simplified approach to the software licensing model. The offer has two categories of licenses – Build and Run. EcoStruxure Automation Expert – Build license The Build software requires a license per seat to create Automation Expert based applications. The Build engineering license provides the capability to create, configure, and manage UAO runtime control applications, HMI, archive, and network/device topologies. The Build licenses can be perpetual or subscription-based(1) and are available in four types: b Trial: The engineering software includes a full function demo mode for 42 days unlicensed. b Lite: A basic set of features is included to focus on machine and small process applications. This license allows the use of machine controller platforms and restricted process control platforms. The limitations of this type of license will be included in future release version 24.1. b Standard: A basic set of features included and can be extended by buying add on licenses to extend functionalities. The add ons that are available with EcoStruxure Automation Expert Standard licenses are: v Asset Link for AVEVA OMI v High Availability Engineering v Asset Link for Bulk Engineering is already included in the Standard engineering license v24.0 b Professional: This type of license includes all currently available features. Any new features available in future releases within the first year following the activation date will be included for the software updates. Each commercial license provides: b The capability to design, develop, simulate with HMI, and commission a complete system b Collaborative engineering (SVN client) plugin b Physical topology editor b Free software updates, within the first 12 months from the activation date b Support desk from 9 am to 5pm b Access to private communities on exchange.se.com for p2p support, libraries, project samples, training material, TVDAs, and so on. (1) For more information, refer to EcoStruxure Automation Expert – Subscription-based licensing Build license compatibility Supported platforms Lite Standard Professional Soft dPAC 1 Max Soft dPAC High Availability 1 Max ATV dPAC M251 dPAC M262 dPAC M580 dPAC 1 Max Add-ons (per seat) Asset Link for Bulk Engineering – Asset Link for AVEVA OMI – Optional High Availability Engineering Optional Optional BUILD Perpetual Lite License (Incl. Asset Link for Bulk Engineering add-on) Basic features High Availability add-on Asset Link for AVEVA OMI add-on (Incl. Asset Link for Bulk Engineering + Asset link for AVEVA OMI + High Availability add-ons) HMI - Panel add-on HMI - Operator Station add-on Standard License Professional License Application License for dPAC RUN Perpetual Application License for Soft dPAC Device Small Micro Large Simplex €/Tiered-pack €/Controller €/User €/User €/Device Version Tiered devices packs *Only for Build = Lite HA 10 Devices* 100 Devices 1000 Devices 5000 Devices 22 Industrial automation systems EcoStruxure Automation Expert Licenses Presentation, references (continued) EcoStruxure Automation Expert – Perpetual licensing (continued) Engineering license references The Build engineering licenses are available in different types: Lite, Standard, or Professional. Standard and Professional licenses can be perpetual or subscription-based(1) and are currently offered for single seat use only. Reference Description EALBTEP24 Lite Engineering License EALBTC Standard Engineering License EALBFC Professional Engineering License EALUAOC Engineering license for UAO vendor The standard engineering license includes the "Asset Link for Bulk Engineering" add-on and allows for the addition of the following add-ons: Reference Description EALBATC Add-on for Asset Link for AVEVA OMI EALBAHC Add-on for High Availability 23 Industrial automation systems EcoStruxure Automation Expert Licenses Presentation, references (continued) EcoStruxure Automation Expert – Perpetual licensing (continued) EcoStruxure Automation Expert – Run licenses In addition to the Build engineering license that is required to create EcoStruxure Automation Expert applications, for the operation and maintenance of the application, each hardware should have a Run license. The Run licenses will be based on the control type of Schneider Electric dPAC controllers and the number of devices connected for the Soft dPAC PC-based control. The Run application licenses are available in perpetual and subscription-based model. For more information, refer to EcoStruxure Automation Expert – Subscription-based licensing. For exact calculation of the number of devices and controller type for the application license, a software license configurator for EcoStruxure Automation Expert is available on our website. Run license compatibility Available Licenses Lite Standard Professional Device Micro Small Large 10 Pack – – 100 Pack – 1000 Pack – 5000 Pack – The available application licenses for dPAC controllers are: Reference Description EALADP Application license for one dPAC runtime instance, DEVICE EALANP Application license for one dPAC runtime instance, NANO EALAMP Application license for one dPAC runtime instance, MICRO EALASP Application license for one dPAC runtime instance, SMALL EALALP Application license for one dPAC runtime instance, LARGE Run Application (A+B+C) Control Control Applicaton A SE or UAO Hardware Select type of controller Devices connected via hardwired or any communication protocols (Modbus, EtherNet/IP, OPC-UA, Profibus) Devices connected via any communication protocols (Modbus, EtherNet/IP, OPC-UA, Profibus) In case of Orchestration or Secondary sensing use cases, EAE Device license = 0.3 * no. of connected devices Control Applicaton B IPC hardware IPC hardware Other Controllers and/or Gateways Control Applicaton C Orchestration DEVICE ATV dPAC M251 dPAC, M262 dPAC M580 dPAC (Ext.Backplane) M580 dPAC (Single Backplane) MICRO SMALL LARGE Tiered devices pack 10 devices* 100 devices 1000 devices 5000 devices EALDXP and EALDHAXP, are only available with Automation Expert Lite Build time EALDXP* EALDCP EALDMP EALDVMP EALDHAXP* EALDHACP EALDHAMP EALDHAVMP Simplex version High Availability version 24 Industrial automation systems EcoStruxure Automation Expert Licenses Presentation, references (continued) EcoStruxure Automation Expert – Perpetual Licensing (continued) The Automation Expert HMI license includes rights to both HMI and Archive runtimes. All runtime licenses are perpetual. Different license types are required depending on the platform on which the runtime is installed, as per the following table: EcoStruxure Automation Expert – HMI license Automation Expert Runtime Platform License type HMI(1) Harmony ST6 HMI range 1 license per HMI runtime instance HMI(1) PC-type HMI (Windows 10/Linux) 1 license per HMI runtime instance (1) Each license includes both Automation Expert HMI and Automation Expert Archive runtime rights. The Automation Expert HMI Runtime licenses are: Reference Description EALH1P Automation Expert HMI Runtime - Panel (ST6) EALH2P Automation Expert HMI Runtime - Operator (iPC) For exact calculation of the number of devices and controller type for the application license, a software license configurator for Automation Expert is available on se.com. Run application license references Reference Description EALDXP(1) Application Standard 10 Devices EALDCP Application Standard 100 Devices EALDMP Application Standard 1000 Devices EALDVMP Application Standard 5000 Devices EALDHAXP(1) Application High Availability 10 Devices EALDHACP Application High Availability 100 Devices EALDHAMP Application High Availability 1000 Devices EALDHAVMP Application High Availability 5000 Devices (1) Only available with Automation Expert Lite build time. Download the HMIBMI, HMIBMO, and HMIP6 ranges catalog 25 Industrial automation systems EcoStruxure Automation Expert Licenses Presentation, references (continued) EcoStruxure Automation Expert – Subscription-based licensing To provide customers with more business and economic model flexibility and reduced obsolescence risk, both Build and Run licenses are available under a subscription-based model consisting of 1-year termed subscriptions. The subscription-based licenses model is available for project business with end-users. Each commercial license provides: b The capability to design, develop, simulate with HMI, and commission a complete system b Collaborative engineering (SVN client) plugin b Physical topology editor b Free software updates b Support desk from 9 am to 5pm b Access to private communities on exchange.se.com for p2p support, libraries, project samples, training material, TVDAs, and so on. Build subscription-based licenses The Build subscription–based licenses are available in three different types: b Trial: The engineering software includes a full function demo mode for 42 days unlicensed. b Standard: A basic set of features equivalent to Standard perpetual-based license. b Professional: this version includes all available features, including: v Asset Link for AVEVA OMI v High Availability Engineering The Build subscription-based licenses are offered for single-seat use only. A license is needed per user. Reference Description EALBTS1 Build - Standard Engineering Yearly EALBTS2 Build - Professional Engineering Yearly Run subscription-based licenses The Run subscription-based licenses are available in two different types: b Standard: for simplex applications. b High Availability: for high availability applications. The Run subscription-based licenses are sized per device. A license is needed per device. To know how to measure the number of devices of your application, refer to the EcoStruxure Automation Expert – Perpetual Licensing. Reference Description EALOMD1 Run - Standard Device Yearly EALOMD2 Run – High Availability Device Yearly Please contact your Schneider Electric representative for additional information. In addition to the advantages included in Perpetual licenses, subscription-based licenses include: b Access to upcoming software releases and features in the scope of your license b Customer adoption support plan, with a Trusted Advisor that will support you to reduce your time to value with each new release and its features, recommend the appropriate evolutions, and support you on license lifecycle and renewal process. Build Subscription (1-year term license, per user) Software Standard License Application Design Service Onsite Training, Lifecycle Consulting, Engineering Service Block of Support Service EAE Configuration Training Cybersecurity Assessment Service Application for Standard Device Professional License (including all options) Included in all packages: Customer Support Plan, Software Assurance, Customer Adoption Management Application for High Availability Device Yearly Services Ad hoc Run Subscription (1-year term license, per device) 26 Presentation, references (continued) Industrial automation systems EcoStruxure Automation Expert Licenses - Example EcoStruxure Automation Expert Licensing – Architecture Example of single high-availability architecture Build license Reference Description No. of Seats EALBTEP24 Lite Engineering License 1 Reference Description No. of Licenses EALBAHC Add-on for High Availability 1 Run license Unit 1 - High Availability Control 50 devices Reference Description No. of Licenses EALBAHC Application High Availability 10 Devices 5 Reference Description No. of Licenses EALH2P Automation Expert HMI Runtime Operator 1 50 Field Devices High Availability 27 Industrial automation systems EcoStruxure Automation Expert Licenses - Example EcoStruxure Automation Expert Licensing – Architecture Example of complex high-availability architecture Build license Reference Description No. of Seats EALBFC Professional Engineering License 1 Run license Unit 1 – High Availability Control 100 devices Reference Description No. of Seats Application High Availability 100 Devices 1EALDHACP Unit 2 – 1 M262d Control 50 devices Reference Description No. of Licenses EALAMP Application license for one dPAC runtime instance, MICRO 1 Unit 3 – Simplex Control 100 devices Reference Description No. of Licenses EALDCP Application Standard 100 Devices 1 100 Field Devices 100 Field Devices 50 Field Devices High Availability M262d Simplex Control Presentation, references (continued) 28 Compatibility Industrial automation systems EcoStruxure Automation Expert Product compatibility according to dPAC platform List of Modicon X80 hardware compatible with Modicon M580 dPAC, Modicon CRD for Simplex/High Availability Soft dPAC (Linux OS) Type Reference Description Compatibility with Modicon M580 dPAC Compatibility with Modicon CRD for Simplex/High Availability Soft dPAC (Linux OS) Rack BMEXBP0400 4-slot Ethernet backplane Yes Yes Rack BMEXBP0400H Ruggedized 4-slot Ethernet backplane Yes Yes Rack BMEXBP0602 6-slot Ethernet backplane redundant PS Yes Yes Rack BMEXBP0602H Ruggedized 6-slot Ethernet backplane redundant PS Yes Yes Rack BMEXBP0800 8-slot Ethernet backplane Yes Yes Rack BMEXBP0800H Ruggedized 8-slot Ethernet backplane Yes Yes Rack BMEXBP1002 10-slot Ethernet backplane redundant PS Yes Yes Rack BMEXBP1002H Ruggedized 10-slot Ethernet backplane redundant PS Yes Yes Rack BMEXBP1200 12-slot Ethernet backplane Yes Yes Rack BMEXBP1200H Ruggedized 12-slot Ethernet backplane Yes Yes Rack BMXXBC008K Backplane extension cable 0.8 m/2.6 ft Yes Yes Rack BMXXBC015K Backplane extension cable 1.5 m/4.9 ft Yes Yes Rack BMXXBC030K Backplane extension cable 3 m/9.8 ft Yes Yes Rack BMXXBC050K Backplane extension cable 5 m/16.4 ft Yes Yes Rack BMXXBC120K Backplane extension cable 12 m/39 ft Yes Yes Rack BMXXBE1000 Standard backplane extender Yes Yes Rack BMXXBE1000H Ruggedized standard backplane extender Yes Yes Rack BMXXBE2005 Backplane extender kit Yes Yes Rack BMXXBP0400 4-slot backplane Yes Yes Rack BMXXBP0400H Ruggedized 4-slot backplane Yes Yes Rack BMXXBP0600 6-slot backplane Yes Yes Rack BMXXBP0600H Ruggedized 6-slot backplane Yes Yes Rack BMXXBP0800 8-slot backplane Yes Yes Rack BMXXBP0800H Ruggedized 8-slot backplane Yes Yes Rack BMXXBP1200 12-slot backplane Yes Yes Rack BMXXBP1200H Ruggedized 12-slot backplane Yes Yes SD card BMXRMS004GPF Optional M580 SD card 4 GB Yes No Analog I/O BMXAMI0410 4 voltage/current isolated high-speed analog inputs Yes Yes Analog I/O BMXAMI0410H Ruggedized 4 voltage/current isolated high-level analog inputs Yes No Analog I/O BMXAMI0800 8 voltage/current non-isolated fast analog inputs Yes No Analog I/O BMXAMI0810 8 voltage/current isolated fast analog inputs Yes Yes Analog I/O BMXAMI0810H Ruggedized 8 voltage/current isolated fast analog inputs Yes Yes Analog I/O BMXAMO0410 4 voltage/current isolated analog outputs Yes Yes Analog I/O BMXAMO0410H Ruggedized 4 voltage/current isolated analog outputs Yes Yes Analog I/O BMXAMO0802 8 current non-isolated analog outputs Yes Yes Analog I/O BMXAMM0600 4 analog inputs - 2 analog outputs Yes No Analog I/O BMXAMM0600H Ruggedized 4 analog inputs - 2 analog outputs Yes No Analog I/O BMXAMO0210 2 isolated analog outputs Yes No Analog I/O BMXAMO0210H Ruggedized 2 voltage/current isolated analog outputs Yes No Analog I/O BMXART0814 8 isolated TC/RTD inputs Yes Yes Analog I/O BMXART0814H Ruggedized 8 isolated TC/RTD inputs Yes Yes Analog I/O BMEAHI0812 8 current isolated analog inputs, HART No Yes Analog I/O BMEAHO0412 4 current isolated high-level analog outputs, HART No Yes Power BMXCPS2000 Standard AC power supply Yes Yes Power BMXCPS2010 Standard isolated DC power supply Yes Yes Power BMXCPS3020 High-power isolated 24 to 48 V DC power supply Yes Yes Power BMXCPS3020H Ruggedized high-power isolated 24 to 48 V DC power supply Yes Yes Power BMXCPS3500 High-power AC power supply Yes Yes Power BMXCPS3500H Ruggedized high-power AC power supply Yes Yes Power BMXCPS3522 Redundant 125 V DC power supply Yes Yes Power BMXCPS3540T High-power 125 V DC power supply Yes Yes Power BMXCPS4002 Redundant AC power supply Yes Yes Power BMXCPS4022 Redundant 24 to 48 V DC power supply Yes Yes Discrete I/O BMXDDI1602 16x 24 V DC sink discrete inputs Yes Yes Discrete I/O BMXDDI1602H Ruggedized 16x 24 V DC sink discrete inputs Yes Yes Discrete I/O BMXDDI3202K 32x 24 V DC sink discrete inputs Yes No Discrete I/O BMXDDI6402K 64x 24 V DC sink discrete inputs Yes Yes Discrete I/O BMXDDM16025 8x 24 V DC discrete inputs, 8x discrete relay outputs Yes No Discrete I/O BMXDDM16025H Ruggedized 8x 24 V DC discrete inputs, 8x discrete relay outputs Yes No Discrete I/O BMXDDO1602 16 transistor source 0.5 A discrete outputs Yes Yes 29 Compatibility (continued) Industrial automation systems EcoStruxure Automation Expert Product compatibility according to dPAC platform List of Modicon X80 hardware compatible with Modicon M580 dPAC, Modicon CRD for Simplex/High Availability Soft dPAC (Linux OS) Type Reference Description Compatibility with Modicon M580 dPAC Compatibility with Modicon CRD for Simplex/High Availability Soft dPAC (Linux OS) Discrete I/O BMXDDO1602H Ruggedized 16 transistor source 0.5 A discrete outputs Yes Yes Discrete I/O BMXDDO6402K 64x transistor source 0.1 A discrete outputs Yes Yes Discrete I/O BMXDRA0815 8 isolated relay outputs Yes No Discrete I/O BMXDRA0815H Ruggedized 8 isolated relay outputs Yes No Discrete I/O BMXDRA1605 16 discrete relay outputs Yes No Discrete I/O BMXDRA1605H Ruggedized 16 discrete relay outputs Yes No Discrete I/O BMXDAI0814 8x 100...120 V AC isolated inputs Yes No Discrete I/O BMXDAI1604 16x 100...120 V AC capacitive inputs Yes No Discrete I/O BMXDAI1604H Ruggedized 16x 100...120 V AC capacitive inputs Yes No Discrete I/O BMXDAO1605 16x 100...240 V AC triac outputs Yes No Discrete I/O BMXDAO1605H Ruggedized 16x 100...240 V AC triac outputs Yes No Discrete I/O BMXDDM16022 8 inputs - 24 V DC - 8 outputs - solid state Yes No Discrete I/O BMXDDM16022H 8 inputs - 24 V DC - 8 outputs - solid state- severe environment Yes No Discrete I/O BMXDDM3202K 16x 24 V DC inputs - 16x solid state outputs Yes No Other BMXNRP0200 Fiber converter MM/LC 2-channel, 100 m/328 ft Yes No Other BMXNRP0201 Fiber converter SM/LC 2-channel, 100 m/328 ft Yes No Expert BMXEHC0800 8 high-speed counter channels Yes No Expert BMXEHC0800H Ruggedized 8 high-speed counter channels Yes No Expert BMXEAE0300 3-channel SSI encoder interface module Yes No Expert BMXEAE0300H Ruggedized 3-channel SSI encoder interface module Yes No 30 List of TM3 hardware compatible with Modicon M251 dPAC and M262 dPAC Type Reference Description Discrete I/O TM3DI16/TM3DI16G 16 discrete inputs Discrete I/O TM3DI32K 32 discrete inputs, HE10 connection Discrete I/O TM3DI8/TM3DI8A/TM3DI8G 8 discrete inputs Discrete I/O TM3DQ8T/TM3DQ8TG 8x 0.5 A transistor source discrete outputs Discrete I/O TM3DQ16T/TM3DQ16TG 16x 0.5 A transistor source discrete outputs Discrete I/O TM3DQ16R/TM3DQ16RG 16x 2 A discrete relay outputs Discrete I/O TM3DQ32TK 32x 0.1 A transistor source discrete outputs, HE10 connection Discrete I/O TM3DQ8U/TM3DQ8UG 8x 0.3 A transistor sink discrete outputs Discrete I/O TM3DQ16U/TM3DQ16UG 16x 0.3 A transistor sink discrete outputs Discrete I/O TM3DQ32UK 32x 0.4 A transistor sink discrete outputs, HE10 connection Analog I/O TM3AI2H/TM3AI2HG 2 high-resolution analog inputs, +-10 V, 0-10 V, 0-20 mA, 4-20 mA, 16-bit, 1 ms Analog I/O TM3AI4/TM3AI4G 4 analog inputs, +-10 V, 0-10 V, 0-20 mA, 4-20 mA, 12-bit, 1 ms Analog I/O TM3AI8/TM3AI8G 8 analog inputs, +-10 V, 0-10 V, 0-20 mA, 4-20 mA, 12-bit, 1 ms Analog I/O TM3AQ2/TM3AG2G 2 analog outputs, +-10 V, 0-10 V, 0-20 mA, 4-20 mA, 12-bit, 1 ms Analog I/O TM3AQ4/TM3AQ4G 4 analog outputs, +-10 V, 0-10 V, 0-20 mA, 4-20 mA, 12-bit, 1 ms Safety I/O TM3SAC5R/TM3SAC5RG CAT3 Safety, 1 function, max. PL d/SIL3, 3 outputs 6 A relays Safety I/O TM3SAF5R/TM3SAF5RG CAT4 Safety, 1 function, max. PL e/SIL3, 3 outputs 6 A relays Safety I/O TM3SAFL5R/TM3SAFL5RG CAT3 Safety, 2 functions, max. PL d/SIL3, 3 outputs 6 A relays Safety I/O TM3SAK6R/TM3SAK6RG CAT4 Safety, 3 functions, max. PL e/SIL3, 3 outputs 6 A relays Mixed analog I/O TM3AM6/TM3AM6G 4 analog outputs, 2 analog inputs, +-10 V, 0-10 V, 0-20 mA, 4-20 mA, 12-bit, 1 ms Thermocouple mixed TM3TM3/TM3TM3G 2 temperature inputs + 1 analog output TC (J, K, R, S, B, T, N, E, C, L) RTD (NI100, NI1000, PT100, PT1000) (+-10 V, 0-10 V) (0-20 mA, 4-20 mA) 16-bit, 100 ms Thermocouple input TM3TI4/TM3TI4G 4 temperature inputs TC (J, K, R, S, B, T, N, E, C, L) RTD (NI100, NI1000, PT100, PT1000), (+-10 V, 0-10 V) (0-20 mA, 4-20 mA) 16-bit, 100 ms Thermocouple input TM3TI8T/TM3TI8TG 8 temperature inputs, NTC, PTC, and TC (J, K, R, S, B, T, N, E, C, L), 16-bit 100 ms Relay I/O TM3DM8R/TM3DM8RG 8x 2 A relay outputs Relay I/O TM3DM24R/TM3DM24RG 24x 2 A relay outputs Relay I/O TM3DQ8R/TM3DQ8RG 8x 2 A relays outputs Other TM3XREC1 TM3 remote receiver module Other TM3XTRA1 TM3 remote transmitter module Other TM3XTYS4 TM3 parallel interface for 4 Tesys motor starters Expert TM3XHSC202/TM3XHSC202G High-speed counting, 2 HSC channels, 10 inputs, 8 outputs Compatibility (continued) Industrial automation systems EcoStruxure Automation Expert Product compatibility according to dPAC platform 31 Compatibility (continued) Industrial automation systems EcoStruxure Automation Expert Product compatibility according to dPAC platform List of Altivar hardware compatible with Altivar ATV dPAC Type Reference Description Compatible Drive ATV340●●●N4 Altivar Machine drives Yes Drive ATV340●●●N4E ≤ D22 Altivar Machine drives No Drive ATV340●●●N4E ≥ D30 Altivar Machine drives Yes Drive ATV630●●●●● ATV630●●●●●F Altivar Process drives Yes Drive ATV650●●●●● ATV650●●●●●E ATV650●●●●●F Altivar Process drives Yes Drive ATV930●●●●● ATV930●●●●●C ATV930●●●●●F Altivar Process drives Yes Drive ATV950●●●●● ATV950●●●●●E ATV950●●●●●F Altivar Process drives Yes Drive ATV660●●●●● ATV680●●●●● Altivar Process drive systems Yes Drive ATV960●●●●● ATV980●●●●● Altivar Process drive systems Yes Drive ATV99●●●●● Altivar Process drive systems Yes Drive ATV6A0●●●●● ATV6B0●●●●● Altivar Process Modular drives Yes Drive ATV9A0●●●●● ATV9B0●●●●● Altivar Process Modular drives Yes Drive ATV6L0●●●●● ATV9L0●●●●● Altivar Process liquid-cooled drives Yes Other VW3A1111 Graphic display terminal Yes Other VW3A1112 Door mounting kit Yes Mixed I/O VW3A3203 Extended I/O module - 6 digital inputs/ 2 digital outputs/2 analog inputs Yes Mixed I/O VW3A3204 Extended relay module - 3 relay outputs Yes Encoder VW3A3420 Digital encoder interface module for Altivar 340 and Altivar 9pp variable speed drives Yes Encoder VW3A3422 Analog encoder interface module for Altivar 340 and Altivar 9pp variable speed drives Yes Encoder VW3A3423 Resolver interface module for Altivar 340 and Altivar 9pp variable speed drives Yes Encoder VW3A3424 HTL encoder interface module for Altivar 340 and Altivar 9pp variable speed drives Yes 32 References Modicon M580 dPAC Local I/O capacity Communication ports Service ports Reference Weight kg/lb Up to 1024 discrete I/O Up to 256 analog I/O 64 MB integrated memory 2 1 BMED581020 BMED581020C 0.848/ 1.872 Standards and certifications The Modicon M580 dPAC automation platform has been developed to comply with the principal national and international standards concerning electronic equipment for industrial automation systems. b Requirements specific to programmable controllers: functional characteristics, immunity, resistance, etc.: IEC/EN 61131-2 and IEC/EN/UL/CSA 61010-2-201 b Requirements specific to power utility automation systems: IEC/EN 61000-6-5, IEC/EN 61850-3 (with installation restrictions) b Requirements specific to railway applications: EN 50155/IEC 60571 (with installation restrictions) b Ex areas: v For USA and Canada: Hazardous location class I, division 2, groups A, B, C, and D v For other countries: CE ATEX (2014/34/EU) or IECEx in defined atmosphere Zone 2 (gas) and/or Zone 22 (dust) b Merchant navy requirements of the major international organizations: unified in IACS (International Association of Classification Societies) b Compliance with European Directives for CE marking: v Low voltage: 2014/35/EU v Electromagnetic compatibility: 2014/30/EU v Machinery: 2006/42/EC Up-to-date information on which certifications have been obtained is available on our website. Modicon M580 dPACs are considered as open equipment and are designed for use in industrial environments, in pollution degree 2, overvoltage category II (IEC 60664-1), and in low-voltage installations, where the main power branch is protected on both wires by devices such as fuses or circuit breakers limiting the current to 15 A for North America and 16 A for the rest of the world. Industrial automation systems EcoStruxure Automation Expert Modicon M580 dPAC BMED581020 EAE_23643079_OPSPH20002 Characteristics Service conditions and recommendations relating to the environment Modicon M580 dPAC automation platform Modicon M580 dPAC harsh I/O platform Temperature Operation 0...60 °C/32...140 °F -25...+70 °C/-13...158 °F Storage -40...85 °C/-40...185 °F -40...85 °C/-40...185 °F Relative humidity (without condensation) Cyclical humidity 5...95% up to 55 °C/131 °F 5...95% up to 55 °C/131 °F Continuous humidity 5...93% up to 55 °C/131 °F 5...93% up to 60 °C/140 °F Altitude Operation 0…2,000 m/0...6,562 ft (full specification: temperature and isolation) 2,000...5,000 m/6,562...16,404 ft (temperature derating: approx. 1 °C/400 m (33.8 °F/1,312 ft), isolation 150 V/1,000 m (3,281 ft)) For accurate temperature derating calculation, refer to IEC 61131-2 Ed 4.0 Annex A Modicon X80 I/O power supply modules BMXCPS2010 BMXCPS3020 BMXCPS3020H BMXCPS3540T BMXCPS2000 BMXCPS3500 BMXCPS3500H BMXCPS4002 Supply voltage Nominal voltage 24 V c 24...48 V c 125 V c 100...240 V a 100...240 V a Limit voltages 18...31.2 V c 18...62.4 V c 100…150 V c 85...264 V a 85...264 V a Nominal frequencies – – – 50/60 Hz 50/60 Hz Limit frequencies – – – 47/63 Hz 47/63 Hz 33 Protective treatment of the Modicon M580 dPAC automation platform The Modicon M580 dPAC platform meets the requirements of "TC" treatment (treatment for all climates). For installations in industrial production workshops or environments corresponding to "TH" treatment (treatment for hot and humid environments), Modicon M580 dPAC must be embedded in enclosures with minimum IP54 protection. The Modicon M580 dPAC platform offers protection to IP20 level and protection against access to terminals (enclosed equipment) (1). They can therefore be installed without an enclosure in reserved-access areas that do not exceed pollution level 2 (control room with no dust-producing machine or activity). Pollution level 2 does not take account of more severe environmental conditions: air pollution by dust, smoke, corrosive or radioactive particles, vapors or salts, molds, insects, etc. (1) In cases where a slot is not occupied by a module, a BMXXEM010 protective cover must be installed. (e): Tests required by European directives (e) and based on IEC/EN 61131-2 standards. Environment tests Immunity to LF interference (e) (1) Name of test Standards Levels Voltage and frequency variations IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11 0.85...1.10 Un - 0.94...1.04 Fn; 4 steps t = 30 min IACS E10; IEC 61000-4-11 0.80 Un...0.90 Fn; 1.20 Un...1.10 Fn; t = 1.5 s/5 s Direct voltage variations IEC/EN 61131-2; IEC 61000-4-29; IACS E10 (PLC not connected to charging battery) 0.85...1.2 Un + ripple: 5% peak; 2 steps t = 30 min Third harmonic IEC/EN 61131-2 H3 (10% Un), 0°/180°; 2 steps t = 5 min Voltage interruptions IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11; IEC 61000-4-29; IACS E10 Power supply immunity: b 10 ms for a and c PS2 (20 ms DS criteria) b Check operating mode for longer interruptions up to 5 s, 85% Un b For IACS, 3 times 30 s in 5 min, 85% Un IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11 For a PS2: b 20% Un, t0: ½ period b 40% Un, cycle 10/12 b 70% Un, cycle 25/30 b 0% Un, cycle 250/300 Voltage shut-down and start-up IEC/EN 61131-2 b Un…0…Un; t = Un/60 s b Umin…0…Umin; t = Umin/5 s b Umin…0.9 Udl…Umin; t = Umin/60 s Magnetic field IEC/EN 61131-2; IEC 61000-4-8 (for MV power stations: IEC 61000-6-5; IEC 61850-3) Power frequency: 50/60 Hz, 100 A/m continuous ...1,000 A/m; t = 3 s; 3 axes IEC 61000-4-10 Oscillatory: 100 kHz...1 MHz, 100 A/m; t = 9 s; 3 axes Conducted common mode disturbances range 0 Hz …150 kHz IEC 61000-4-16 (for MV power stations: IEC 61000-6-5; IEC 61850-3) For remote systems: b 50/60 Hz and c, 300 V, t = 1s b 50/60 Hz and c, 30 V, t = 1 min b 5 Hz…150 kHz, sweep 3 V…30 b For a: 10 V b For c: 10 V cont. or 100 V, t = 1 s Where: b PS1 applies to PLC supplied by battery, PS2 applies to PLC energized from a or c supplies b Un: nominal voltage; Fn: nominal frequency; Udl: detection level with power on (1) Devices must be installed, wired, and maintained in accordance with the instructions provided in the manual "Grounding and Electromagnetic Compatibility of PLC Systems". (2) These tests are performed without an enclosure, with devices fixed on a metal grid and wired as per the recommendations in the manual "Grounding and Electromagnetic Compatibility of PLC systems". (e): Tests required by European directives (e) and based on IEC/EN 61131-2 standards. References (continued) Industrial automation systems EcoStruxure Automation Expert Modicon M580 dPAC 34 References (continued) Modicon CRD, I/O bus over Ethernet for Simplex/High Availability Soft dPAC (Linux OS) RSTP Communication ports Service ports Reference Weight kg/lb 2 1 BMECRD0100 BMECRD0100C 0.848/ 1.872 Standards and certifications The Modicon CRD platform has been developed to comply with the principal national and international standards concerning electronic equipment for industrial automation systems. b Requirements specific to programmable controllers: functional characteristics, immunity, resistance, etc.: IEC/EN 61131-2 and IEC/EN/UL/CSA 61010-2-201 b Requirements specific to power utility automation systems: IEC/EN 61000-6-5, IEC/EN 61850-3 (with installation restrictions) b Requirements specific to railway applications: EN 50155/IEC 60571 (with installation restrictions) b Ex areas: v For USA and Canada: Hazardous location class I, division 2, groups A, B, C, and D v For other countries: CE ATEX (2014/34/EU) or IECEx in defined atmosphere Zone 2 (gas) and/or Zone 22 (dust) b Merchant navy requirements of the major international organizations: unified in IACS (International Association of Classification Societies) b Compliance with European Directives for CE marking: v Low voltage: 2014/35/EU v Electromagnetic compatibility: 2014/30/EU v Machinery: 2006/42/EC Up-to-date information on which certifications have been obtained is available on our website. Modicon CRD is considered as open equipment and are designed for use in industrial environments, in pollution degree 2, overvoltage category II (IEC 60664-1), and in low-voltage installations, where the main power branch is protected on both wires by devices such as fuses or circuit breakers limiting the current to 15 A for North America and 16 A for the rest of the world. Industrial automation systems EcoStruxure Automation Expert Modicon Ethernet Remote I/O BMECRD0100 BMECRD0100_main Characteristics Service conditions and recommendations relating to the environment Modicon CRD automation platform Modicon CRD harsh I/O platform Temperature Operation 0...60 °C/32...140 °F -25...+70 °C/-13...158 °F Storage -40...85 °C/-40...185 °F -40...85 °C/-40...185 °F Relative humidity (without condensation) Cyclical humidity 5...95% up to 55 °C/131 °F 5...95% up to 55 °C/131 °F Continuous humidity 5...93% up to 55 °C/131 °F 5...93% up to 60 °C/140 °F Altitude Operation 0…2,000 m/0...6,562 ft (full specification: temperature and isolation) 2,000...5,000 m/6,562...16,404 ft (temperature derating: approx. 1 °C/400 m (33.8 °F/1,312 ft), isolation 150 V/1,000 m (3,281 ft)) For accurate temperature derating calculation, refer to IEC 61131-2 Ed 4.0 Annex A Modicon X80 I/O power supply modules BMXCPS2010 BMXCPS3020 BMXCPS3020H BMXCPS3540T BMXCPS2000 BMXCPS3500 BMXCPS3500H BMXCPS4002 BMXCPS4002S BMXCPS4002H Supply voltage Nominal voltage 24 V c 24...48 V c 125 V c 100...240 V a 100...240 V a Limit voltages 18...31.2 V c 18...62.4 V c 100…150 V c 85...264 V a 85...264 V a Nominal frequencies – – – 50/60 Hz 50/60 Hz Limit frequencies – – – 47/63 Hz 47/63 Hz 35 Protective treatment of the Modicon CRD automation platform The Modicon CRD platform meets the requirements of "TC" treatment (treatment for all climates). For installations in industrial production workshops or environments corresponding to "TH" treatment (treatment for hot and humid environments), Modicon CRD must be embedded in enclosures with minimum IP54 protection. The Modicon CRD platform offers protection to IP20 level and protection against access to terminals (enclosed equipment) (1). They can therefore be installed without an enclosure in reserved-access areas that do not exceed pollution level 2 (control room with no dust-producing machine or activity). Pollution level 2 does not take account of more severe environmental conditions: air pollution by dust, smoke, corrosive or radioactive particles, vapors or salts, molds, insects, etc. (1) In cases where a slot is not occupied by a module, a BMXXEM010 protective cover must be installed. (e): Tests required by European directives (e) and based on IEC/EN 61131-2 standards. Environment tests Immunity to LF interference (e) (1) Name of test Standards Levels Voltage and frequency variations IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11 0.85...1.10 Un - 0.94...1.04 Fn; 4 steps t = 30 min IACS E10; IEC 61000-4-11 0.80 Un...0.90 Fn; 1.20 Un...1.10 Fn; t = 1.5 s/5 s Direct voltage variations IEC/EN 61131-2; IEC 61000-4-29; IACS E10 (PLC not connected to charging battery) 0.85...1.2 Un + ripple: 5% peak; 2 steps t = 30 min Third harmonic IEC/EN 61131-2 H3 (10% Un), 0°/180°; 2 steps t = 5 min Voltage interruptions IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11; IEC 61000-4-29; IACS E10 Power supply immunity: b 10 ms for a and c PS2 (20 ms DS criteria) b Check operating mode for longer interruptions up to 5 s, 85% Un b For IACS, 3 times 30 s in 5 min, 85% Un IEC/EN 61131-2; IEC/EN 61000-6-2; IEC 61000-4-11 For a PS2: b 20% Un, t0: ½ period b 40% Un, cycle 10/12 b 70% Un, cycle 25/30 b 0% Un, cycle 250/300 Voltage shut-down and start-up IEC/EN 61131-2 b Un…0…Un; t = Un/60 s b Umin…0…Umin; t = Umin/5 s b Umin…0.9 Udl…Umin; t = Umin/60 s Magnetic field IEC/EN 61131-2; IEC 61000-4-8 (for MV power stations: IEC 61000-6-5; IEC 61850-3) Power frequency: 50/60 Hz, 100 A/m continuous ...1,000 A/m; t = 3 s; 3 axes IEC 61000-4-10 Oscillatory: 100 kHz...1 MHz, 100 A/m; t = 9 s; 3 axes Conducted common mode disturbances range 0 Hz …150 kHz IEC 61000-4-16 (for MV power stations: IEC 61000-6-5; IEC 61850-3) For remote systems: b 50/60 Hz and c, 300 V, t = 1s b 50/60 Hz and c, 30 V, t = 1 min b 5 Hz…150 kHz, sweep 3 V…30 b For a: 10 V b For c: 10 V cont. or 100 V, t = 1 s Where: b PS1 applies to PLC supplied by battery, PS2 applies to PLC energized from a or c supplies b Un: nominal voltage; Fn: nominal frequency; Udl: detection level with power on (1) Devices must be installed, wired, and maintained in accordance with the instructions provided in the manual "Grounding and Electromagnetic Compatibility of PLC Systems". (2) These tests are performed without an enclosure, with devices fixed on a metal grid and wired as per the recommendations in the manual "Grounding and Electromagnetic Compatibility of PLC systems". (e): Tests required by European directives (e) and based on IEC/EN 61131-2 standards. References (continued) Industrial automation systems EcoStruxure Automation Expert Modicon Ethernet Remote I/O 36 Modicon M251 dPAC Local I/O capacity Device ports Service ports Reference Weight kg/lb No embedded I/O, supporting Modicon TM3 I/O expansion modules 2 1 TM251MDESE 0.848/ 1.872 Standards and certifications b Standards v IEC/EN 61131-2 (Edition 2 2007) v UL508 v ANSI/ISA 12.12.01-2007 v CSA C22.2 No. 213 and No. 142 b Certifications v e v cULus Listing Mark v RCM v Achilles v UKCA Environmental characteristics Service conditions and recommendations relating to the environment Temperature Operation Vertical installation: -10...35 °C/14...122 °F Horizontal installation: -10...55 °C/14...131 °F Storage -40...70 °C/-40...158 °F Relative humidity (without condensation) Operation 10...95% Storage Altitude Operation 0...2,000 m/0...6,562 ft: complete specification for temperature and exposure Storage 0…3,000 m (0…9,842 ft) Immunity to mechanical stress 1131 b Rail mounting: v 5...8.4 Hz (amplitude 3.5 mm/0.138 in.) v 8.4…150 Hz (acceleration 1 g) b Panel mounting: v 8.7…150 Hz (acceleration 3 g) Merchant Navy 2…13.2 Hz (amplitude 1.0 mm/0.039 in.) 13.2…100 Hz (acceleration 0.7 g) Supply charecteristics Power supply 24 V c Voltage limit Including ripple 19.2...28.8 V c Immunity to micro-cuts Class PS-2 10 ms Max. consumption 45 W References (continued) Industrial automation systems EcoStruxure Automation Expert Modicon M251 dPAC TM251MDESE EAE_23643079_OPSPH20005 37 Modicon M262 dPAC Local I/O capacity Device ports Service ports Reference Weight kg/lb No embedded I/O, supporting Modicon TM3 I/O expansion modules 2 1 TM262L01MDESE8T 0.655/ 1.444 Standards and certifications b Standards v IEC/EN 61131-2 (Edition 2 2007) v UL 61010-1, 61010-2-201 v ANSI/ISA 12.12.01-2007 v CSA C22.2 No. 213, No. 61010-1, No. 61010-2-201 b Certifications v e v cULus, cULus HazLoc Class I Division 2 CSA 22-2 No 213 v RCM v Achilles v KC v EAC Environmental characteristics Service conditions and recommendations relating to the environment Temperature Operation Vertical installation: -20…50 °C/-4…122 °F Horizontal installation: -20…60 °C/-4…140 °F Flat mounting: -20…45 °C/-4…113 °F Storage -40…85 °C/-40…185 °F Relative humidity (without condensation) Operation 5...95% Storage Altitude Operation 0…2,000 m/0…6,562 ft Storage 0…3,000 m (0…9,842 ft) Immunity to mechanical stress 3.5 mm at 2…8.4 Hz 1 gn at 8.4…200 Hz Supply charecteristics Power supply 24 V c (-15...20%) Voltage limit 20.4...28.8 V c Immunity to micro-cuts 0.01 ms Max. consumption 82 W References (continued) Industrial automation systems EcoStruxure Automation Expert Modicon M262 dPAC Modicon M262 dPAC module TM262L01MDESE8T_image 38 Altivar ATV dPAC ATV dPAC module Local I/O capacity Device ports Service ports Reference Weight kg/lb Supporting Altivar Drives I/O embedded, expansion and encoder modules: b Up to 23 discrete I/O b Up to 7 analog I/O b 12 MB integrated memory 2 – VW3A3530D 0.020/ 0.044 Standards and certifications Depending on the specific drive type used for ATV dPAC integration, the standards and certifications must be checked in the corresponding ATV340/600/900 manual. b Standards v EN/IEC 61800-3 v EN/IEC 61800-5-1 v IEC 61000-3-12 v IEC 60721-3 v IEC 61508 v SEMI F47-0706 v UL508C and UL61800-5-1 v RoHS-2 according to EU directive 2002/95/EC v REACH according to EU regulation 1907/2006 b Certifications v CE v UL v CSA v RCM v EAC v ATEX v DNV-GL Environmental characteristics Altivar Process and Altivar Machine drives are designed to operate in a variety of environments, including harsh environments. The conditions stated below are general data and must be verified with the respective ATV600, ATV900, and ATV340 manuals for the specific drive type used. Service conditions and recommendations relating to the environment Temperature Operation As standard: -15...50 °C/+5...122 °F With derating: -15...60 °C/+5...140 °F Storage and transport -40…70 °C/-40…158 °F Relative humidity (without condensation) Operation 5...95% Storage Altitude Operation b 0…1,000 m/0…3,281 ft without derating b 1,000…4,800 m/3,281…15,700 ft with derating of 1% per 100 m/328 ft Protection of drives IP20 to IP55 Withstand to harsh environment b Chemical class 3C3 conforming to IEC/EN 60721-3-3 b Mechanical class 3S3 conforming to IEC/EN 60721-3-3 b Printed circuit boards with protective coating Environmental characteristics Compliance with electromagnetic compatibility requirements has been incorporated into the design of Altivar Process and Altivar Machine drives. They are e marked according to the European EMC directive (2014/30/EU). Note: Depending on the specific drive type used for ATV dPAC integration, the EMC compliance values must be checked in the corresponding ATV340/600/900 manual. References (continued) Industrial automation systems EcoStruxure Automation Expert Altivar ATV dPAC VW3A3530D EAE_23643079_OPSPH20001 39 Graphic display terminal Description Reference Weight kg/lb To be used with ATV340 (ATV600 and ATV900 are equipped with the graphic display terminal as standard) Display 240 x 160 pixels, 8 lines Real-time clock with 10-year backup battery, to keep time when the drive is powered off Protection IP65 To be procured separately for ATV340 (delivered as standard with ATV600 and ATV900) VW3A1111 0.020/ 0.044 Remote mounting kit Description Reference Weight kg/lb Remote mounting kit For remote mounting of graphic display terminal, suitable for ATV340, ATV600, and ATV900 families Protection IP65 VW3A1112 0.020/ 0.044 Remote mounting cordset Description Length (m/ft) Reference Weight kg/lb Remote mounting cordset Equipped with 2 RJ45 connectors for connection of the graphic display terminal to the drive 1/ 3.28 VW3A1104R10 0.050/ 0.110 3/ 9.84 VW3A1104R30 0.150/ 0.331 5/ 16.4 VW3A1104R50 0.250/ 0.551 10/ 32.8 VW3A1104R100 0.500/ 1.102 Connector cable Description Length (m/ft) Reference Weight kg/lb USB/Mini B USB cable for connecting the display terminal to a PC – TCSXCNAMUM3P – VW3A1111 VW3A1112 PF130899PF130903 TCSXCNAMUM3P TCSXCNAMUM3P VW3A1104R10 EAE_23643079_OPSPH20003 References (continued) Industrial automation systems EcoStruxure Automation Expert Altivar ATV dPAC 40 Services Industrial automation systems Schneider Electric offers lifecycle services for your industrial automation systems based on EcoStruxure Automation Expert. Our lifecycle services include field and digital services. We believe, with our advanced processes and tools, we are your trusted expert in field and digital services to help you achieve greater functional safety, efficiency, sustainabilty, and resilience in your plant operations. We offer services that are designed to address your needs as you plan, install, operate, and optimize your industrial automation systems based on EcoStruxure Automation Expert. These include: b Consulting services b Maintenance and support services b Training Services b Migration Services For more information, visit our Industrial Automation Services page. Consulting services Consulting services are about bringing our expertise to help find solutions to some of your key operational challenges. Be it about maximizing the business value from your digital transformation initiatives, identifying improvement opportunities in your industrial automation system lifecycle management plans, or improving your cybersecurity posture and compliance, we can help. Take a look at some of our consulting offerings: Security consulting Our cybersecurity consultants will help you assess and review your EcoStruxure Automation Expert systems to detect gaps, identify risks, uncover any security malpractices, assess your staff's security competencies, provide emergency response services, and more. For more information, visit our Cybersecurity Services page. IA lifecycle consulting Audits performed by our service team provide insights and recommendations to help improve the maintenance plans of industrial automation assets. This service helps identify potential risks to the reliability and maintainability of these assets and plan mitigation actions. Watch the video to learn more about our IA Lifecyle Consulting Service. Maintenance and support services Our maintenance and support offerings help you quickly restore your operations in the event of an unplanned downtime incident. They can also help reduce the risk of occurrence and the associated costs. Take a look at some of our maintenance and support offerings: Extended warranty The extended warranty offer gives you the option to extend the warranty of selected Schneider Electric hardware by up to three years. Note: Please contact your Customer Care Center for offer availability. Spare parts, exchanges, and repairs These solutions help you to respond, in the most optimal manner, to requests for spare parts for your EcoStruxure Automation Expert system based on Schneider Electric hardware. Services include: b Parts management service: Onsite or shared spares inventory, managed by us, to help ensure parts availability, while optimizing costs. b Repair: Product repairs performed onsite when possible, or at our repair centers. b Exchange: A refurbished product is provided in exchange for a product returned with a detected fault. Note: Availability of these services may vary depending on the applicable Schneider Electric hardware. Please contact your Customer Care Center for offer availability. 41 Services (continued) Industrial automation systems Maintenance and support services (continued) Maintenance and support contracts Our Support and Maintenance Service Offers, are a simplified and modular annual support services agreements, designed to provide you with the right level of flexibility and confidence to meet your support and maintenance needs for your industrial automation systems based on EcoStruxure Automation Expert. Available as Advantage Service Plan (ASP) for Automation Control or as Customer FIRST (CF) Program for Automation Control, they offer a pre-packaged set of services relevant to operating & maintaining an EcoStruxure Automation Expert Systems. For further customization, a set of optional services are available. The following table provides a snapshot of the plan: Included Services Support Levels ASP CF Essential Primary Core Support and Services Priority Technical Support Access – NBH(a) SLA(b) SLA (b) mySchneider Portal Access – Premium support Yes Yes Software Version Update(c) Yes Yes Optional services(d) 24/7 Priority Technical Support – Phone Block of Support Hours (a) Normal Business Hours (b) Service Level Agreement (c) Excludes labor and hardware (d) Subject to local availability With the enhancements to EcoStruxure Automation Expert V24.0 licensing system, we will progressively offer a more digital experience for customers seeking to maintain the currency of their EcoStruxure Automation Expert software. With this experience, customers with our support and maintenance service offers, will be able to update, in a self-service mode, their EcoStruxure Automation Expert software installation, as and when installations are ready. Please contact your Customer Care Center for offer availability. Training services Our training services are designed for users to take maximum advantage of our industrial automation systems based on EcoStruxure Automation Expert. Our training catalog includes courses on: b Automation fundamentals b IEC 61499 concepts b EcoStruxure Automation Expert engineering and configuration For more information, please visit our Learning Services Home Page or send us an email. Modernization and migration services Over the years, we have been involved in migrating many major automation systems to Schneider Electric. Our migration services, based on this expertise and complemented by a set of dedicated tools, helps to minimize the risks and costs involved in such upgrades to an open EcoStruxure Automation Expert-based system. The available set of tools and services are outlined below: Tools and services Source platforms Tools and services Reverse engineering Application conversion service Wiring systems for Modicon X80 Schneider Electric Modicon Premium Yes 2023 Yes Rockwell Automation SLC 500 Yes Yes Yes PLC-5 Yes Yes Yes ControlLogix Yes 2023 _ In addition to the above, we can also offer project-specific solutions. Please contact your local service teams for more information. 42 Industrial automation systems EcoStruxure Automation Expert Product reference index Index A ATV340D11N4 31 ATV340D11N4E 31 ATV340D15N4 31 ATV340D15N4E 31 ATV340D18N4 31 ATV340D18N4E 31 ATV340D22N4 31 ATV340D22N4E 31 ATV340D30N4E 31 ATV340D37N4E 31 ATV340D45N4E 31 ATV340D55N4E 31 ATV340D75N4E 31 ATV340U07N4 31 ATV340U07N4E 31 ATV340U15N4 31 ATV340U15N4E 31 ATV340U22N4 31 ATV340U22N4E 31 ATV340U30N4 31 ATV340U30N4E 31 ATV340U40N4 31 ATV340U40N4E 31 ATV340U55N4 31 ATV340U55N4E 31 ATV340U75N4 31 ATV340U75N4E 31 ATV630C11N4 31 ATV630C11N4F 31 ATV630C13N4 31 ATV630C13N4F 31 ATV630C16N4 31 ATV630C16N4F 31 ATV630C20N4F 31 ATV630C22N4 31 ATV630C25N4 31 ATV630C25N4F 31 ATV630C31N4 31 ATV630C31N4F 31 ATV630D11N4 31 ATV630D15N4 31 ATV630D18N4 31 ATV630D22N4 31 ATV630D30N4 31 ATV630D37N4 31 ATV630D45N4 31 ATV630D55N4 31 ATV630D75N4 31 ATV630D90N4 31 ATV630U07N4 31 ATV630U15N4 31 ATV630U22N4 31 ATV630U30N4 31 ATV630U40N4 31 ATV630U55N4 31 ATV630U75N4 31 ATV650C11N4F 31 ATV650C13N4F 31 ATV650C16N4F 31 ATV650C20N4F 31 ATV650C25N4F 31 ATV650C31N4F 31 ATV650D11N4 31 ATV650D11N4E 31 ATV650D15N4 31 ATV650D15N4E 31 ATV650D18N4 31 ATV650D18N4E 31 ATV650D22N4 31 ATV650D22N4E 31 ATV650D30N4 31 ATV650D30N4E 31 ATV650D37N4 31 ATV650D37N4E 31 ATV650D45N4 31 ATV650D45N4E 31 ATV650D55N4 31 ATV650D55N4E 31 ATV650D75N4 31 ATV650D75N4E 31 ATV650D90N4 31 ATV650D90N4E 31 ATV650U07N4 31 ATV650U07N4E 31 ATV650U15N4 31 ATV650U15N4E 31 ATV650U22N4 31 ATV650U22N4E 31 ATV650U30N4 31 ATV650U30N4E 31 ATV650U40N4 31 ATV650U40N4E 31 ATV650U55N4 31 ATV650U55N4E 31 ATV650U75N4 31 ATV650U75N4E 31 ATV660C11Q4X1 31 ATV660C11T4X1 31 ATV660C13Q4X1 31 ATV660C13T4X1 31 ATV660C16Q4X1 31 ATV660C16T4X1 31 ATV660C20Q4X1 31 ATV660C20T4X1 31 ATV660C25Q4X1 31 ATV660C25T4X1 31 ATV660C31Q4X1 31 ATV660C31T4X1 31 ATV660C35Q4X1 31 ATV660C35T4X1 31 ATV660C40Q4X1 31 ATV660C40T4X1 31 ATV660C45Q4X1 31 ATV660C45T4X1 31 ATV660C50Q4X1 31 ATV660C50T4X1 31 ATV660C56Q4X1 31 ATV660C56T4X1 31 ATV660C63Q4X1 31 ATV660C63T4X1 31 ATV660C71Q4X1 31 ATV660C71T4X1 31 ATV660C80Q4X1 31 ATV660C80T4X1 31 ATV680C11Q4X1 31 ATV680C11T4X1 31 ATV680C13Q4X1 31 ATV680C13T4X1 31 ATV680C16Q4X1 31 ATV680C16T4X1 31 ATV680C20Q4X1 31 ATV680C20T4X1 31 ATV680C25Q4X1 31 ATV680C25T4X1 31 ATV680C31Q4X1 31 ATV680C31T4X1 31 ATV680C35Q4X1 31 ATV680C35T4X1 31 ATV680C40Q4X1 31 ATV680C40T4X1 31 ATV680C45Q4X1 31 ATV680C45T4X1 31 ATV680C50Q4X1 31 ATV680C50T4X1 31 ATV680C56Q4X1 31 ATV680C56T4X1 31 ATV680C63Q4X1 31 ATV680C63T4X1 31 ATV680C71Q4X1 31 ATV680C71T4X1 31 ATV680C80Q4X1 31 ATV680C80T4X1 31 ATV6A0C11N6 31 ATV6A0C11Q4 31 ATV6A0C11Q6 31 ATV6A0C11R4 31 ATV6A0C11S6 31 ATV6A0C11T4 31 ATV6A0C11T6 31 ATV6A0C13N6 31 ATV6A0C13Q4 31 ATV6A0C13Q6 31 ATV6A0C13R4 31 ATV6A0C13S6 31 ATV6A0C13T4 31 ATV6A0C13T6 31 ATV6A0C16N6 31 ATV6A0C16Q4 31 ATV6A0C16Q6 31 ATV6A0C16R4 31 ATV6A0C16S6 31 ATV6A0C16T4 31 ATV6A0C16T6 31 ATV6A0C20N6 31 ATV6A0C20Q4 31 ATV6A0C20Q6 31 ATV6A0C20R4 31 ATV6A0C20S6 31 ATV6A0C20T4 31 ATV6A0C20T6 31 ATV6A0C25N6 31 ATV6A0C25Q4 31 ATV6A0C25Q6 31 ATV6A0C25R4 31 ATV6A0C25T4 31 ATV6A0C25T6 31 ATV6A0C31N6 31 ATV6A0C31Q4 31 ATV6A0C31Q6 31 ATV6A0C31R4 31 ATV6A0C31T4 31

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Meetings January 2.00 0.20 6/1/2011 5/31/2013 IESSACIEmeetings003/11 Illumination Engineering Society of South Africa Refresher courses CIE Meetings March 2.00 0.20 E-Learning All Categories SAIMM01353 The Southern African Institute of Mining and Metallurgy E-Learning "An overview of the global lithium mining industry" Engineer 1.00 0.10 Engineering Metallurgical 4/30/2020 4/30/2023 AeSSA21-02-22 Mr Frik-Jan Kruger E-Learning "Electrification of Aerospace", presented on 09 June 2021, 17h30 SA time All Categories 2.00 0.20 Engineering Aeronautical 6/1/2021 6/30/2022 UP-T/L_2023 University of Pretoria (Faculty of Engineering: Built Environment and Information Technology) E-Learning "It's not cool to be an engineer with feelings": Diverse staff and student perceptions of academic resilience Engineer 10.00 1.00 Engineering All Disciplines 11/10/2023 11/10/2023 SAIMM01402 The Southern African Institute of Mining and Metallurgy E-Learning "Training, mentoring and knowledge transfer, futureproofing our industry" A virtual panel discussion Engineer 1.00 0.10 Interpersonal Skills All Disciplines 8/18/2020 8/18/2020 WISA2021-0079-001795 Water Institute of Southern Africa NPC (WISA) E-Learning # WATER 2 ME- INNOVATIONS All Categories 3.00 0.30 Engineering Civil 3/17/2021 3/17/2021 Alerts Information: * mandatory field Alert name * Add a title to the alert, this will be used in the subject of the notification. 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Non Employment Equity Employment Equity Unknown status Leave blank to include all jobs Contract Types Filter jobs by one or more contract types. Permanent Fixed Term Contract Temporary Temporary with possibility of being permanent Student job Internship Freelance Franchise Apprenticeship Leave blank to include all jobs My alerts Create and manage your job alerts. Recieve daily/weekly notifications for jobs that match your specific criteria. Note: Please check your spam and trash folders for sent emails. If you still do not recieve the email please contact support. ENGINERING ELECTRICAL TRADE SENIOR,JUNIOR CADET MINIM , Frequency: Weekly Last notification sent on NEVER Personal details Edit Title Mr Gender Male First name tshingombe Last name tshitadi Ethnicity African Disabled No Is citizen Non South African with a Work Permit Citizenship Congo Republic of the Democratic National ID number Not filled Passport number tircog000910610 Current home location Congo Republic of the Democratic Birth date 1982-10-11 Do you have an unabridged drivers license? No Do you have your own transport? No Email tshingombefiston@gmail.com Mobile number 0725298946 Alternative number Not filled Preferred Job Title engineering electrical Availability 1 Month Willing to relocate? Yes within my country of residence Current salary 250 - 300K Annually Desired salary 150 - 200K Annually Introduction engineering trade Skills Add Adding skills increases your chances of being discovered! Good Panelboard Employment History Please add your full employment history I have no previous work experience Education Please add your qualifications and accreditations I do not have any formal education Profile Completeness 100% Cv Current: Professional Resume_CV - Atlantic International University tshingombe_pdf.pdf Drop file here or click to browse to change My documents Drop file here or click to browse March 6th at 2:48pm Access-to-HE-Diploma-Specification-Policing-2024-25_pdf.pdf Privacy Statement Disclaimer Terms & Conditions SAQA 30,625 Building a world-class National Qualifications Framework for South Africa, which contributes to the full personal development of lifelong learners SAQA 6 days ago Beware of Bogus Qualifications! SAQA was on the ground at the DHET Bogus Awareness Campaign in Johannesburg, spreading the word about the dangers of fraudulent institutions and unregistered qualifications! Location: Pixley Seme & Lillian Ngoyi Streets Mission: Protect students from scams and help them verify accredited institutions & qualifications through the National Qualific ... See More Photo View on Facebook · Share SAQA 7 days ago Wrapping up our SAQA Blitz Campaign Tour at the Kathu Campus of Northern Cape Rural TVET Colleges! We provided valuable information to students and staff about the advantages of obtaining qualifications registered on the NQF #nqfinformationcentre #nqftothepeople #freedom30 Photo View on Facebook · Share SAQA 1 week ago SAQA's 30-Year International Conference – Save the Date! 7-9 October 2025 Location: Gauteng, details TBA A Global Gathering on Education, Skills, and the Future! Join us for a prestigious international conference as we celebrate 30 years of the South African Qualifications Authority (SAQA). This landmark event will bring together global education leaders, policymakers, industry experts, ... See More Photo View on Facebook · Share SAQA 1 week ago The South African Qualifications Authority (SAQA) and City of Johannesburg participated in the DHET's Bogus Institutions Awareness Campaign at the corner of Rissik and Smit streets. SAQA informed the public about the importance of verifying the registration status of a qualification before enrolling and highlighted the various services it provides #KnowyourNQF #bewareofbogusinstitutions #freedo ... See More Photo View on Facebook · Share Can I do SAQA online? Does SAQA recognise Alison courses? AI Overview Yes, Alison courses are recognized in South Africa and by some South African employers. Some Alison courses have even been provisionally accredited as a SETA NQF Level 3 National Certificate in IT. Explanation Alison is a free online platform that offers courses to help people develop their skills and careers. • • Many employers recognize Alison certificates and have helped graduates start their careers, switch jobs, or get promotions. • • Alison's system of accreditation allows employers to verify what someone knows or doesn't know at Certificate or Diploma levels. • • Employers can take the same tests that employees have taken, or watch employees take the same tests again. You can verify your educational qualifications on the National Learners' Records Database (NLRD) via SAQA VeriSearch. Generative AI is experimental. Learn more South Africa - Alison Blog Discover what thousands of Alison's learners across South Africa already know – that free online courses can empower you with new ... Alison Are alison diplomas accredited in south africa ALISON courses are recognized in South Africa and by South African employers, with some courses even receiving provisional accredi... irp-cdn.multiscreensite.com Verify qualifications | South African Government You can verify your educational qualifications on the National Learners' Records Database (NLRD) via SAQA VeriSearch at the South ... South African Government Alison Accreditation Explained 'Here and Now' Competency Based Testing. The proof of the currency of Alison courses is with the employers who recognise the value... Alison Is Alison a diploma? Alison offers hundreds of free, online diploma programmes for those seeking career or vocational training. Our diplomas are available in a wide variety of industries, including healthcare, technology, and business. What's the Difference Between a Diploma vs a Degree? - Alison Alison https://alison.com › diploma-courses › difference-diplom... What is NQF Level 4 equivalent to matric? National Senior Certificate What is NQF Level 4 Qualification Equivalent to? National Qualifications Framework (NQF) Level 4 corresponds to the National Senior Certificate (NSC), which is achieved upon completing Matric or Grade 12. It is equivalent to the Senior Certificate awarded after passing the Matric exams.29 Jul 2024 What is NQF Level 4? Key to Secondary Education in SA Regenesys https://www.regenesys.net › reginsights › what-is-nqf-lev... Can I get a job with Alison certificate? AI Overview Yes, you can potentially get a job with an Alison certificate, particularly for entry-level positions or roles where the specific skills gained from the course are highly valued, although it may not guarantee employment on its own; employers often prioritize practical experience alongside the certification, and the recognition of Alison certificates can vary depending on the industry and location. Key points to consider: Skill demonstration: While an Alison certificate alone might not be enough, it can demonstrate your willingness to learn and acquire new skills in a specific area, which employers value. • • Relevant field: Choose Alison courses aligned with your desired career path to showcase relevant skills to potential employers. • • Combine with experience: Pair your Alison certificate with practical experience, volunteer work, or other certifications to strengthen your application. Where Alison certificates might be beneficial: Entry-level jobs: For roles where basic skills in a particular area are required, an Alison certificate can be a good starting point. • • Remote work: Many online-based jobs may consider Alison certificates for digital marketing, customer service, or administrative skills. • • Upskilling: If you're looking to enhance your existing skillset and demonstrate your commitment to continuous learning, an Alison certificate can be valuable. Generative AI is experimental. Learn more Can You Get A Job with Alison Certificate in South Africa | TikTok 24 Feb 2025 — 23421w ago. missruguruu. Natasha | SOLO TRAVELER. Replying to @Lisa 😊 #remotework can include. •Digital Marketing. •Onli... TikTok I want to know more about Alison certifications. Does it attract ... 09 Sept 2023 — How good are alison.com courses? Can we add them in our resume? A big Yes! They are definitely helpful and you can def... Quora South Africa - Alison Blog Are Alison Certificates Recognised in South Africa? Yes! Alison is a popular free online skills and career development platform in... Alison Meet the African Businesses Hiring Alison's Graduates - Alison Blog 22 Mar 2024 — Looking for a job in Kenya, Nigeria, South Africa or beyond? Discover how millions of Alison graduates across Africa ha... Alison I just acquired an IT support certificate on Alison. What remote jobs ... 26 Sept 2024 — In my experience, what matters most to employers is whether you have the relevant skills and knowledge for the job, re... Quora Did most people get job with Alison certificates. - Facebook 02 Jan 2025 — Guys you can get Employment with a Alison qualification. Where I work there is a Safety Officer with a Alison certifica... Facebook · Alison- Free online courses Alison Graduates Get Jobs Alison Graduates Get Jobs | Alison Help Center. ... Over 50% of respondents to the Alison Learner and Graduate Survey stated their... Alison Help Center Show more Does an Alison certificate expire? AI Overview No, Alison certificates do not expire. They are lifelong achievements that can be used to highlight your commitment to learning on your CV or LinkedIn. Explanation Alison certificates are always current because employers can challenge them at any time. • • Alison certificates are compatible with global CPD requirements and can be used to meet CPD requirements. • • You can verify your Alison certificate by scanning the QR code on your certificate with a QR code scanner on your smartphone or tablet. This will redirect you to the Alison website where your certificate will be verified. Additional information Alison offers free online courses and diplomas. • • Alison also offers a Premium Monthly subscription that includes additional features and benefits, such as ad-free learning and exclusive monthly discounts. • • To become an Alison Graduate, you must successfully complete your chosen course and achieve at least 80% in all assessments. Generative AI is experimental. Learn more Alison Accreditation Explained An Alison certification is always current because it can always be challenged by an employer who wishes to test the certificate ho... Alison How do I add my completed course to LinkedIn? - Alison Help Center Name = Name of course. Issuing Organization = Alison - Free Online Learning. Time period: From = The date you completed the course... Alison Help Center How much does an Alison Certificate cost? | Alison Pricing PREMIUM. Premium Monthly is an optional, affordable monthly subscription that unlocks additional features and benefits on Alison. Alison Our Alison Certificates and Diplomas are lifelong achievements that ... 18 Jan 2024 — Our Alison Certificates and Diplomas are lifelong achievements that don't have an expiry date. Perfect for CVs and Link... Instagram · alisonlearning Go Premium with Alison Why upgrade to Premium Monthly? * Monthly discounts that never expire. Get a 10% discount every month that will never expire. You... Alison How do I get my Certificate? - Alison Help Center Validate/verify completed courses The Certificate or Diploma that you purchased from Alison includes a QR Code. Use a QR code scan... Alison Help Center Are Alison courses accredited/recognised? This CPD Certification Service provides recognised independent CPD accreditation compatible with global CPD requirements. This mea... Alison Help Center What's the Difference Between a Diploma vs a Degree? - Alison At Alison, our online diploma programmes are more comprehensive than our certificate programmes, focusing on several subjects with... Alison Get your Course Certificate - Alison To become an Alison Graduate you must successfully complete your chosen course, achieving not less than 80% in all assessments. AI... Alison Legal Name of Skills Development Provider(SDP) Qualification information: Qualification / Curriculum Title SAQA ID NQF Level Credits Curriculum Code An Occupational Qualification consists of three (3) components: Knowledge, Practical and Workplace. By completing this form, the institution should indicate a thorough understanding of how an occupational qualification should be implemented. Please study the relevant qualification document, curriculum document and assessment specification document before completing this form (available on the QCTO website www.qcto.org.za) 1 PROPOSED DURATION FOR THIS QUALIFICATION: FROM (insert date): TO (insert date): 2 MODULES AND FACILITATORS/LECTURERS: (list all relevant modules; extend table as required to include all modules) Knowledge Modules: Hours on time-table: Module Code: Facilitator: (Initials & Surname) Highest Qualification: Type of Industry experience & no. of years: Practical Modules: Hours on time-table: Module Code: Facilitator: (Initials & Surname) Highest Qualification: Type of Industry experience & no. of years: Workplace Modules: Curriculum Code: 2 Confirm whether your institution has all the relevant physical resources for the implementation of this qualification as per curriculum requirements: List of required resources as detailed in the Curriculum: (Extend table as required) Module Name: YES: NO: 3 How would your institution ensure that your staff and learners have a thorough understanding of the occupational qualification, including the final External Integrated Summative Assessment? 4 Explain how your institution would quality assure occupational qualifications offered: Legal Name of Skills Development Provider(SDP) Qualification information: Qualification / Curriculum Title SAQA ID NQF Level Credits Curriculum Code Although the QCTO is not prescriptive in the form or manner of learning material that will be used to implement the curriculum, it is nevertheless still important to indicate how the content will be covered. Bear in mind that learning material for this qualification should be aimed at the implementation of all three components that would best benefit the achievement of all competencies, in order for learners to achieve a Statement of Results. The three components (Knowledge, Practical and Workplace) should not be presented in isolation, but should rather be integrated, and any exercises or applied practicals should be occupationally directed (work tasks). Guidelines on the completion of the below matrix: The name(s) of the learning material or text books to be used should be inserted vertically in the yellow blocks: Complete the table by indicating on what pages the content will be covered for each item in all modules in the curriculum (extend the table as required to include ALL MODULES) For example: Learning Material: Module CODE: Manual(Page/s Number): Learning Guide Page/s Number): Educational Teaching Aids: KNOWLEDGE COMPONENT Module 4: Public Service Communication & Administration 334102001-KM-04 Pp 68-94 Pp 59-72 Organisational structure and functions of Departments KM-04-KT01 Pp 68-75 Pp 59-61 Functions and types of policies KM-04-KT02 Pp 76 - 94 Pp 62 – 64 Policy roles and responsibilities KM-04-KT03 Pp 65 - 67 Monitoring & Evaluating Service Delivery KM-04-KT04 Pp 68 - 72 Learning Material: Module CODE: Manual(Page/s Number): Learning Guide Page/s Number): Educational Teaching Aids: KNOWLEDGE COMPONENT PRACTICAL COMPONENT WORKPLACE COMPONENT (may also be in the form of a logbook, covering the competencies required in the workplace) topics Inbox tshingombe fiston 11:34 AM (51 minutes ago) to me Feedback on Security Service Provider Application and Complaint Process Application for Exemption Terms of Section 23(6) Key Points: Applicant Information: Full Name: Tshingombe Fiston Date: January 18, 2025, 6:36 PM Contact: Not provided Application Details: Terms of Section 23(6) of the Private Security Industry Regulation Act 56 of 2001. Despite Section 23(1) and (2), the authority may register any applicant as a security service provider on good cause shown. Requirements include applicant's age, training, and clearance of any criminal offenses in the last ten years. Particulars of Appellant: Full Name: Tshingombe Fiston Contact Address: Not provided Refusal Reasons: Refusal to grant application for registration. Refusal to renew registration. Cancellation or suspension of registration. Conviction of improper conduct. Complaints Management Process: Statutory Mandate: Derived from the Private Security Regulation Act 56 of 2001. Complaint Definition: Dissatisfaction reported to PSIRA regarding the quality of service rendered by a private security service provider. Complaint Handling: Complaints are processed, referred, or dealt with by PSIRA in accordance with the code of conduct and statutory mandate. Security Equipment Definition: Types of Equipment: Alarm systems, safes, satellite tracking devices. Intrusion detection, access control, bomb detection, and fire detection devices. Security containers, X-ray, and communication devices. Improper Conduct: Examples: Operating without registration. Deploying unregistered security officers. Failure to meet training and uniform standards. Non-payment of prescribed wages and allowances. Complaint Resolution: Time Frame: Standard period to finalize any complaint is 30 to 90 days. Common Complaints: Include wage disputes, improper conduct, and training deficiencies. Digital Records: Last Updated: 12-05-2022 Batch Numbers: Batch 383731: Pending since June 28, 2024. Batch 383732: Termination pending since June 29, 2024. Job Career Information: Current Status: Application for registration as a security officer in progress. Job Requirements: Basic salary, education qualifications, and employment history. Ability to work under pressure and interpret legislation. High administrative skills and problem-solving abilities. Investigation and Complaints: Details of Complaints: Complainant Name: Tshingombe Fiston Incident Date: July 14, 2023 Nature of Complaint: Dismissal from job, irregularities in exam processes, and issues with certification. Legal and Administrative Actions: Court Cases: Labour court cases and appeals. Complaints lodged with various authorities including the Office of the Chief Justice. Outcomes: Pending decisions and unresolved issues. Requests for reviews and rescission rulings. Training and Development: Police Community Support Officer (PCSO) Training: Duration: One month initial training. Key Areas: Radio procedures, evidence gathering, crime scene management, human rights, and diversity awareness. Student Placement Programs: Areas of Placement: Financial crime investigation. Estate and asset management. Construction and building engineering. Essential Skills: Planning, organization, communication, technical skills, and teamwork. Expression of Interest and Withdrawals: Record of Interest: Successfully withdrawn from certain roles. Feedback: Encouraged to explore other opportunities within the organization. Freedom of Information Requests: Recent Requests: Request for validation and information under the Freedom of Information Act. Requirements for resubmission and personal data verification. Integrity and Defense: Research Focus: Issues related to justice, education, and low development. Emphasis on technological support and criminal investigations. Summary: Feedback: Comprehensive review of the application, complaint process, and training details provided. Emphasis on proper documentation, clear communication, and adherence to statutory mandates. Virus-free.www.avast.com tshingombe fiston 11:36 AM (48 minutes ago) to me Feedback on Various Topics and Processes NQF Monitoring and Irregularities Key Points: Monitoring Issues: Umalusi monitoring in terms of policy and sections 17 and 18 of the General and Further Education and Training Quality Assurance Act 2001 (Act No. 58 of 2091). Student Records: Integrated information system to provide proof of qualifications for part-time students. Remuneration and Employment: Governed by the Future Educator Act 2006. Irregularities: National Certificate: SAQA includes part-time qualifications. Portfolio: Collection of evidence for students. Judgement and Assessment Key Points: Judgement Need: Describing evidence learning view group lecture approach to assessment. Policing Learner Overview: Introduction to crime information management system. Crime prevention principles and applied communication in policing. Investigative principles and professionalism in policing. Community Policing: Framework: Community policing involves a proactive, problem-oriented approach with interrelated roles of law enforcement officials. Creative Law Response: Policing strategies and tactics are introduced to address underlying causes of crime. Assessor Training and Work-based Assessment Key Points: Purpose: Guide to learning material and assessment protocols. Work-based Holistic Assessment Model: Includes planning, activity forms, and witness testimony. Assessment Standards: Emphasize validity, authenticity, reliability, and standardization. Portfolio Assessment: Components: Collection of evidence, assessor comments, and learner reporting. Technical Competency: Shown through project reports and presentations. Research and Methodology Assessment Key Points: Overview: Research design and methodology for CAPS, NCV, trade, UCPD, SETA, and SASSETA. Participants: Teachers and HODs' responses to research findings. Recommendations: To the Department of Education (DBE) and DHET. Ethical Considerations: Research Design: Includes literature review, data collection, and analysis. Teacher Roles: Attitudes towards integrating technical subjects in civil technology. Library Research and Grant Proposals Key Points: Grant Proposal: Submission details for non-profit and research proposals. Request for Proposal Template: For qualifications and award certificates. Project Overview: National system examination and qualifications framework. Case Studies: Electro Energetical Stability: Reports on rural sector safety and resource management. Training Support: For learners in electro energetical systems. Project Goals: Workplace Training: Regulation and irregularity in attendance and outcome criteria. Resource Allocation: Value breakdown and retrospective cost projections. Summary Feedback: Comprehensive Review: Covering various topics including NQF monitoring, judgement and assessment, assessor training, research methodology, library research, and grant proposals. Documentation: Emphasis on proper documentation, clear communication, and adherence to statutory mandates and assessment standards. Recommendations: To improve processes and address irregularities in the education and training systems. Virus-free.www.avast.com tshingombe fiston 11:39 AM (45 minutes ago) to me ISC2 Security Congress 2025 Proposal Submission Details Submission Type: Call for Papers Proposals Presentation Proposal Status: Complete Presentation Proposal ID: 2070815 Presentation Proposal Title: Thesis Master Engineering Thesis Master Doctoral Engineering Electrical Subject Curriculum Framework Qualification Education Technology Speaker Information Speaker Name: Tshingombe Tshi Tshitadi Role: Facilitator Pronouns: He/him/his Presentation Proposal Details Audience Experience Level General (Everyone will obtain value) Early (0-3 years) Mid (4-9 years) Senior (10+ years) Audience Career Track All Engineering/Architecture Management/Executive Operational/Tactical Preferred Presentation Type Breakout Session Bright Ideas Roundtable Full Description Proposal of Thesis Content / Final Project Content: Name of Thesis Index Introduction Description General Analyzing Key Differentiator / Originality: Description: At the heart of solutions to framework qualification and national trade implementation sub-sector training. Trainer experimental workplace industrial, more students and institutes, college trade years external internal work value increase price macro. Content Area: Governance, Risk, and Compliance (GRC) Additional Details/Supporting Information Recommendation/Endorsement: 3.4 Synopsis of Content: The stability design, projection system trade marketing board, information system electrokinematic dynamic physical state engineering science introduction, used to trade theory electrical, manufacture process inventory low stamp system low stable loadshedding week manufacture. What prompted you to submit a proposal? Email Have you presented this session or content at any other conferences, webinars, or events? Yes If Yes, what other conference(s) or event(s) was this content presented at? 3.4 Synopsis of Content: The stability design projection system trade marketing board, information system electrokinematic dynamic physical state engineering science introduction, used to trade theory electrical, manufacture process inventory low stamp system low stable loadshedding week manufacture. Prior Speaking Engagements/Experience: Engineering Webcasts, Podcasts, & Videos: 3.4 Synopsis of Content: The stability design projection system trade marketing board, information system electrokinematic dynamic physical state engineering science introduction, used to trade theory electrical, manufacture process inventory low stamp system low stable loadshedding week manufacture. Books, Papers, Etc.: 3.4 Synopsis of Content: The stability design projection system trade marketing board, information system electrokinematic dynamic physical state engineering science introduction, used to trade theory electrical, manufacture process inventory low stamp system low stable loadshedding week manufacture. Would you like to be contacted about additional opportunities to contribute as a speaker or writer for other ISC2 programs? Speaking on Webcasts Speaking at other Virtual Events Speaking at Future Security Congress Speaking at In-Person Events Speaking at ISC2 Chapter Events Authoring Content for Magazine Articles/Newsletter/Blogs Authoring and/or Reviewing Content for Professional Development Would you like to be part of a speaker database, made available to ISC2 Chapters? Yes Additional Demographics Collection Questions ISC2 is committed to ensuring the cybersecurity profession is as diverse, equitable, and inclusive as the world we serve. Age: 45-54 Nationality: Congolese (DRC) Gender: Man Pronouns: He/his Ethnicity/Race (US): American Indian or Alaska Native US: If you selected "Other ethnic group", please list it below: Black Ethnicity/Race (UK): Mixed or Multiple Ethnic Groups (White and Black Caribbean, White and Black African, White and Asian, Any other Mixed or Multiple ethnic background) UK: If you selected "Other ethnic group", please list it below: UK Highest level of education (US): High school graduate, diploma or the equivalent (for example: GED) Highest level of education (UK): College or university Preferred spoken/written language: English Do you identify as a member of any of the following groups? Veteran or Prior Armed Forces Service Deadline All submissions must be received no later than 11:59 p.m. ET on Feb. 28, 2025. Deadline subject to change per the discretion of ISC2. Virus-free.www.avast.com tshingombe fiston 11:43 AM (42 minutes ago) to me ISC2 Security Congress 2025: Call for Presentations Your Feedback Submission Details Date Submitted: Dec 27, 2024, 9:10 AM Feedback ID: [Not provided] Submission Type: Call for Papers Proposals Presentation Proposal Status Status: Complete Presentation Proposal ID: 2070815 Title: Thesis Master Engineering Thesis Master Doctoral Engineering Electrical Subject Curriculum Framework Qualification Education Technology Speaker Information Speaker Name: Tshingombe Tshitadi Role: Facilitator Pronouns: He/him/his Feedback Content Overview of Topics Submitted Locksmith / Safe Technician Management Skills: General management skills applied to the role of locksmith and safe technician. Health and Safety: Emphasis on applying health and safety standards in the workplace. Traffic Management Vehicle Identification: Accurate identification of vehicle types and configurations. Operational Procedures: Data captured and assessed according to standard operational procedures and legislation. Road Traffic Management: Includes traffic signal design, installation, and maintenance. Electrical and Electronic Engineering Professional Skills: Usage of digital electronics, advanced telecommunications, and data transmission systems. Maintenance and Repair: Installation, maintenance, and repair of electrical and electronic systems. Traffic Signal Installation Planning and Design: In-depth planning and design by skilled professionals. Operational Supervision: Effective supervision and control during installation to ensure compliance with specifications. Security Practice in Education Security Concepts: Introduction to basic security concepts and administrative procedures. Criminal Investigation: Overview of criminal investigation techniques and the role of technology in security. Labour Relations and Mediation Pension Funds Act: Application of the Pension Funds Act to the administration of retirement funds. Labour Conciliation: Conducting conciliation processes and understanding labour relations legislation. Skill Development in Legislation and Training Sector Training Authorities: Emphasis on skills development and adherence to safety standards. Workshop Tools: Proper use and maintenance of workshop tools in various engineering tasks. Additional Comments Diversity and Inclusion: Emphasis on ensuring the cybersecurity profession is diverse, equitable, and inclusive. Demographic Information: Collection of demographic data to assess representation and improve processes. Recommendations Continued Education: Importance of continuing education and skill transfer in various fields. Practical Training: Emphasis on practical training and on-the-job experience to ensure comprehensive skill development. Feedback: Detailed and constructive feedback provided to improve future submissions and ensure alignment with ISC2 standards. Conclusion Thank you for submitting feedback to ISC2 Security Congress 2025. Your detailed insights and recommendations are highly valued and will contribute to the ongoing improvement of our processes and programs. We look forward to your continued participation and engagement in ISC2 events. Virus-free.www.avast.com tshingombe fiston 11:46 AM (38 minutes ago) Virus-free.www.avast.com tshingombe fiston 11:50 AM (34 minutes ago) to me ISC2 Security Congress 2025: Call for Presentations Your Feedback Submission Details Date Submitted: Jan 18, 2025 Submission Type: Call for Papers Proposals Presentation Proposal Status Status: Complete Presentation Proposal ID: [Not provided] Speaker Information Speaker Name: Tshingombe Fiston Role: Project Lead Pronouns: [Not provided] Feedback Content Overview of Topics Submitted Application for Exemption Terms of Section 23(6) Private Security Industry Regulation Act 56 of 2001: Despite provisions of sections 23(1) and (2), the authority may register any applicant as a security service provider on good cause shown. Applicant Requirements: Includes age, training, and clearance of any criminal offenses in the last ten years. Complaints Management Process Statutory Mandate: Derived from the Private Security Regulation Act 56 of 2001. Complaint Definition: Dissatisfaction reported to PSIRA regarding the quality of service rendered by a private security service provider. Complaint Handling: Complaints are processed, referred, or dealt with by PSIRA in accordance with the code of conduct and statutory mandate. Security Equipment Definition Types of Equipment: Alarm systems, safes, satellite tracking devices. Intrusion detection, access control, bomb detection, and fire detection devices. Security containers, X-ray, and communication devices. Improper Conduct Examples: Operating without registration. Deploying unregistered security officers. Failure to meet training and uniform standards. Non-payment of prescribed wages and allowances. Recommendations Continued Education: Importance of continuing education and skill transfer in various fields. Practical Training: Emphasis on practical training and on-the-job experience to ensure comprehensive skill development. Feedback: Detailed and constructive feedback provided to improve future submissions and ensure alignment with ISC2 standards. Conclusion Thank you for submitting feedback to ISC2 Security Congress 2025. Your detailed insights and recommendations are highly valued and will contribute to the ongoing improvement of our processes and programs. We look forward to your continued participation and engagement in ISC2 events. Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 1 of 18 Cookies We use some essential cookies to make our website work. We'd like to set additional cookies so we can remember your preferences and understand how you use our site. You can manage your preferences and cookie settings at any time by clicking on "Customise Cookies" below. For more information on how we use cookies, please see our Cookies notice. Title Ms Accept cookies Close Progress Review Review Back Review Review Surname tshitadi Your details Your details First name tshingombe Company name Email address Phone number 0725298946 Your request Your details Your request Review Change tshingombefiston@gmail.com Change Reject cookies Sorry, there was a technical problem. Please try again. Request an intellectual property (IP) licence tshingombe enging/st peace college Customise cookies Your cookie preferences have been saved. You can update your cookie settings at any time on the cookies page. Your cookie preferences have been saved. You can update your cookie settings at any time on the cookies page. Request an intellectual property (IP) licence To understand how your data is collected and handled read our privacy notice. 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 2 of 18 Your request Select the option that most applies to you Request an intellectual property (IP) licence to use a trademark belonging to the Met or Mayor's Office for Policing and Crime (MOPAC) for any purpose Details of your enquiry Letter experimental job experience: theoretical practical n diploma, employees learner n diplomat ,basic advance filing ,posted minim cadet junior senior principle trademarks Workbased - Microsoft certification close Pearson instituts Graduate institute high Education. -Department : DHET high act No,101 of 1997 ,as private.reg high Education reg Certificate No:2004/HE7/004 -accreditation qualities (HEQC),(CHE. continuing and training,act No16 of 2006 amendment,NQF ,act No 67 of 2008 ,as amended , determination phase N1-N3 term ,sect 42(1)(a) training dhet ,N1-N3 juanert ,2024 , dr zimande trade test ,trade occupation revise.. Record transcription academic , -- -bakc log ,Sita -Ref saqa . -pearson instituts/St peace college instituts, Africa police instituts , Intec institute, saqa foreigners instituts -- -Qualification|minimum admin req--- - foundation| national NSC certificate -- Programme| diploma ordegre - bachelor. | International school. Degree |living certificate,accompani | Saqa certificate | national senior NSC NQF | Exemption certificate usaf -- Honours. | A recognised under grad Degree | degree module level -- Point institute Pearson NSC%. |90-100%|80-89%|70-79%|60-69% |50-59%||40-49|30-39|-- Ncv%. | Nated%| Ucpd%| -- Faculty humanities :/ Bachelor of arts , Saqa I'd : 62761|NQF level: career opportunities child care communication humanity resource management marketing research , public relations research teaching writing -nated : educare : subject record transcription, personal training facilitator assessor saqa Ncv abet NC's matric technical record : Lecture - -- -bachelor of arty in graphics design saqa ,ID : 99332 ,NQF level : career opportunities advertising branding design ,3 D modelling animation broadcasting copy writing desktop publishing layour and illustrations entrepreneurship web design. - Nated : drawing engineering,PC business record -- Bachelor of arts in journalism saqa I'd : 488832 NQF : level 7 : career opportunities communication editorial work for magazine communication editorial work and news papers journalism , - presenting television social media research . Education actually technologie Nated : media record prensted rwiten-- -faculty of applied sciences. - bachelor's of science in computer science saqa : is 74131 NQF,6 level 7 career database administration IT management net work admnistration programming software developer system analyse project administrator specialist enterprise architecture and open system : - Bachelor of science saqa ,ID 62754,NQF level : Career opportunities business analysis database administrator IT management project management specialist position.it system analyst .. -bachelor science in internet communications saqa ,ID : 6274 NQF : level ,: Career journalism networks administration technical liason technical writing web editing . - bachelor's of science in biomedical,saw I'd : 6275 NQF , Level: career scientifice communication technical position in laboratory project management academic research. Management science communication technical , - bachelor of science honour information technology , .ID saqa : 84566 ,NQF level 8 . Career opportunities: academic it manages programming project administrator specialise Technical position position in data mining and entrepreneurship architecture system analyse -- Faculty of commerce and low ,saqa 48858 NQF level , admnistration:career opportunities business business consultant economist entrepreneurs.- bachelor of commerce in accounting: Career auditing budget financial management ,tax consultant account charted financial cost . - bachelor's commerce hr manager consulting personnel consultants recruitment training and development employment relations manager and count. - bachelor's of commerce low business administration entrepreneurs politics . - saqa I'd commerce in marketing manager I'd 488822 advertising sales manager marketing Anat media ,to - tourism management is eco, tourism planning event strategies, market research bachelor's of commerce in business management,saqa ID 84326 NQF level 8 counseling entrepreneurs management. ----------- Faculty engineering: Bachelor Nated saqa I'd lecture learner Bachelor nated trade engineering trade Distance :level 7, degree I'd: instituts engineering council engineering electrical instituts engineering Bachelor: Faculty, police police instituts Saqa instituts: level 7, degrees Bachelor:--trade sector training trainer bachelor's Serta ,seta career opportunities guide schools leavers , university of technology,and university leaver,and college leavers . Career ICT : information communication , technology ICT: technical skills research design development testing installation commissioning maintained product software prodt modem via media land wireless.. - computer. | NQF|4|5|6|7|8| total req networking|lev3|. | | Occupation code 263101: developm program 261302 ICT business analyst 261303 ICT customer support officer 313104 computer system technical 263193 system ,test engineering ICT : securite special ICT : project manager ICT : sales represent - systeme representative system analysis project , database admnistration telecommunication,web development network ______________________________ ICT Microsoft office Occupation | recommend It| recommend -13510-projec| language,c#,have,ado,asi,nsd Management| Database ,Oracle,htk,sap java,net .. - 31314 , systeme techniciens| hardware at, ICT support engineering PC network and Eng - description of the top ICT occupation: Project plan organise direct control co-ordinate qualifition account day to day operations of resourcing schedule priority. Task : skill analizing need. - software engineer design modified documents test implementation installation software support with . -ict : assurance ,create maintence manage quality assurance functionalite performance of PC audit ensuring compliance accreditation scheduled qualifications inspection analysed review system data docut, identified potential risk area in security non compliance with stolen detect. - network ,systt plan deployment test optimisation taking responsibility analizing interpretation data model in developm research monitoring assessing improve network , provided network performance. - ICT securite special established organisat ICT securite procedures ensure prevention recovery strategy internal exterior , ensure prevet recovery strat . - customer support Offit provide support Education developm maintence infrastructure resolution technical problem issue may work. - determined hardware response program to meet usase installation appropriate soft , implementation PC network,repairs performance. -business selling compagny using director ,quotat price record order ,monitor client competition active maintenat submitted record business. - continuing and training,act No16 of 2006 amendment,NQF ,act No 67 of 2008 ,as amended , determination phase N1-N3 term ,sect 42(1)(a) training dhet ,N1-N3 juanert ,2024 , dr zimande trade test ,trade occupation revise..-- -testability checklist at the schematic level. - testability checklist at the PCB layout level , - revising design. Win existing ICT creating a test point report manufacture.,PC designer PCB relay project status information,PLC. - PLC wiring ,main breaker switch busbar circuit breaker SMP digital input output analif input terminal. -reaning PLC wiring diagram, profit bus communication PLC , digital input card diagram ,PLC digital -1. requirement: .letter experimental work based log activities theoretical practical school institutes employees learner , orientation practical school disciplinary didactic work based, -1.1 explanation assessment :trade claim inventory low Triggered: gitlab,/ GitHub /azure Issue test .. -Triggered electronic elektor technologies -Circuit microcontroller ,, -Gitlab ,fail running Issue kananga ,, Engineering tshingombe Project ,committed contributing ,code source ... 36..Explanation: gitlab ,GitHub azure data ,work Running -projects , pinned , issues,merge , request, contributors analytic , - repository analyse: Manage,plan ,code , building, secure, deployed, operate , monitoring. - measured in byte code exclude generated . - percentage , ,- coverage static for main mars 26-jun 24.. September Bi Weet code covered. Commit statict for main may 09-june 24.-august -total 4 commit , average per day , authoritie. Drag up date kananga5 .. overview commit pipeline., assignment, review milestone,time participate: Issues... Project code source , Marketing --- Azure :,work item ,epic printed Pipe line , ,test pipe - measure in byte: project existing Engineering tshingombe ___________________________________ -github : tshingombe Issue contribution, Repository: run project code data source Pipeline: Repository: -Dhet St peace college running projection: Contribution GitHub collectivity; __--- -38. pratical school: instituts research and development learner lecture vocational - isita project back log dhet and DBE umalusi : pratical school trade experiemental workbased Teaching learning student assessor , student educator technical trade student trainer training student learner facilitator technical ,student : engineering businesses study, Isita project subject engineering electrical : national examination learner topics examin: Time table examination ,n3to n6 orientation industrial , plant operations, electrotechnology ,electric trade theory conduct assessment - project isita project total grand : experiemental theoretical and practical,engineering ,orientation industrial trade theory ,orientation industrial plant operations, orientation industrial electrotechnology -Project low examin rules ,in dhet in high school orientation assessment teaching workplace workshop technologie electrical , technologie construction,technologie ,grade 1to grade 12 technologie, Educational technologie circulum,grade 1,6teach pratical skill trade ,,9-12 teaching orientation technologie electrotechnology, organisation supervisor planing manager supervisor Phase circulum,module conductor, insulation,matter ,AC ,DC current ,AC machine ,DC machine instrument, transmission rectified -Teaching orientation industrial class: grade period basic workshop Orientation . -workplace experiemental relate: explanation , isita in dhet in DBE teaching workshop work class engineering vocational career Guidence -Framework work qualification saqa: Undertake material engineering , Teaching qualify n3subject isita project Council trade, orientation industrial trade occupation trade isita workplace manufacture city power power: technology trade electrotechnology letter topics CVS ,, in DBE teaching technical DBE orientation industrial Eskom ..city power -organisation supervisor duty Eskom city Power Under printed learner assessment self assessment peer in dhet project. ,in dbe teaching grade circulum, orientation industrial Eskom expo science : teaching teach grade electrotechnology orientation, electrotech industrial ,social project computer Back log project skill fund .. ,- orientation industrial CDs ..close tendered-lesson social worker practice Marksheet student orientation industrial time table ,student organisations planing supervisor time table , student educare time time table , student Education,student Engineering studies time table, : student policing traffic , business, pratical office school student marksheet workplace experiemental learner close bid : close material trade theories in dhet in DBE isita ..umalusi - DBE subject workshop grade to working CVS circulum study in trading isita ______________________________ - teaching and lecture Irregularite Pratical material candidate processing learn Regulation back log after Assessment center -non attandance subject appear letter application letter workplace in dhet conduct learner project in dhet Afric instituts training shalom traing ,out mark term Non attandance: subject non registered Irregularite material: subject engineering science , mathematics,electrotechnical , industrial electronicien dhet in DBE ,ucpd Record academic years . -Total subject ,to back log project Management system information learn , policy in DBE trade theory subject registration second additional subject Rwiten subject : extra circular in dhet in DBE pratical regulation . - practice police , orientation life teaching , literature mathematics ncv teach vocational guidance in DBE level 4 certificate pratical skilled panel control wiring electrical DBE workshop development: teaching workplace to trade in DBE panel ,,teach ucpd irregularity project back log printed ... Introduction technologie,workshop electrotechnology , electrotechnic, electromechanical manufacture process 1.3purpose: -planta d shop layout , -insustrial safety , -ferrous materials , -non ferrous materials. -meeting furnaces -properties and testing of metals -heat treatment carpentery . -patter. and core making -foundry tools and equipment -mold and core making . -casting -forgi g . -hot working of metals . - cold working , Sheet metal work,lathe machine drilling plane and sloping -powder metalling . - inspection quality 2.explanation :Manufacturing Engineering: process planing , Claim 2.1 process planing , 2 process sheets, 3 route sheet ,tooling , 5 cutting tools machine tools , traditional,numerical jogs and fixture ,7 jigs and mould ,manufacturing information generation , CNC port program ,10 robor programmers ,11 flexible manufacturing systems ,FM's group , integrated manufacturing cm. -3. Explanation:Production process : process planing. Manufacture process , classification of manufacture row , -primary shopping process size casting melting . -secondary machining process job understanding operational hot working processing forging rolling hot sprinning extrusion hot drawing. 4.explanation cold working process : Cold forging cold rolling heading cold drawing wire stretch forming ,sheet metal working Piercy punching lancing notche. ,coming sequence ,deep drawing. -5.explanatiin join process: reffiling assembly, welding platisc or fusion , -soldering reverting screwing welding plastic,press fitting sinter , bonding shrinking fitting ,explosive welding diffusion welding key and cotter ,coupling and nut and bolt joint .- surface finishing process. -6 explanation:honing lPpi g supper finishing belt grinding, polishing tumbling spraying ,pouring inorganic coatic analizing ,sherodizing parkerzi g galvanizing plastic ,metallic . -7 product simplification and standardization: policy a counting procedure personal policies performance evaluation control of expenditure safety aspect security procedure regulation,design manufacture material and part supplies ,methods of testing drafting method abbreviations -inspection and quality control ,size shape other dimensions involved measure. -mechanization and autonomy Control device increased productivity reduced cost of labour and dependence on labour short improve quality reduce in process inventory reduce dependence on operator in tease safety reduce risk humans fixed automation programmables automation flexible automation . -fixed automation cam . -Product system , manufacturing system . Detailed design prototype development test simulation design manufacture. - computer manufactt..- - factory level production management planing , production management material Requirements planing . - bill of materials capacity planning , inventory - CIM technologt compl networks system design and analysis distribution process , modelling and simulation expert system quality engineering. - CAD :soliD modelling variation computer .-meeits of a good plant layout , reduce machine how workflow process inventory is , manufacture time relatively less floor area is required , material handling is less. - explain types of layout ,fixed or position -men tools component yes , workplace yes ,finished product to store -explanation S.No| line or product layout | process or function Industrial safety ,safety precautions while working different 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 3 of 18 hand tools . Approved : screw drives wrenches ,hammers files chisel,saw tap -engi seeing material yes = metallic material yes or no. Metallic yes , Metal yes ,feroos or non ferouse , steel plain carbon ,allot , Cast ion grey while react metalloid ductile, - non ferrous , aluminium copperwood papperleather ,mineral cement class graphic, - -iron ore heanotite Fe304 colore red ,iron 70%, -magneite (Fe203, colore blanc 72% -lemo ite ,colore brown. 62% siderite ,brow,48% ____ _-explanation market forms of steel structure shapes : laball _free cutting ,c=0,13max,MN=0,7-0,12,,S=0.16 -steel quality ,carbon tools steel Anees ,plain carbons , - Properties: application % tensile strength kg/mm.sq -Typical blast furnace: -Blow yes ,yes stove yes ,blast furnace yes ,slag ,oxygen yes ,mixer , .-basic oxygen produce yes carbon yes Stell ,bessirer convert bessure ,, Basic open heart basic operation , acide open heart ,, electric furnace yes acid , pudding process wraug iron , acide crucible ,steel ,iron ,mealable ,steel , , ____ Tools Plastic plaster ,5wax - factor effecting selection of pattern material,-number of casting to produce metal pattern are prefu required large in number ,type of mould process methods ,of molding hand or machine ,6 degree of dimensions accuracy surface finishing requirements minimum thickness requirements shapes complexity piece cost of pattern chances repeat order . -types ofpatter : -properties of moulding sand refactoring permeable cohesive green ,found sound casting test moisture content test clay chemical composition of sonde ground shape and surface texture of sound grand size distribution sans specific water absorption capacity permeability shatter index ---____________________________________ Explanation: welding process ozyfuel gaz ,air acetylene welding oxyacet, oxyaceten ,oxy - hydrogen welding pressure ,-arc welding process car on arc welding ,sheelded metal arc ,welding , submerged arc welding ,gas tungsten arc welding , resistance welding ,solids state ,welding process theemique radiant energy welding -explanation: claim low machine used in sheet metal shearing machine,bending machine, grooving machines peini g machine ,beading machine ,swaging , machine ,blurring machine,double seaming machine. -types of press -method of operations an born press .methods of power source Manuel press mechanical power hydraulic press , -fitting : explain introduction device equipment tools marking tools , measure device measure instruments, supporting tools holding tools striking tools , cutting tools ,tightening tools .. -explain : inspection and quality control: checking components or product with requirements specification ,tolere Ce on port , interchangeable dimensions. Size numerical value lengthimjte size : .-uppee deviations algebraic difference between the two maximum limited of any size ,low deviations,mean fundamental deviations ,tolerance -fits allowance fit difference hole size and shaft size allowance. Fits yes clearence fit yes sliding fit yes or running fit yes ,,, Interference fit yes or forcefit yes or strink yes press fit .. -control chart : used quality industrial yes maintenance yes continuous yes evaluation yes , manufacture yes, -statistical control yes ,device cast yes , -surface finish yes ,routines primary yes ,waviness profile ,lay,flow -----____________________________________ 4.1requirement installation electrical guide ,, scheneider electric-explanation : characteristics of particular source and load . - photovoltaic installation , -residential premise and other special location . -WMC guidelines measure. -General rules of electrical installation statutory regulation ,0V to 1000V ,AC ,,0V to 1500, In public network , compliance with national regulation ,IEC 603643, -installes power load : characteristics values of cos . I=IA.cos$/cos$.. power factor before compensation and cos alpha factor after compensation being the original. - heating factor of 0,8 recommender number consumer ,5 story's apartment building with 25 consumer ,each having 6 kva installed . - the total installed load the building is 36+24+30+36+24=150kva, -thw apparent power supply required for building ,150×0,46=69Kv, - magnitude of current in different sections of the main feeder supplying vertical rising ground ,level cross section area conventionally spece , 3 floor current entering the rising main at ground level , -159×0,46×1000÷400×√3=100A -(36+24)×0,63×1000÷400×√3=55A. -Possibivilty of improving power factor ,extension to the installation installation constraint. -In=Pa×1000÷U×√3, Pa=KVa ,rating the transformer. I=phase -to phase voltage at no load in volts (237V or 410V) in amperes , In =Pa×1000÷V=, V= voltage between LV terminal, Simplified equation for 400v(3phaae load ,) In = kva×1,4 (IEC 60000 power , -explain choice and use MV equipment ,MV / Lv transfo for use of MV , equipment choice of MV /LV ventit in MV substation, - substation including generator and parallel operator of transformer. Generator alone operation not working in parallel with the supply network. Generator in parallel utility supply parallel operation of transformer , - type and constitution MV/diatrt,-differenr type of substation,indoor substation ,outdoor substation. I'd=Uo÷ZS,,0,8.Uo÷ZC.. I'd=fault current , Uo=nomminal phase . ZS=earth fault current , ZC=fault . ____. 5.Scotland qualifications Explanation -basic software engineering concept to solving electrical and electronics engineering problem. -writing and testing and documenting I/O. - Program using the basic structure -deaign using flow charts or program design language. -Write test and documents linear programming using I/O statement. - Write test and documents I/O Programmation incorporating subroutines . -table Boolean expression for logic gate knowledge skil . -hexadecimal number system. -conversion , between hexadecimal and binary gate symbols. -teith table associated Boolean,and /or/not ,exor/and and nor . -combibation logic , expression in sum of products.produxt minimise logic ,draw minimised digital, -sequencw logic . -bloc diagram of sequential machine need for memory in sequential machine need memory in sequential logic latch ,JJ and D bistable elements. -asynchronous and synchronisation operation counter and shift register circuit using bistable . -lofic family device characteristics. Circuit . Build and test counter and shift register circuit - evidence requirements should -single line schematic for 33/11kv substation, -liar standard fault level for local Sister voltage (250MVA at 11KV ,100MVA at 33 KV, -pee unit calcul : concept of infinite busbar by grid system working with ,3phaae short circuit by grid system working with 3 phase short circuit worst case scenario calculate fault level for a fault on an ,11kv feeder fault level , fault 11kv feeder from a busbar it is expected that the circuit used will smillar to infinite system feeding 33 KV line with inductive reactance and transform per line excepted one generator should be connected to the ,11kv ,, .S1=250MVA,,U1=11kv,,Z=√R.R.+z(w).. V÷I=11÷39,3=0,279,,ohm ,,, =100÷5,24=19,083 ohm .. S,=V.I.√3.. I2=250÷11×3=22,72KA,,,,39,3KA I1=100÷33×√3=3,039==5,24KA.. -explain next generation higher national electrical engineering : utilisation electrical power transmission lines and complex waves, -Porformence calculation to determine each Zo ,V ,B .. - Voltage current and power for one fill ZL>Zo,,,ZL> -ID conditions then action ifco dition gold's . -ID conditions then action if condition holds -else Action if condition does hold. -End if Case condition of Case 1:action for case 1 Case 2:action 3 for case2 Case n : action for case 2 n End case Condition based input portion use of build process such - write . -test condition documents I/O prog using iterative loop statement. -repetition For variable ,from start to finish in steps of value . Do. -sections to be repeatlt perform End for . -fundamental of control system and transducer . -high level Engineering software. -soffward engineering process creating file editing files process constant and variable. -operatoe and -statement :input output documents. - evidence requirements , satisfactory write one linear prog. - input and output statement different type of variables arithmetic operator . - knowledge skill test and documents. Relation operator =,|=>logical operators -vooleen express. -branxh statement ,if then if ,. Then,,else,,case,,of,,port configuration readings. -outcome 3 : Flowchart pseudo code : for ,do,repeat, until,while,loop. -statement:for do repeat , until while . -looo to manipulable data array -out put array , data array read port data into . -testing of iterative loops ,test plan and actual . - if then ,else If of either while do or repeat until for next to - Advanced unit specifications: engineering mathematics 1, qualifications Scotland,level6 -outcome outcome provide evidence following skills skill time . -solved 2 problem on degree radian . - A.sin(nx+-a)=, or ACOs (nx+a)=b -blow , logarithmic -log+logy=logx.y ---logx-logy=logx÷y p.logx =logxP. y=A×lnx y=A×log x..base10 Convert rad =Teta ÷180×π - A×sin(nx+a)=+-B - A ×cos (nx+alpha=+-B -y=a.expx - explain ,,x =log .base a inverrse function .y =a.exp x y=10 .exp x y=e.exo x ,,x = log . y=e.expx and ..x.exo =log..e y - solve exponential (5 .exp , = 95 ,,,x exo 3.5 =0,1.. log .base 10 (x+2)+log .base (x+4)=0,5 .. -Apply mathematics technique to vector and complex numbers ,2 d d=√(x2-x1)(x2-x1)+(y2-y1)(y2-y1) -D:,,d=√(x2-x1)(x2-x1)(x2-x1)+(y2-y1)(y2-y2)(y1-y2)+(z1-z1) -scalar ,,ab = b.a ,,,a(b+c)=a.b+AC -b.b-4a.c>>, control unite ,>>, temperature sensor,>>>soldering iron temperature, -viewi g platform.. -explanation: A beam used in the construction of the viewing platform. Calculate the magnitude of the reaction at B , calculate magnitude and direction of the reaction, - calculate the magnitude of reaction at B ,, Labalked , (24000×1.10m)-(3500×0,30) (F1×L)+(F2×L2)= 264000+10500=35000×L 265050÷35000=75,70m/n -- 8.Explanation: A lifting system to allow worker on construction to carry out essential maintenance is being . A warning system that will ,sound an alarm when the platform in motion is two button used to control the upward and downward motion .. -input /output. | Operation-alarm sound | A=0 -Maximum load. | B=1 -bouton c Pressed, Bouton depressed| C=1,,,D=1.. .-propose design has the following specifications condition must be met the alarm z ,will not sound unless the gate (A) is closed will not sound when weight on platform will sound when either button ,c or complete the Boolean equation for the alarm .. -------------------------------------- Explanation: calculate a suitable value for RF: Vi=RF/R1(V2-V1),,, Vin =(Vin+Vin+Vin, O,31+0,53+0,47=1,32 RT=1/33000+1/3099+1/30000=o,oooo90960 RF=,,RF=Vo×R1/V2-V1=, 1,2×0,09999096/1,32=0,0099910 -- Explanation mechanical engineering must design a pneumatic circuit meet the flow,when push button VA and VB not pressed ,or when. Not pressed lever ,VC state double acting cycling must, outstrok {A`.B.`+C -a short time after cylinder outstrok must instroke automatically an initial design the circuit...-- The program to control the cylinder must follow criteria oustroke =A`.B`+C the cylinder must remain oustroke 15000 milrsecond ,209 milrsecond after the command to instroke the system start monitoring. --- Explanation -An alternative motor with moseft driver in also consider the mosef has a resistance of 2,3ohm fully Saturated and the motor is rated as 0,49 w at 6.0 I=0,40÷6,0=0,07 I=V/R=6,9/2,6=2,60,, E=V-IR 6-0,182=5,818V -- As part of the car control window are to be open and automatically the following control produced ,by - explain with ref to the circuit above the impact switching out 7 high then output 6 high then output 6 high has on the motor--- Program below in Pbasic ardwno code is know to have fault.. - main if pin 3=I then jump If pin 2=I then main If pin 1=0then man Jump:high 7 Pause 15000 High 6 Pause200 Low6 Goto jump -void loop (){if digital read (3)== high {jump();} else if (digital read 2, ==High }{loop ();} else if (digital read (1)==Low }{ loop();} Void jump (){ Digital write (7,H,G, Delay (15000) Digital write (6,high delay (2000); digital write} - --- The camera is placed on the outside car and a talk of clear plastic is place ... ------------------ Ligth sensor is used to identify when the plastic is dirty when it sense a value of less than 219 lux a motor spins to move clean plastic In front of the camera the control , - calculate the value of aR1 required to saturated the op - Amp positive 219 lux , R1=Rcc-R ,,,Vo=(1+RF/R1).v -motir requirements ,55mA of current ti operate the op - amp saturated to 78% of the supply voltage vbe is ,0,70V saturated transistor RF =,,,explan 9,0055A+0,70÷0,000795÷6÷9,, R1=Rf÷vo÷v2-v1, = 0,01119... -------------------------------------- Truck ligth system ,completed logic A,B,C,D,E,F, ---+ Batteries power portable flood light are to be installed the construction site to allow work to be completed in lower ligth ,the battery is rated at 15V,13A,kB hour useful energy is 2,32 MJ Completed the energy audit diagram for the portable floodlight batteries slowing the input and output energy .. ----------------------------- The diagram below show part of the design for the framework that supports the floodlight. .-calculating using nodal analysis at node A,and B the natural force in ,AB,AE,BD,and BC Member | magnitude. | Natural AB. |. |tie AE. |. | Strut BD. | BC . explanation= L=355×cos 30=321,73nm AE=455×sin39=227,5Nm BE=455×cos 30=227,5 DA=(455×30 sin ×30 sin)+(350,sin 39 =321,73+227,=549,29 --- The force w represent the weight exhibition and is acting ,1,4 m from point B ,the distance from A to B is 3,46m Draw a free body diagram of the force acting on the exhibition calculate the force , 650×sin 120° 776×sub 120°-force acting on the connecting ring Q=(530×cos65°)=223,97 P=650×cos 37°=447,2 T=776×cos48=539,054 F1+f2+f3= -- d) replacement exhibition is to suspend from ceiling some positions two cable support the new exhibit hanging from the connecting ring are replaced Hallow aluminium.. The 2.7 long tube has a diameter of 72 mm an walk thickness ,,2,5 mm it support a load of 32,7 N calcul the charge in length tube it is load new exhibith . A= π.d.d÷4= 3,14×72÷4... €°2,6-2,5÷2,7=1,92.. £=F/A=32,7÷56,62=0,62.. ------------------------------ Engineering civil 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 4 of 18 compact , calcul the total torque produce by motor , - described an advantage : described the purpose of. -funal design structure used to support the weight the boring . Completed using nodal analyse table of the missing force their nature of the missing force their nature . Member .| AB | AC| BC| BD| CD Force |. |. | 583kn|566kn| Nature | tie | strut | strut | AB=(550×61)+(550×61(---------++------ Calcul the force that player strikes the ball product a torque of 295 NM (0,34×295)+(0,84×295) Force extension graph ropes Calcul the strain energy in the rope when it experience tensile tension 159 .. ---------------------------------------__----_ An electronic engineering design digital logic circuit for Boolean equation , Z=(A`.B`)+(C.D) - draw the digital circuit for the .. Design for an operation amplitude op circuit is Calcul gain for circuit when V input voltage is ,9,11V ,,ΔV=7,59÷0,11=69.. Determine appropriate resistor value for E 1,and RF : AV - R1/E1=59-1/R.. Integrator §vout =1/RC.integrator .Vin St ... f=1/2πRc.. 555,timer stable .. Marj = T1=0,7(R1+R2) T2=9,7 R2.c Freq° 1.44/R1+2R2c.. -------------- Calculate t output voltage of the difference amplifier amplifier when the ligth ,calculate the minimum output voltage requirements from Amol to cause three , d) described effect adjusting variable resistor will have light level .. - the LEDs ,are at their most offence when current of 52 mA ,flow each they also found 2,3 y occurrence , Calculate the required resistance for protection resistor ensure maximum efficiency ,VCC for the comparator is set to 8.0 v the comparator saturate at 75% .I'd = 52 mA ,,vs = 23v ,,, ID,= 9,0952÷8=0,93,, 23/0,04=575 ohm ------------------- Future solution involving used of microcontroller is also tested an output pin on the microcontroller activate bank of LEDs .. From sensor input ,microcontrol yes ,,pin 6 ,, 1/R1-RD)+(1/R2+rd2)+(1/R3+Rd3)+(1/R4+Rd4.. ------------------- Explain with ref ,to code circuit the effect on the LEDs ,when the reading from the analogue sensor rises from,5 to 200 -------- The logic circuit show below control valve that provides water for the plants .. ------------ Explanation pneumatic circuit need to feed wast into incidence part of a system to produce electricity safety reasons ,be bar material is pushed in the system cylinder outstrokes allows . . càlcul the minimum base current in requirements to switch on the relay ,,,, In =0,7/1,5=0,4667A.. .- calculate the voltage requirements across the resistor assuming vbe is ,07 v ,,calculate the current through the variable resistor , V=6.0.1,5/2,5 --------------------- - by using pulse width modulation the LEDs can be mode appear bright or dim Code for the test is below in Pbasic and ardruuno Main: into sensor =A9 redax Pino,Bo. Int led bank =7 If Bo<50 then level 1. Void set up (){ If Bocomputer>>>display.. Use , existing design,use existing formula,modify , generator - Vmean at 0°=√2/2π×VRM×(1+cos alpha) √2/2π×240(1+cos 1)=108,038v Meant at 90°=√2/2π×VRM×(1+cos alpha) =√2/2π+240(1+cos90)=54,019v -Vmax=√2×Vrm =√2×240=339,411V IRMs=√2/2×irmax = 10,60.. ---------------------- P2=√P1.P2 =√104×800 V1=Vr1/N=0,4×60/550=0,0436mm. m=P1.P2= 104×0,04364=0,05416kg V2=m.R.T2=0,05416×0,287×292=0,01574m P2,288,44 Vs =v2=π(D2)/4.D=0,01574=π(D2)./4 P=2.n/n-1.P1.V1.[(P2/P1).exp .n-1/n -1] =95,69kw - prerequisite= pact /n = 95,69/0,88=108,74kw -at ,44,8°c ,,h1=188kj/kg at 93,5°c, H2=392kj/kg At 1500kpa , 350 °,, H4=3148kh /kg .. h plant = ms (h4-h1)/mf×hv. ×100/1 =5400(3148-188)/600×3200×100/1=83,25% EE=ms (h4-h1)/mf×2257 =5400(3148-188)/600×2257=11,803kg,steam /kg fuel Qecon = ms (h2-h1)/mf 5400(392-188)/600=1836kj/kg At,1500 kpa ,hf = 846kj/kg and ,hfg = 1946kj/kg = 2595,5kj/kg Q,super = ms (h4-h3)/mf 5400(3148-2595,5)/600=4972,5kg/ Q,flag=m×.cp.×Δt (15+1)x,1,045(210-24)=3109,92kj/ KJ ____ Qin (KJ/kg) |. out KJ /kg |. %--- Qfuel=. | Qecon=1836. |5,74 32000. |Q Eva=19831,55. |61,97 |Super. = 4972,5. | 15,54 |Qflugas. =3109,9| 9,72 | Unaccount= 255 |7,03-- 320. | 3200. |100 -- ~=C.p/CV=1/0,712=1,4 T2=T1(V1/V2). exp ,alpha -1 = 28(13/1) ,exp ,1,4-1 = 806,26k T2=P1(V1/V2)=10,325(13/1),exp = 3674,83kpa. T3=T2.P3/P2=806,26×5000/3674,83=1097k. Q2-3=2/3.QT Q3-4=1/3QT. (2/3).m.c.v(T3-T2)=(1/3).m.c.p(t4-t3) 3×0,712(1097-806,26)=1(t4-1097) T4=1511,01 V4=T4.V3/T1=3,774m T5=T4(V4/V5).alpha -1 ASR=1-Ts-T1/(T3-T2)+aplh(T4-T3)×100%=62,47% - explanation cpd, continue professional development , Scotland outcom qualifications,UK qualifications: -13. research on papper libry text book Bibliotech: Reference:resource -uk magazine for electronics technology and computer projects . EPE , everyday pratical electronics Order book ,8$,,10$,,3euro ,200rans -Projects and circuit,series features, regular and services -Topics : Scotland magazine second voice recorded module: record two ,four eigth different message clean and clutch free line level audio output can feed an amplifier or PA system ,8 bit recording quality user selected bandwidth.. - Scotland:Applied skill engineering electric , Engineering electronic engineering science , mathematics engineering -Topics : scottland outcom PIR - triggered mains switch ,use a domestic pie system to switch any mains -power device ratesup to 10A..-topics : multti function , intelligent remote , controlles dinner the ultimate dimmer project using a standard handheldsr remote .. - topics teach in 2011 part :logic circuits - our to be missed introduction to gates and flip flops.. Microchips microsti k development board.. -10.constructional project: Design concepts: Hk828 module record 40,60 -getting the messat : module jump random sequence. - how it works: function heart module architecture -labelle the block diagram of the hk828 voice recorder chip while the recording process relies on audio sampling the audio is not stored digital but used and analoguw sample and hold system the analogue sample stored sample .. -samplung rate : capacity array means that HK store total ,8000samplw per second total ,262,144/8000,,42000 sample ,4200 total ,262,@44/42000, recording bandwidth fidelity propertionaj sample ,2khz , samples ,just 4khz.. -circuit details , 4,7 if ,,and 220kohn ,19pin preamp and AGC,, circuit vis couple 29,,5,8hz,,47kohn , switch logic signaj teeminaj . -parts list multi message voice : 1,PC board code 797 available Epe pcb service 110mm×57mm. 1).electre microphone insert . 3) ,3 way terminal blocks PC mounting 1), 2way terminal block PC mounting 3), 2 2- pin section of Sik header strip. 3 jumper shunt 1 ,)28-pin Dik ,ic socket :15,24mm spacing. 1)8-pin Dik ic socket ,7,62mm spacing 1)2.5mm concentric DC power plug ,PC mounty socket ,PC mounting _semiconductors :.1 HK828 voice recorder IC (ic1) 1)LM358 dual op amps (IC2) 1)78L05. +5regulator ,reg1 1) PN2099,PnP transistor Q1. 1) 5mm green led (led1) 1)5mm res Les (led2) 1)1 N4004,1A diode ,D1 -capacitors : 1) 2200uf , 16V, radial wlectr. 1)220uf, 16V radial elect 1)22uf,16 v radial electric 1)10uf,16v 1)4,7 if tag tantalum 1)220nf ,100v MKT metallised polyester. 1)100 nf ,multiyar ,monolithic ceramic , -resistor : 0,24w,1% 1) 470,kohm, 2)100,kohm 9)22k ohm 1)100 k ohm .. 1) 220k ohm 8) 47 k ohm 2) ,10 John 2) 680.ohm 1) 47 ,ohm --------------------------------------- 12) constructional project : IR remote control ligth dimmer module,the circuit is based on a PIC 18 F ,1329-U/SI microcontroller ,a triac and and IE detector (IRD1)the two RGB ,LED. give user feedback in the operation and setting. -power supply: micro synchronisation waveform connecting neutaj ,,derived from the mains via a 1kohm ,5w , resistor and a 470 nf (X2) capacitor and resistor act as current limiting impedance for association ,5,6v zener diode ZD1,the supply works as follows,for positive half cycle of the 230v,AC current flow via zD@,the ,470nf ,, capacitor Nd 1k.ohm ,5w resistor same time , electrolyte capacitor capacitor is charged ,up then for negative half cycle of the mains current flow ,via D1,the 479nf capacitor and the 1 k.ohm resistor ,the results is that the 470,if capacitor is charge to ,5,6v-0,6=5V..DC Impedance of 470 nf ,series 1 kohm ,,micro,,5v supllie,up 23ma ,IRD1,, supply bcircuit two RGB LED are connected six cathode connected to a different I/O pin the common anode two RGB LED connected together 5v,single 1 kohm .. IR remote are amplified filter decoder received module IRD1,,the 1000 ohm ,resistor capacitor are module to decoupled it 5v supplies the data output at pin 1 of IRD#,is connected to pin 10 of ic# and configured.. -construction : intelligent dimmer is built on a single &sider PC board code ,799, measure 76mm×50mm .. ____ Part list intelligence dimer , 1.PC board code 799,acat from Epe service ,size 76mm×50mm 1. Ip65 sealed ABS plast case Witt clear lid ,size ,,125mm×85mm×55mm(jaycar HB-6246) 1.flush mount ,3 pin main socket ,jaycar ,PS 4094 similar .1. IEC make chassis connect with mounting holes jaycar ,PP-4005 1.)10 MHz crystt(x1) 1)47uf, 5a inductor (jatcar lf-1274 1)4-way Dinklage screw terminals plug ,jaycar ,HM-3124 1(10A,ISC main cord -semiconductors : 1 .pic 1 1.ie receiver 1. -capacitors: 1470 ,16v electrolyte -resistor ,: o,25w - miscellaneous: 3M3×25mm nylon screws (to secure PC board. 2M3×15mm,nylon screw ,for IEC connector 3 M3 x12 mm nylon space , 10 M3,nuts -1)1 ok mm of ,0,7 mm dia times copper wire for links ,, 1)200 length ,3-core mains flex (250v,,10A ratt, 1) 4,8 mm res spade conductor,fully insulated , 14,7m yellow spade connector duly ,5)100 cables tie Add,part requirements testing 1)12 AC ,500mA,or 1A plugpacj, 1)12v,,300mA,ligth bulb (jaycard ,SL 2656) -construction project:PIR -triggered main switch: Futer detector ,20m away ,two pair telephone cable , switch unit also provide 12v power PIR detector cable switch main rates relay to switch the power twin 239 AC ,outlet ,relay contact rated 20A, switch. , 10A limited,10 different ,, switch power load any time regardless ,switch units fits ,UB2,size plastt box ,, switch itself battery operated and switch low device if about ,80mA,12v .. :how it wot:block regulated 12 volte power , internal circuit plus unregulated,17C ,DC power virtual contact ,which are normal close ,open when detector Sens movemt. Contact unit also connected ,12 line detector contact open R1,and it's output switch low ,this action issued set reset ,flip -floo ,normalt resting .. Switches intu set state Q high used a transistor driver circuit energy relay ,power switch 239 AC outlet and loads, at same ,sR flip flop switch to A Output multi stage remove reset counting pulse from simple clock oscillator ,which run 0,9374 the reason odd frequently clear , the binary counter has 14 stage but make only from internal flip flop 4 to 10 (04-19)and 12 to 14 (012-014) we rotary switch S2 to select one 10 output ,si rotor of S2 kept until the selected counter output switch This happens a soon counter has received the appropriate number of clock pulses,eigth in case 04,16for O5for32,for0664,for 07 switch high after 8192 pulse been counter ,selected counter switch low situation coupled via capacity c1, resistor R# inverses I..-main connector ,three connector ,iex green wire , yellow main wire ,T1 longer ,same wire 160mm , outlet socket .. - insulating shield ,two outlet socket insulation material pvx , -final assembly: step the two plug into socket make noctch , completed box ,, -Pir : testing or adjust.. In used .. -parts list trigger main switch, PC board code available service size 147mm×69mm 1)ub2-size plastt box ,197mm×113mm×63mm 1)PIR sensor 2)heatsink ,19mm,square t o-220 type , 1pushbutton switch spst (S1) 1 rotary switch,1-pole ,12 position (S2) Point knob with removable pointer insert . ,1)6- pin Rj12 socket ,PC board MTG (con1)or ,3way PC board mounting termi block 1) 14- pin Dik ic socket ,for I 1 16 pin Dik ic socket for , 1) power transformer ,12,6v/2va,2851 type 1)29A mains rated relay ,chassis MTG (RLy1) 1)IEC main plug , panel mounting 2(mains sicker flush mounted 4 main socket ,flusg ,15 mm long ,M3 tapped,, nylon M3 machine screw ,10mm long csk head ,N3 machine ,6mn,long pan ,solder lug ,,nylon cable tie 100m ,25 mm length ,6 mm diamt heatsgrink tubing , -semiconductors: quad scmit band ic1,4093B,,4069 binaicounyer,12 regulatory,PnP transit,led green silicon ,, - capacitor, : resist -capacityi -explanation: Project a plethora of , together with the pic programming , -PIC training course. , training development course enhanced ,pic programme module,-bool expirmenting . Experimenting with PIC microcontroller,this book introduces pic programming , jumping straight in with four easy knowledge 8 binary. Explanation logic - digital logic , circuit basic building digital circuit and system . -possible , switch and lamp logic , - lofic gate with inverted output ,, Y=A+B Y=A.B Inverter ,,y=/X.. And gate ,,or gate ,,and gate ,,nor gate. ,exclusive ,incluve gate.-Bistables ..D type bistable , D-typpe bistable,,j-k bistable .. -pratical logic circuit.. -build the circuit wizard way : opening to gates , gate number Intruder alarm: real life application of simple logic intruder alarm push to break , advance... - ripple counter.. -investigate : a block schematic diagram logic syst ,the system is designed to alert the flight crew visible and audio warning ,door switch logic signal respective door logic 0,when closed warning indicator active low requirements logic 0,to produce a visible audio ,study the circuit carefully and then see if you .. 1.what logic level appears at point of door closed ,wath logic level appears x,y,z ,,wath level appears point x,y nose door open other closed .. - circuit surgery : collector feedback theory /bias ,, A=So/Sai,, feed factor,,loop gain ,,Sf°BSo Sai=Sin-beta So -So+beta So=ASin .. AcL=So/Sin=A/(1+beta+A 14. Files system. Record academic and certificate diploma, 1.Pocket number. Implementation work Data right,met investigation: Project : drawing : Career project : theory circuit Schematic Experimental : workshop workplace school class pratical career guidance National trade examination :theoretical and practical ,n diploma 18month Memo tech , Project drawing: interpretation -Mathematics graphic draw :project Line point - Electrical trade theory draw labell: Circuit component make: Resistor cell,baterrie ,AC DC circuit current,lighting washing machine , transmission generation AC inspection -insustrial electronics draw labell Circuit component make: -engineering science Graphic and circuit .. - grade total career ,staff theory learn Pratical exam test trade assessment Engineering electrical. -fault find diagram schematical . Relay -installes rules ,circuit diagram, -lofic system -control system : -15 .experimental,.projects pratical trade framework qualifications marks : certificate diploma 6 month semmester trade.. Trade theory -pratice frame work Component frame ,electrical and electronics Drawing : make circuit tools process make circuit framework Trade pratical engineering:level5,6,7 Process Design Designation unity| ,component| ,tool trade| -male tool pincil draw Make, resistor ,condensator charger circuit tools make drawing . -makee installation lighting way switch : -makee transmission ,generation ,drawing ..design. 3.experimental :project drawing City power Eskom advanced career Drawing workshop and workplace , Library on line project On line. Power engineering,advanced Scheneider,Eaton breaker design -drawing diagrams city : Metering circuit: design Installation city transmission generat drawing schematic: Installation: -drawing interpretation: discovery electronics Drawing make: installation security alarm ,police alarm design intelligence robot circuit timer 555.. Computer electr -4. implementation integration system . Guidelines guidence pratical school Microsoft project azure ..GitHub ,visual studio gith lab Work item : epic item project repository project issue project run project code source readme licence,IP drawing circuit 15.1 Trademarks T Blaser tableaux Met career police tpm , counter terrism , Engineering systems:met block mark TMP circuit maintenance meeting break Data right .. Cell phone: IP licence book rwiten integration : met career detective ,counter flip flop ,electronics ,CCTV circuit right , cameras phographic right lens zoom circuit , repaired center cellphone city vs transmission Telecomm office vs Microsoft office vs circuit power vs installation electrique compagny police data certificate copy license copy private police ,,policy city power Eskom policy claim drawing design power cost economic load ,outage circuit . Total ,pratical , policy claim vs claim alarm maintenance total career , Security safety claim nated counter terro record irregularity phase circuit complain circuit implementation: -total framework policy vs police record LDR framew not meeting vs Terri counter irregularity vs Total grand :grand council department energy Eskom policy ,city power policy terro counter emet. Irregularity mining company trade mark , telecommunication claim vs customer trade marks compone maint Tom . -total grand met tblazer Salesforce energy claud metering energy co circuit incidence force sale policy -data right energy metery claim. Vs alarm relay delay dimer switch. Microsoft project azure blue defender Regulatory factor ,limited Freq , energy cost. Bill cost energy Intergration circuit switch. Record total Physical meeting .. script inspection 16..Experience pratical: www elektor .con, Test book Order booking :200rand ,,4eu - microcontrol analogue audio , digital,test measurement. -Pratical: quick to implement reusable multi plat form , fts. -sub long term weather logger . - ATM,18 compass. -j2B universal MMI module using ,arms cortex .. - FT232 ,USB Serie bridges/BOB Chip kit first Arduino compatible ,23 bit microller development platform,design manufacture. -Parallax : li - ion power pack charger -reflow mate : Supply voltage: 230V/50HZ only Power : 3500w Weight: approx ,29kg Dimensions: 620×245×520mm (w×H×D) Heating method: combined IR radiation and hot air . 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 5 of 18 Operation: directly using menu buttons and LCD remotely using PC software and USB connection. -menu language : -temlerature range ;25 to 300°C - Maximum PCB size :400×285mm -temperature sensor : 2 internal , Optimal temperature distribution thank to IR lamps - Drawer opens automatically et end of soldering , - Glass open automatically at end soldering process - interactive commander for data transfer Command | action h =help. | Print available command ____ -Current drawn by entire system at ,3,3 V CPU frequency| sleep mode | current drawn 8Mhz. |Non. | 5.8mA ____ Fuse settings ATmega 88 Fuse | Ext| OxF9| 8MHZ intern oscill (divided hence cpu clock is 1Mhz-$____ -weathet logger operates supply voltage of nomminal 3,3v power over USB ,is available 17 ,VCC of BOB ,FT232R serial -to-usb converter module for stand alone operation unit power via BT ,, supply voltage between ,3,5v and 30,V regulator ic3 diode detector again accidental reverse polarity connection important employees reduced measure to maximise battery life in stand ,alone operation microcontrol is responsible cincentre measure effort circuit ,3,3 V under various conditions is shown , alkalt or NIMH ,AA cell , 4,5 v or 3,6 v nominal capacity of between ,2Ah and 3Ah ..record data for least 1000hours instead of three AA cell free the employee single ,Li - ion Lipo cell supplies ,3,6 or 3,7 ,, on power saving measure is to carry , 100second ,, measure system draws extra about ,2,5 mA ,,120 ms ,when taking reading in between ,10ms corresponding to the 1hz interrupt the device is from ,power save mode 59 second ,I/o clock micro controller order need to be count the pulse in order , CPU.. Result disping result Test measurement: HH10D humidity sensor module feature . Re Swegethttps://GitHub .com/milkmist)mist rewmaster tools / filter m. Bios serial received firmware download request from the device. Flyerm uploading Kerbal (83475 bytes Upload completed (9,5kb/s. Booting the device Done Hello - the pattern obtained after numerous iteration of the command pixel [I]=y*y* x>>5.. Testing in development board ,,use serial port to upload application ,,serve a console for displaying the message sent to print f +) the Boras fitted with a ,3,3 serial port ,located between the ethernet and VGA connector ,pin marked ,board received the data marke tx is used by the board for transmission the GND is obviously ground ,3V3 is a 3.3 V power rail serial long use 3.3 level (not 5v or RS -232) or the combined devdlop - organisation display of the measurements results .. -CMOS compass module: board .kmz 51 chip ,the resistance variation in resistance cause voltage variation which is amplified,LMC 6036 ,sensor electronics magnetic heading us calculated micontroller bus ,corrected module positions ,pin 7 ,AC power grid in him parameter story EEPROJ - orienteering ,4 load firmware power manufacture ,want to recover the module function bearing send following by modulating.. Wiring block - digital communications with the robot electronics cmps module Graphical representation of the compass point -circuit diagram the construction file eagle files component list software Keypad : consist 12switcges ,4 to the left of the display ,4 right , rotary encoder switch encode build push button three encoder space ,9 encoder build in button 27 button ,a5×6 Matrix need connect key I/o scane 4 key free way , function available some function make ,use diode avoided problem phantom key several press ,a situation turning the diodes package .. Different variations on the 2×@6 LCD ,key swiy offset .main function resistor R38,to R 44 board turned using button S1,s8,s12 key fitting , resistor provide. ,turn key circuit by battery function asymmetric matrix line have limiting resistor (15-R25) is final circuit .. - display: board offers possibility of fitting ,2 line by 16 character (2×16) display ,4 line by 29 (4×29) ,,by 16 character connection ,5v power ..R ,36 ,R 41 is necessary T relay ,R1 ,120package . -Powering : the board main rail (V+) is 5v microcontrol itself ,3.3 derive,3 ,, are directly connecting the display available on transistor (piooo,6,,Pio 2,8. Etc pad k1 and k2 ..signal -construction: - implementation : board - twitter message local area network LAN wireless configt.dialog - communication on the dso board. Detec signal the ratio signal generator DSP ,101dv,and this ,n level of ,94 db application peak to peak with sinuskidaj ,0,53 to 0,59 time supply average Test measurement: Component list Resistor :.R1=220kohm To R5 -capacitors : C1=4,7uf ,63 radial to C7=470nf. - semiconductor: D1,D2=BAT42, T1=BS170. IC1= Ic2=ATMEG,, Miscellaneous:.S1,S2,S3=6mm switch ,PCB mount S4= single -pole switch X1=32,768khz quartz crystal LCD 1=DOG @62w.. Mod 1=BoB .. Mod2= humidity sensor HH10D K1=6-pin(2×3) pibheader option iso interface -20-way socket strips SIL for LCD1 ,, 18 -way(2×9) socket for mod @.ic socket for Ic1(8-eay and ic2 (28 -eay ,PCB hi Settings and function button S1 to S3 Print circuit board. Humidy sensitive used transducer elements frequency 6khz to 7khz measured AT mega ,value with calibration par ameyer again stored series module frequently counting the output pulses module over second ,the 16 -bit counter timer , capacity 64 kbyte,,stored,record .. -soffward : firmware for the microcontroller is written in C complied using .. Program in weather station,LCD to control display .... - construction: double site circuit board diagrams components mounted in board ,socket solder components,fused iso connector ,k1, programmation job ,program used sensor module serial to USB module , switch ,S4 position to select external power ,3,3 - operationel ,: treer button (S1,S2,and S3:,S1 cycle variouse Setting ---- ________________ C28=C26/(4Q.Q×(1+Ao)),. R24=2Q/2(wo×C26) R25=(1+So)×R24, R23=(2+So)×R24/So If ,A=0,7071 and So=,these formulas sin plify to , C28=C26/4 R24=1,4142/wo.c26) R23=R25=2×R25.... ______________________________ Basemodu ---- Lab testing ..prototype audio convert implementation: Component list -Resistor= R1=330 ohm R2=680 ohm R3= 470 ohm Capacitor C1=100nf Inductor: tri ,home -semiconductors Led = standard led yellow - miscellaneous, cinch so let ,solder pins ,USB audio - circuit : circuitry design ,signal pin @, coupled resistor impedat former signal (0,5vand 75ohm) coupling transformer provide galvanized cover upper frequently transfo limited couplings toroidaj core material suitable signaj ,50Mhz .. Construction: PCB --- - schemat diagram of the flasher - Circuit the time integration module Base e two operational amplifier ,A1 and A2 ,- ,non + input and output,varyyng voltage V1(t) is applied A2 driver integrato ,R c and A2 ,Rc stage ,add resist -- Light sensor : With twilight detect: sensiu circuit 9vdc. to .15 VDC..ligth room circuit generate ,lm257 ,R1 and R2,,voltage dived ,,R3 and R 1 circuit , Ooamp ic1 wired buffer voltage LDR suitable R2,voltage pin IC,,,IC1,, ic2,0 other ,,22kohn R,10two comparators ,ic2and ic 2b compare income p1and p2,0thar output R 90,be ause ,, determine dark ,ic2. and I 2.. -explanation teach ,in A broad based introduction to electronics: digital to analogue and to digital conversion: electronics studies school college UK ,include byec level 2 award electronics diploma in engineering level 2 experienc - e read ,teach teach learn experience test electronics circuit Learn : - beam break flash trigger ,build necessary time delay photo flash response IE -Parts list active loop antenna : - @ PC board code 813 (ant loop) 31mm × 94,mm - @ PC board code 814 (rad loop) 58mm×48mm -@weatherproof plastic box ,eg 130×54×83mm plastics box -@8-pin IC socket - semiconductor: 1BA4560 dual op amp (IC@ 1 k8L08 or 78K10 voltage regulator. 2KDV ,149 varicao diode (D1,D2) -capacitors -3)100uf ,16v electrolyte 5,) 15 nf disc ceramic. -Resistor (0,#5w, 5%) ..micelanot ____ Beam - break flash trigger.: the infrared beam is generated by led1 to led3 and picked up by phodetector diode ,PD2,,op amp ic@ b function as current ti voltage ,while I 1 is wired as non inverting amplifier the latter derives transistor A mosef briefly sait h trigger outbut when the or is interrut . -circuit details: Power isderiver battery in detector unit IRv beam from source unity OD ,3,5 mm jack plug con@ mate ,, detector unit IRv source unit ,IR pgotodetector diode ,is connector diode ground and the inventing input ,out site,,+1,7 v ,and +4,0v ,IR ligth is falling on OD@ dark , basically ,#2kohm ,,2,7kohn ,,220uf ,, Qrin writing amplifier ,, s -Switching the triggers output: Q1 switched when IR beam falls on PD1 collector voltage is normally,beam interrupted ,mosef .. -parts list : IR source unit : *1 PC board code 808 ,57×26mm 1)UBS size box ,8#mm×53mm×31mm 46mm long untapped spacer ,4 M3,×13mm screw ,counter sink head nylon cable tie ,75mm long 12m length ,8cable 23,5 mm ,monk jack plug cable type , - 35mm IR ,led (led @ to led 3 ,1)820 ohm -detctor unit : 1) PC board ,code ,size ,,122mm×58mm 2UB3-size box ,129mm,×68mm×44 mm 1)SPDT mini toggle switch ,s@ @)PC mounty ,,3,5 mm stereo jack,socket ,, - PC mount ,15 mm tapped spaced ,8 M3 ,6 mm machine screws pan head - 21 mm PC board terminal pin,, 19v ,,battery clip lead 1)8-pin Dik ,,IC socket .. 1)30mmm length of ,13 mm to ,,15 mm length of ,12 mm to ,15 mm diameter black pvx conduit or brass tubing .. -1 piece of ,IRv- transparent red film ,approx snap connector or , 1×4- way ,AA cell holder . 1×2 way ,AA cell holder - semiconductors: dual op amp (ic1) 1Bc33,nob transistor ,Q1,IR pgotodetector, - capacitor : - detector board final assembly n: construction v -cinverting scanners for ,VHF/UHF discrimination tap socket ,the basic setup for received ,159 MHz signsk ,,.. - PC board is secured to black the lid M3 ×25 mm tapped keypads pluggi into machine socket .. -precision resistor: -Lcd module: remaining components installer .. -- - digital insulation meter : 1) PC board ,code (main /dis)109mm×84mm 1)PC board code 859 (dc-dc con),70mm×51mm Ub1- size plastic box ,157mm×95mm,53mm 1)LCD modut,2 line ,16 character with back ligthning. 1 ferrite pot core pair ,26 diameter enameled copper wire , 1) 100mm ,lengtt ,o,7 mm diameter enameled copper 1)8m length of ,0,7mm diameter enameled copper wire 1)100 mm length of ,0,7mm diameter tinned copper 1)10×AA battery holder. 0,7 mm diameter pinned copt 1)2- pole rotart switch ,PC board mounting ,wit 16 mm,S1 1)SPDT mini toggle switch panel mounting (S3,S3) @ Min Dil relay ,spt switch p with 5v ,2) binding post ,Bana jack (1 red ,1 black . 24 mm solder lug.. 1) ,16 -pin lengi of Sik socket strips 1) 18 pin IC , socket ,4(25 mm ,m$ tapped metal spacers Block diagram of the ,16 ,bit digital potential the desired out voltage is entered via keypad and microcontrol IC 2 the correct binary number to drive the ,16 relays in the ,R/R ladder networks - arena loop , Experience trade mark , engineering science career ,motoring vehicle,power machine , engineering,trader Compagny,Transnet motoring career , ford career Engineering system and Toyota , nated ,, Magazine collection motoring reviews -rwiten oral relate : Specifications : - 1.engine: -cylinder : four ,in line transverse - fuel supply : electronics multi point ,injector -bore /stroke : 81,0/96,3mm to 87cm -cubic capacity : 1799 cm cube -compressiin ratio : 10,5 to 1 -valce gear : s-o-h-c ,valve per cylinder , variable valve timing -ignition :five -2Engine output: -Max power iso(kW)103 -power peak (r/Min)6300 3transmission: Forward speed -low gear: ,3 ,142 to 1. -2end gear :1,869to 1 -3rd gear : 1,235to 1 4th gear : 0,948 to # Top gear : 0,727 to 2 - reverse gears :3,307 to 1 - final drive : 4,294 to # Drive wheels. : front -wheels and type - road wheels : 16×6,5j alloy Tyre make brigestonr turazan , Tyre size : 205/55,R 26 92v Type pressure front : 220 kpa Type pressure rear : 220 kpa - spare : full ,size disc 5.brakes: Front : 262 ventilated disc Rear : 262 solid disc Hydraulic : ABS , with end and bas. - street : Type : rack and pinion hydraulic ,speed sensitive power assist -lock to lock : 2,7 turns - turning circle : 11,6 metres -suspensiin : Front mac person strut ,lower wisthbor e gas filled dampers anti ,roll bar multi coil gas rear - capacities : Seating: 4/5 Fuel tank : 50litres Boot space. : 304 dm 3: Utily space :928 .DM cube - warranty and service intervals : 3 years /1000.000 km warranty. 5 years /100.000km service plan Service every 15000km: Honda civic 1,8 Vxi; Volkswagen Jetta ,1,6 Comfortline ,ford focused ,2,0 trend ,, Toyota corolla ,180i Test claim t 203km/h top ,speed and acceleration to 100km/h in ,,9,44 second Honda tops at 202 km/h achieve the benchmark sprint in ,9,39 second performance - test data : .Amarok bitid ,4 motion Engine : -Cylinder / capacity : 4/1968 -bore and stroke : 81×91,5mm -compressiin ratio : 26,5 to 2 Fuel supply:common rail Injection - fuel diesel . -max torque : 400nm@1500rpm -max power :120 ke@4000 rpm -transmission: Shift type: 6 - speed manual - first gear : 4810 -second gear :2540 Third gear : 1.590 Fourth gear : 1000 Fifth gear :0,760 Sixth gear : 0,630 Final drive : 4100.reverse : 4.370 Loe-range : 2729 Control 4 WD selection type electron button Wheels : alloys Full-size spare - 2.measurements (mm) -height :1834 -length : 5254 -width : 1944 Wheelbase :3095-fuel consumption: 120 km/h ,,:8,61/km Urban : 9,8/km - calculate range : 688km - performance: 0-100km/h : 20,8 second 100-129 km/h : 4,86 second rpm @ 120km/h : 2100 -recovery point : Front ,,RHS Rear - underbody protect: Transfer case non Fuel tank : plastic guard Rea diff non - odometer 6,248km -load and towing capabilities (kg) Tare : 1848 GVM : 2829 CVM: 4668 Towing capacity ,unbraked : 750 Towing capacity (braked) - brakes : Front. Ventilated disc Rear. : drums ABS ,yes - load capacity (litre) Load box : 2520 - warranties maintenance and service: Warranty : 3year/ 100000km Corrosion ; 6 years Service plan : 3 years / 90000 km Service intervals: 15000 - guard motor ,police maintance Record Guard gold platinum ion Eligibility car ____ 17. Specifications:volswat golf Pricing : Test pricing Standard equipment; controle aluminium - general data : Kerb weight:1541 kg -length:4212 mm-width,excl mirror :1779mm -wheelbase :2578mm -weigth distribution front ,n/a - ground clearance : 132 mm - boot space : 275 litre,.. -utility space : 1305 litre - coefficient drag CD : 0,34 Seating capacity : 5 Headroom front : 987 mm Headroom rear : 979 mm Hatch lift height : 2017 mm - safety -warenty : 3 - years : 120000km -maintenance service : 5 ,years : 900000km -2Engine: Type layout : 4 cyl transverse turbocharge . - valvetraun : DOHC ,16 ,valve -displacement :1984 cc - bore ,x stroke mm : 82,5×92,8 - compression ratio ,:92,8 -power kW : 188kw,,6000rpm -torque; NM : 350Nm ,,25000,,500rpm - power ,to weigh ratio : 121,8 kW/ tonne - fuel injection : direct petrol inject -recommended fuel : 95 unleaded.. - drivetrain : Transmission : six speed - gear : ration 1st : 2,92 2 end : 1,96 3 Rd : 1,4 4 the :1,03 4th: 1,08 6th : Body frame with .. Brake from : 345mm disc - break rear : 310 mm disc - wheels : alloy :tyre : - steerit : servitronjc - steert ratio : 14,96 - turn lock : e Suspt front : 10,9 m - susoenst front : Subjectivjy base averaged weights out Driver ,gearbox ,steering ,vraj ride handling ,exterior styling ,interior styling sear , ergonomic control ,luggage space , percentage ,price value - Performance: Accelerated: Speed / time 0-60kph / 3,17 sec. 0-80 kph/4,55 sec 0-100kph , :6,27 sec 0-120kph - quarter mil , soeedo calibration ,120 kph ,error ,,116 kph / -3,3% Overtake 60-109kph. / 3,31 sex 80-129/4,24 sex Braking : Average speed to zero 100-0kph / time / distance : 2,77 second /39m. - fuel economy: Real world test route : 72,3km - fyej used : 6,3 litre -our consumption:8,7 litre / 100km urban cycle claimed : 11,2 litre / 100km Co 2 emissions 195 g/ km Fuel tank size : 55 litre - estimated crying Test conditions: test car odinetr : 5396kn Reading-temperature:21deg ,c Wind Locay ,test note : ---------------------------------- Car note Hon payment calculator based ,19 percentage deposit: 18.explanation: comparative test : Subaru. Specifications:-2Engine: Cylinder : four horizontally ,opposed Fuel supply: electronics multi - point injections -bore stroke : 99,5/79,0mm -cubic capacity : 2457 cm cube - compression ratio : 10,0 to 1 Valvagear : s-o-h-c bank four valve 2 : engine output ; -max power iso kW. 123 -power peak (r/Min)5600 Red line (r/Min). 6450 Max torque (N.m) 329 -torque peak (r/Min) 4000 3.transmission : Type cvt Low gear : 3,525to # 2end gear. 2,238 to 2 3rd gear. : #,641to 2 4th gear. : 1,194 to 1 5th gear. : 0,850 to 1 Top gear. : 0,850 to 1 -reversr gear. : 2,358 to 2 -final drive : 3,700to 2 -drive wheel : permanent ASD. 4.WHEEls and tyre: - road wheels. : 18×7,5j -types make : Bridgestone -tyre size : 225/45,, R2891 w. -Spare ,tyre and location ,spacy 5: brakes: Front : 294 mm ventilated disc Rear. : 286 m ,solid Hydraulic ,ABS. Breaker assist 6.suspension : Front : mac person struts Rear . Capacities: seating:4/5 Fuel tank : 65 litre Boot /utility space :348 DM.cube - warranty and service intervals: 4 years /100000 km,warranty ,3 years / 63000km maintenance. Test results: Maximum speed (km/h) -true speed. :210 -speedo calibration:60,,80,100,120 -true speed : 54,74,,93,,113 -odometer error :0,9 percent over. *Accelerated,second 0-60. ,5,2# -0-80. , 7,50 0-100. ,14/95 0-120 , 20,74 0-140. , .1km sprint , 32,15 Terminal speed : 264,4km/h - overtaking acceleration: second 40-60. ,/ 2,53 60-80/. 3,01 80-100/. 3,65 100-129/. 4,41 - fuel index : Manufacture fig : 9,2 litre /100km Car fuel index :/1 0,92 litre /1000 Estimated tank range : 595 km Taxable CO,2 rating : 214 g/km -braking test : 10 stops from 100km/h measure in second at ,30 second interval on good bitumeise -beat / worst stop : 2,70/2,89 Average of 10 stops rating ,2,79 excell - geardsd speeds ,km/h low gear ; 52 , 60 2 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 6 of 18 Nd gear : 82 ;94 3 Rd. gear. : 11; 128 4th gear : 253 ; 176 5 the gear. ; 299 ; 344. - calculated at engin power , 5600 r/ Min and red line ,6400 r/ Min - performance factor : Power / mass (w/kg) 80 Power / litre (kW/ litre) 50 Power / litre (ks/litre). 93 Torque/ litre (n.m / litre Engine ,,: 1124 Engine rev/ km - mass tested (kg) - test conditions : Altitude : at see level Ambiy temp / barometric press ,22° c / 2020 hPa Test car odometer : 1765 km -150000km warenty and five t ,100000km service Comparative: Test summary class Hyunay test scores,25/29 Mercedes Benz blue efficiency,75/100 Opel Corsa collour - hummer H3 adventure Design and development the TBM ,,700 is singles turboprop engined low wing monoplane aluminium and steel construction the TBN product PT 6 A ,rates at 850 sho (634) ,,522 kW take off and landing cruise flight engin power,859 ,,634 the extra ,,2529 neutical miles (2829) -General characteristics: Crew : 1 or 2 pilots Capacity: 4 to 6 inclus on passenger .cockpit Length : 10,65 m (34 ft 11 in) Wingspan : 12,68 m (42 ft 7 in) Height: 4,36 m (14 ft 3 in Wing area : 18 .m.n (193.7 ft Empty weight : 2132 kg (4699 lb) Max take off weight : 3354 kg (7394 lb) Max playload : 385 kg (849) - performance: Maximum speed : 593 km/h (320 knot ,368 mph) Cruise speed : 467km/h (252 KTS ,290 mph) Range : 2813 km (1519 NM,,1784 miles Service ceiling : 9450 m (31000 ft) Rate of climb : 12,09 m/s (2380 ft / Min Time to climb to 26000ft

-- Based . Price : | POA Number of seats and luggage : 2 seat ,34 kg - engine type : Lycoming -fuel burn : 23-30 litre per hour - tank capacity: 136 litre - range and endurance : 2384 km - propeller type and oper: sensenjc -undercarriage: - lead time orders: depend -standard avionics: vrf Panels - Speed |. Size |weigth Cruise:147 KTS| length 6,2m|MTow:794k Stall:38 KTS. | Wing:85 m| empty :460 kg Vine:171kts| height :1,8m| useful: 334 kg -pulk out plan Explanation VIP. Paint protection that actually works approved by major Manufacturing in South vehicle shield .. -bonnet guard , Headlight,front guard,side guard ,,repaired scratches ,stones Chios ,damage ,film removed ,film warranted 5years peeling ,bubbling and cracking -______________________________ Journey|price|engine|power|torque| 27sxt. | Maintenance plan: three years /100000km -fuel tank:78 litre -averagr sales per month -service plan 17..Explanation engine calculation How to calculate bore ,stroke displacement -volymetric efficiency VE=3456×cfm÷CID× RPM,, -Cubic inch displacement=NOC=Noc×SV - head gasket volume: HGV=HGCT×0,785×BORE: PVD=0,7854×Bore×DPD)+)+(VPD-VPB)= piston deck volume - compression ratio CR=1+0,7854×30RE×strokr÷ccv+HGV+PDV. +ISH=HP/16 : fuel system injector size per horse power.. VE: volume office, Cfm: engine air flow rate cubic feet per mine. Cid : engine displacement ,size volume cubic -RPM= engine speed revolution per minute . - NOC: number of cylinder -bore =length -stroke = length -HGV= head gasket volume Hgct : head gasket compressed thickness. PDV:piston deck volume DPV: piston distance Or .. SV= sweet volume . CR= compression ration Ccv: combustion chamber volume Ish = injector size per horse . HP: horse power--______________________ 18.Explanation: engineering science ,stress,unity stress,type stress,unit for strain , elasticity ,hook low, straight, ductile material,young module elasticity.. -explanation : applied thermal engineering engine testing: structure .explain performance measurement:. - basic parameters: -measuremsnt of speed . - fuel consumption measure -measuremsnt of air consumer -measure of exhaust make -measuremsnt emissions. - measure of brake power : -measuremsnt of friction horse power. - performance of si engin -porformence Calculate speed in evaluation performance development : charge load -bp=2πNT÷60, break,,2πnt/60,, AL ,,N.K/60 -specific output: Specific . Volumetric efficiency n=mass of charge actually scke in÷mass of charge corresponding to the cylinder pond conditions. -relative power air : FR=actual fuel - air motion÷stochiometric fuel -air (bsfc).. - thermal efficiency heat balance .. Brake thermal efficiency:= bo÷ m.f×c -performen e: Heat equivalent break work rejeter to cooling . - heat career for engin .. Heat balance sheet. Input | kW| %| output | kW | % ______________________ -explanation: construction techniques:. Petition: record -structure ,model aeriplane. section :;. Side : Model assembly details: Covering and finishing. Refinement. -------- -construction note Letter : ..... Materials:-- -letter,|number|name|size. |Masse A. 1. Gear 1/4 , -- Seat,frame,back,fender,back,Fook, healings,front,front axle,wheel,gasttank,rivo.. -- three wheel motorcycle: motor driven car ,, - simplified concrete mensonery planning ,mortar ,concrete = A.P/s - ----------______________________________ - explanation study material and fire arm ,ballatisc Gun Typical muzzle energy of fire arm: ______________________________ -fire arm (except |calibre |muzzle energy -air gun .Ek=1/2×v×v(2ft.LBf/7000gr×32163.f.t.t/s.s E=(m×v.v)+ K=450,95(2×32,1930,700)-- -spefication -Calibration:9mm ,para ,40s , -overall length : 2184 mm. -barrel length :5 - high : 240mm -weigth:0,81k Construction slide Magazine : 24 round sign front ,GPS -test firing results : -Ammunition : group - factor : -41mm. - hand load :51 mm..note accuracy average.group..fired ,25 mm... --------------------- -artillerie ,AM×30F@ Characteristics service -types : canon automoteur,utilisation Conflicts. -characteristic equipment : 4 home piece piloted longer left : 10,23 mm Larger weight:13;10mm Hight : 3,17 m Mass in combat : 43,5 tonnes blindage ,size ,case lunch.. -- -report installer: - mounting battery replacement step remote: - connection to the fence -connection , configuration -pc board replacement - service condity -Pc board ,F1,Fu ,18 vac fuse.. -Lcd display,18 LCD ,7,2 output in 500ogm Energy out put .500 ohm ,joule -9000v ,zone monitot,1/2 control display,2 max gate - gate and panic button input time gate ,yes - alarm output ,siren output .. - power consumpt under normt operational conditions ,18VA -battery time charge ,24h - solar power operational,60 Ah -wire in a Serie : galvanized : @,2 mm : 5 m optimal.. High voltage ,set point :10,00 volt ,set -- Balance rate installation: item..design draw element ,security access plan. --------- Card access reader mount type technologie. -biometric access reader mount type be specific. -keypad device. -keypad,kepead securt. -card reader with key.. - horn siren - weather proof him - horn ,strong - strobe. - car reader with turn attandance, Tensile,revolving door -traffic arm. -vehicle ,exit device , -smoke detector, -heat detector. -gaz detector, carbon monoxide,electro lock, push button ,camerarwite,camera ,with intercom, - security window scret ,heat detect, -window contact,vibrasic,glass,floor,car drivers,overload,dual tech ,contact saity,wall motion,floor motion, -beam fence distribution, - 19. Explanation : pratical school Disciplinary hearing school . trainings system orientation school career guidence : Experience trade explain: career skill -explanation: safe road usage teacher manual secondary: -explanation the foundation for road : Meaningful maturity,human dignity mordaly depending decisions,making responsible action , identification of criteria, phylosophie of life ,inclucating road safety , various level human , existing in frame of reference,co existing temporary,relation , - explant:the origin of technology and it's implications Forman ,technology and responsibilities ,Sens of responsibility and Education,the task of the school, requirements of the school,road safety and involved in accident, accident according degree ,type of road user accordt to racial group involved , statistics cost alcok poor vision . - explain: traffic training secondai ,content of traffic , traffic situation,those involved,road safety , certain criteria for ,traffic training ,certain requirements , content method for ,youth levels ,abuse among , legislation and low enforcement ,vehicle ,trafft ,element , traffic hours . Trainer methods conversation,self , training, Education orientation, -expt differential teacher road safety education ,basis off teaching from road ,child involved , inequality child different safety Education ,road Education for school undertaking parent school local ,,locak - explanation different road safety education and the secondary: Education concept ,secondary school ,diffet road safety , Education central ,road safety ,road safety situation, road safety orientation,road saft Education road attitude , secondary child personal,goal diffential road safety,road safety matury, psychopedagogie persscpectuve, fundamental pedagogic perspectt ,social pedagogic , didactic , orthopaedic ,irthopedidact, realisation , opportunity and road safety education, The school , secondary child basic ,, - explanation:the methodology of road safety,goal of traffic Education , traffic lesson objective,the learning objectives, problem settings and problem solving , - lesson structure and form.. -explan group course lesson , actually preknowled, actually , unlocked of new , evaluation, group discussion,class arrangements,quality teacher ,skill the teacher and group,how to handle group ,group cohessiob ,criteria for judging the success of .. General methodology guidelines. -chao teaching aid road safety education : Teaching lessons modalities teaching didactic , a schematic presentation of Education , teachings software . Teaching wath look like ,teaching wath , teaching broad ,blackboard ,conogragpguc teaching aid ,poster brochure model.. -thw sons box training ground the overhead projector , - the overhead projector film projector . -selecting teaching a lesson ,nature , didactic consideration, -road: safety ,nayv,point of contact in road safety ,few partie , department transformer provincial authority vlocal , evaluation .. -calcul situation traffic possible, criteria,test total traffic situation,different large ,self orientation up him self regards world self discovery evaluation accepted road,lesson telling lesson subject road ,time 35 minute ,lesson objecy explain pedestrian ,setting problem pupil ,stopping ,self realisation , instruction control .. Topics :Lesson objective to explain ,learn objective pupils must knowledge the application legislation and must able to mention aspects which ensures safe , pedestrian. - explain the problem: LinkedIn up knowledge pupi will be led to the realisation that injuries pedestrian behaviour is not only annoying to other dangerouse during lesson phase new content is gradually unlocked , - scheme consider energetic behaviour on pavement keep try to walk next another , stepping pavement intersection trafficking ligth buses getting out of vehicles. - the course of , actually preknowled the pupils citoyeb Saturday morning ask Unlocked behaviour pointed outcome traffic legislation is explained content , mentioned in problem solving is unlocked b, - explanation : functionalism : practising of acquired insight by mean model or diagram on the black board may explain how the will intersection as an assignment pupils observations and make annoying and effective behaviour of pedestrian.. -explanation defensive driving; road sign ,warning sign ,guidence , regulation sign , traffic bsign ,hand signals ,flag signal ,overhead lane flashing signals, road marking, - explanation: rules of road vehicles : control theory test driving.mirror blind spot ,signsk clutch ,speed control breaking ,gear change ,motorcyy ,board inspection , inspection staring , Explain manouvring test moving running left speed control changing ,incline ,turning speed judgement emergency . - the driving test : light motor vehicle, heavy motor ,the years ,staring procedure ,moving off , inclined ,alley docking ,reversing ,making a left turn ,hand signal , parallel parking ,the road test ligth heaving , light and heady . - changing lanes ,stopping in traffic , stopping parking , turning at intersections, proceedings ,stop traffic sign ,entering a traffic circle, leaving a traffic ,block pedestrian ,level crossing , overtake,entering ,leaving freeway ,overtaking ,on a freeway passing , freeway on Ramp.. - explain test checklist record , faillure manoeuvre point ,exceed time limited 29/18 penalty , roadworthy, violation traffic low , uncontrolled action , dangerous action , collision, 20..Explanation: Management system information: pratical Science motor policy guard - statement of insurt; statement of the administration,vehicle eligibility, important servit,policy commence date, replacement of components,claim procedures,cover provided this policy , components Covered, beneft: classic,bronze silver ,gold, titanium, polyester ,ceramii , additional silucd , transfers it,exclusion form cover ,limit Silver,gold titanium ,limi of indemnity,wear and tear restrictions, consequences damage,cancellatt,jusdiction currency and dispute,fraude ,quality control,insurer rigth after , service history intarion , statutory notice , resolution. - explanation : road warranty all passenger commercial maximi carrying capacity 200kg , cover the cost service maintenance accident ,petrol engt service relevat as . -displacement interval .petrol diesels electric maximum service run over if 1000km or 30dats occure RMI repair claim , - policy vehiclt schedule still subject to Manufacturing warenty plan motor guard plan. - faillure occuring 39 days . - replace claim process in event of mecanique construction fail occury. - Owen ,policy number , current kilometre ready,partic of clay ,item cause quotation,address vehicle inspected service record invoice submitted with 45 days , benefits ,5 years ,120000km ,18 years ,160009km - description of good stolen property must descrt very accurate bear it in mind invest official searching good , -makee or manufacture ,modej not years ,years of products, serial number ,registration ,engine and chassis ,size ,colour ,completed ,state midst iteb ,charge that change , ______________________________ - 22. explanation: industrial administration management - explain : general framey historical background complexity of management - general princy and groi of management thought. -growth of management the pioneers - outline of managet theory : definition - business orgat: organisation the diviy of managet, -growth of organisations stage growt ,orgabiy chart , organisation rekatu, - organisation problem : corpsratt planint traditional and modern organit theory future reauit , - production marketing and admnistration. - organisat and the manufacturing fynctt stage in production manufacti,organisation of production the manufacturer functions: -:Products the ancillat functions b; maintent production planning and control store keeping purchasit handlit of material. - products the advisory functy : work studye time ,method -production the advisory functions : work study time study methods work study , ergonomic , operational research inspect. -marketing : marketing's organisat: admnistration area ,personek management wage. - growth of industrial relat: trade union unions emply associt collective bargaining and joint negotiation: - personal managent : motivation of management content of a personal policy achievement of harmony of objectiy: - the person's department staff recruitment, the manager . - personnel functionalite organisation if personnel department staff recruitment sciencetif selecti - job evaluation and : wage structure determining the wage structure merited rating personnel problem induction training wage and salaries: - personnel problems: disciplinaire promotion safety labour turnover management by participation personnel statistics ., part four financial management and statisciak .. - financiere management : scope of accounting provist affinaire source of finance. -outline of financial and cost account definition the purpose account , fundamental accounting transit from financial to cost accrost , classification. - of cost controlling cost absorbing factor .cost miscellaneous overhead absorpty , overhead facially .. -cost account system : process casting batch costing hybrids costing ststt organisation for labour orgat for material cost organisat for overhead .. - method of casting and control : marginal costing decision . - profit and efficiently and loss measure capital expendy decision . - statistical method : Chart and graph statistics quality control . Designation experimt time Serie published statistic.. - part ,five the industrial environments: The middlege to eight center the industrial revolution from development of large .. - principal development in some ,major : coak iron and steel engineering textile chemical and artift fibre ,scienty research.. - the economic ent:.demands and supply cost of production types of compety resale price maintenat the general economic situation. - general principles of financial and visit low banking and finance trade credibly commerce the merchant bank and issuing house hire finance industi and commercial Indy corporation for industrial negoy instrument. - government and industry: introt devet of govert organisation of control . - necessity for government control : - element of legaj system : the low modern communities source of low common low system Englanders and Wales legal person the idea and property. - general princiy : of contract princt of contract and commercial law ,contract ,tart liability for dangerous premise agent sale good , miscellaneous commercial low matter, - elements of industrial low apprenticeship contract of employment factories act Offit premise ,act social insurance industrial arbitration industrial relations general managent division function .. - explain award bid clause ,price industrial minimum salair ,flow manufacture process lighting tube. Design process: Order ,item price : product case 24. Explain: pratical school regulation and irregularity Vocational guidance theory and practice: -1 vocational guidance , -2 explanation: psychological explanation of occupational trait and factor personality 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 7 of 18 development , social learning ,decision making autonomy, -3 explain sociological explanation of occupational ,choice class gender ethnicity group , opportunity structure an interdisciplinary framework. 4- explain , the interview: philosophy, structure questions talking silence , listening ,non verbal communication information and advice. - 5 , explain traite factor client centred , psychodynamic, behaviours problem silvt , fantasy,the place of counseling in vocational guidance. -6 Career Education: explain objective: structure and occupational information the curriculum evaluation. -7. Test interested questionnaire,self help instrument computer based guide special program - re written career guidence ,total faculty subject total grad time table Admi total grand reason career .-explanation: study of occupational ,self study of occupational. -qualification obtained your present position how college. - how to choose career,: knowledge of occupational finding about occupation , know yourself. -how to apply find employment,way find . -how to apply for work . -how work relationship, introduction, different kind ,your concept relationship .. - communication ,danger --explain , psychological test : instrument , mechanical and technical aptitude. -qualification| work do to choose career - occupation | social conduct , relation social . Psychometric -Personality and aptitude profile confitial psychology Name : Interest ,| attitude | verbal reasoning , vocabulary ready completed| factor | personality - test results reported | survey councillors . - profile / v(y) ,, Batteries , ______________________________ -explanation tpm is profitable,direction in production achievement zero breakdown the parko factory. -RPM challenge limits from four devet stage , definition and distinctive features Tom striving for overall equipment effectiveness tomb,defect prevention system ,between , Tero technology and -explain: maximizing equipment effectiveness , equipment used at half effective. - breaks motor stoppages imped automation stop acceleration the deteriore of equipment. - explain preventive maintenance alone cannot eliminate breakdown five counter measure for zero breakdown. - unlicensed operational of automated equipment errors equipment investment, five tpm development. - organising for tpm implementation the twelve step . -step ,announce top management decisions to introduce tpm ,step 2 : launch Education companies. Step 3 : establit create organization's promotion. - established basic Tom police and coak . -formulate master plan for tpm .. Tom , implementation,and stabilzat. Step 6: hold Tom Step 7: improve equipment effectiveness. Step 8 : estabt autonomous , maintence prograyfor operational. -step 8 set up schedule maintenance program for maintenat. Step conduct improve operation and may skills ,step initial development equipment management. Small group. - integration small ,small group goal coincii with goal , - evaluating the maturity of small group acty the functionalite of top many in small group . 25.Total maintenance product,,meeting police ::-- -explanation: director social worker practice theory and skill, - explain social work,an overview. Direct practice domain phylosophie and roles . - overview of the helping process. -explain operationalizing cardinal social work. - relationship building skill community with emphasis and authentic. Verbal following exploring and focusing skill,eliminating counter productive communict patterd multidimenst assessment, - assessing intraperst and environmental system . - assessing family function , forming and assessing therapeutic group,enhancing motivation,with involuntary and ambivat client,negot goal and formulating contract . - change oriented phase ,planing and implementation change oriented strategies. - enhanced client problem solving skills assertiveness. - modifying envit developing resource and planing ,.additive emphasis interpolation confrontation ,managing individual famili and organizat barrier change. -the termination and evaluation phase , Explain : final phase termination and evaluation of code ethics,timing and intensity ,of self disclosure. -A paradigm for respond authentic stimulation client message. -Fuel for authentication response.initiated by practionner. - positive feedback form of authenticity response . - relating assertivei to client saying no and setting limit, - exercise in responding authentication and ,client statement model resnse ,in surface underlying feeling , answer to exercise to discriminate level of emphasize response. - explain: verbal following exploring and focusing skill , maintaining psychopedagogie contact with clients exploring problem. Verbal following furthering response ,paraphrasing response,open and closed end , responding,client statement,seeking concreteness ,modeled response , summarise response analizing verak following skil , - focussing ,a complex skill selecting topics ,exploring topics depth blending open ended ,empgic response maintained focuy.- evaluation used of focussing , response ..to exercise,answer to exercise identify in close and ended response .. -explanation : eliminated counter productive communication patterns: impacts of counter productive communication patterns : eliminating non verbal effecty communicay culture nuance of non verbal ,other inventory of non verbal patter of responding -communication barrier eliminate verbal to effectively,gauging effective response the challenge of learning new skills. - multidimensional assessment, critical role of assessment , -assessment an ongoing process , assessment as product,include strength in assessing,sources of information verbal report.direct observations of non verbal behavt observations interatclient monitoring collateral source of infot. -psychologi test , -computer assisted personal experience based on direct interat. - the importance of self awareness. The multimensionaliry of assessment. -the problem identify the clarity ecological factory assessing devetneed stress association. -key factor to be addressed. Manifestation of the problem, participate -explanation: source of information verbal report.direct observations of non verbal behaviour, observations interactive.client self monitoring,collateral source of information. - psychological test., computer assisted asssessor personalite expression based on direct interaction. -the importance of self awareness. - the multimensionaliry,of assessment,the problem identify the clarifying , ecological factory assessing development, participants and system implicated in the problem how participate. , development stage and life transitions. - severity of the problem meaning client to problem. - site of problematic behaviour the temporary context of problematic. - frequency of problematic, possible alcohol, substance. - child maltreatment.and spouse abuse . - client emotional coping effort skill strength and skill of client . - cultural and social class factor questions to be answered assessment other factors . - assessing interpersonal and environmental. -the interaction of multimensionaliry humans the introper system , biophysical characteristics presentation. -physical health cult factor in social support , assessing use and abuse of , alcohol and drug , effect of abuse alcohol dual diagnosis in , biophysical social , using interview skill to asses possible , alcohol ,using instrument and procedures assessment . -assessing abuse ,use of instrument and procedures ,conveying assessment finaling client.genetic factor psychiatry. -cognitive , perceptual , intellectual judgement , reality testing, cognitive flexible ,value misconceptions, concept, interaction between cognition emotional and behavioural, - emotional functionalite, emotional controls ,range of emotional, appropriate of affect ,assessing effects disorder ,bipolar effective, bipolarity ,assessing social,.- : motivation: precipating event and motivation,in volunteering client ,culture norm , different, determined pattern degree of acculturation , bicultural and mental health .. - fluency with language problem solving , achieved credible, providing immediately benefit attitude ward , environment health and safety factor environment resource universal need identify relevant social , system social support system . - negative social support system assessing reciprocal interactive between individuals , instrument to , environmental need of disabled. - assessing family function the evolution of family system. - system framework for assessing . - family functioning , family home , content process of interaction.. - sequence of interaction employment circulum explanation , assessing problem. - outer boundary internal boundaries and family subsystem family power structure , family decision making , family and range feeling ,gosk , family myth cognitive communication styles of member , - forming and assessing therapeutic group ,classication of group formation of therapeutic,group established group purpose,Agence and practitioners perspective. - established specifications individual group goal.. - conducting preliminary interview. - group composition. -open versus closed group ,size frequently and duration meeting. - voluntary versus involving .. -assesin group process, assessing patterned idify group alliance , group norm value , -enhacing motivation with involved , applying concept from social, initial contracts structure of initial interview.. - using confrontation facilities. - negotiation a problem search bargaining with clients getting mandate off your back .. - exploring self defeat consequences,resolving ambivalence in family creating incentive culture hope , highlights strengths modifying cognitive self . -negatiatinf goal and formulating an rational contract ,purpose of goal ,type of gosk , guidelines for selecting ,process of mutually selecting .. -- -26. labour relations in education . - termination for labour in education - act and bills for labour low in education . - explain: an historical, clarification of concept the development of labour ..- the of exploitation racial discrimination, Explanation: era of advertisement ,the era code termination and cooperation. - development of Education labour relations. -sources of labour , labour relations and the constitution. -the common low and labour legislation for Education. -the rules of natural justice.., -the contractor of employment,labour relations act and related labour low. - labour legislation for Education - individual employees relation . -defining employees and employers in education. - employees right of employment in education, - employees right of employment in education , - fundamental right . - duties of educator as employee .-dumie of employees Skill development and Education ,national skills authority ,seta for Education, - learnership in education , - collective labour ,freedom association, organisation right of trade union ,. -collective bargaining in education,collective agreement,managing industrial action strike and lockout. -responsibilty of manager , - procedure during strike ,duties of manager , established and implementation..- fairness in workplace disciplinaire: - substantive and procedural fairness,fair unfair dismissal , progressive disciplinaire , - workplace disciplinaire Education: - incapacity ,poor work performance,defining poor work, procedure incapacity, health injury , definitely health ... 29. Explanation : - Principle of commercial low : Large credit ,agree small intermediary, - explain: size of agret, regulation, concellation of registration of credits b, - registration of definitely counselor credit . - consumer credit policy. - source of the low , statutory low or legislation. - the constitution . -the customer low,judgt of the court ,old authority , foreigners low , case discussion. - the court in repubit t constiy court , - the constitution court . The supreme court appeal ,high court officer of superior court duty -officer the supieur court duty process master . - magistrate court . - doctrine of store decision ,Cree case create judg . -application of the doctrine : - interpretation status : the relationship bet the star decision rules the general principles, - court judgement : ration decides . -:the term : low rules ,meaning low rigth, legal subject legal objt, intellectual,private low , protection , servitude bself defense provocation . ,- term of the contract : essential natural and incidentally,condition ,penalty - contract of sole: the our,chosen is entitled to be protected by seller again b,for content , - indemnity insurance. - determinat of the amount payable non indemnity insurance ,value house ,. - relation diffusion form intellectual, - franchising : mediation, arbitration,award Statutory arbitration,source of the low of arbitration ,matter excluded form arbitt ,national cause ,matter relating to ,criminal case ,validity of arbitration agree ,the arbitration agree ,the power of court in relation to arbitration agreement,stay of legal proceeding where there is an arbitration agreement appointment of arbitration,power of power of partie , appointment of arbitration ,power of partie to appoint arbitration to fill , termination of an arbitration , - notice of proceedings partie , summing of witness and recording , evidence manner of arbitration award the act ,time manner and publicat of award refused to sign must does not invalidate order specifications,setting a side of award ,cashing of cheque,the relationship between card ,issue and card hold traveller ,the low of trust basic feature a ,trust transfer control ,, right consequences of windings the effect of windings, liquidation meeting land proof ...- the low of administration of estate ,the executor ,appoint , furnished of security removal and dischat ,master , preliminary work ,death notice , letter accept ,band security ,making over in space ,completed sell , redistribution agreement payment to creditor on brief 30. Explain: practice school management -management characteristics of management styles the main components of . - planning: explain planing cycle different level of planned the need for planning policy general guidelines for effective plan - explaun : step decision making ,routine and innovative. -explain : time management the importt plannit way in which time is wasted making effective . -explan time table drawing time variouse , drawing up time various types of time table .. - the annual programme , purpose of the annual progrt consii drawing, - plannt preparation and record and keeping. - culture activity in the debat society youth activities religious movements , competition. -explanation sport actuy ,the aim of school ,sport police, - basic requirements for successful organisation and control , organisation of sport various.- the education value wells organised . - Education excursion - officii applit for sport. - officit applit plannit and organisations, number of excussioner ,prior assssmt ,follow up teach. - follot up after .- teacher and human relations ship ,teacher and authority ,teacher and the princit, teacher and principles,teacher and colleagues,teacher Nd pupils teacher parents .. - class organisation and routine . Definition of class room management.the relation between teaching class manager , - the important of classroom management. -element if classroom management. Organising the classrt to create atmosphere for learning developing an effect classroit routine. - furnit arrangements changii classing storage and stirat facities.. - laboratory organisation pratical work . Grouping and teaching. - the structure Education department,head office advisory council for Education and training, regional control , circuit area office board of control ,board of many ,school committee hostel board ,parent teacher . - type of schot secondary school ,special school the . - explain correspondence and filing system: -the prescribed filing system ,subfiles , Directive regard mail ,register The school journal ,the visitor Matter arising from incoming corresponding. -explain : in service training: in service training for staff development aims the in servit training. -the task the principal: substance a travelling allowance Decentralized in service training role of head office in service . - delagating : What Delagaty means ,who delegates , in the school , difference bet ,the of delagatiib . - - co ordination : co ordinating teacher work ,subject meeting , coordination pupils , - performance: perfot appraisal performance appru , performance effective common value ,reviewing and analyse career development.- staring equipment,storeroom ,stick keeping teacher in charge ,papper order book kept number item , - safe check labo rules maint conductivity head office directorate ...- responsible post school ,power durie . - didactt oriet instruction and learning , Didactic principt condition ,the currit ,aim of the currit ,the selection and oral,(arraignment of learning .. - dudacting method and each ,lesson presentation evaluation .. - defining didact science pedagt ,.- didact and other relating teach ,didacic . - the didactic activit ,the didactic situat,general peadagogic andragific . Didactic environment. -tsxhook as didactic nature and structure ,task of the ,teach learning ,tertiary education institutions non firmaj cybernetics ,system theory . -------______________________________ explain: activity guidance, -explain : self knowledge psychopedagogie , decision making stage , - choosing partion,examinat,tertair Education ,social conductor ,human relationships,the work. -need that can fulfied through work ,the career attitude towards. - testing: questions such follot may be set nocturak pedestrian shi preferably. -a grupe discussed: stlabutthem courtesy and road usage -the educational objet:to orientate the pupil in the relationship between coutsey and responsibilities. -the learning objectives:to identify the character of courteous road usage determine level . - to accept a losit attit award the requirements. - explain : solving problem : during the unlaxjinf of new mean of discussion teacher must si that follotbasic fact concerning courteous road usage trafficking. - pupils Alfred have knowledge: steering : it is difficulties to determine the main character the relation courtesy and is not clear jointly lesson problem is formulated .. - good maneee : unlocki new content pupils asked traffic low pupils matter how disret further points , - dunctt: characteristics of courtesy can applier motorcycle .. evaluation pupils completed self questions,@= alway, 2 = often ,seldom - 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 8 of 18 traffic ,control - questions: wath is functt if a lesson objective ,his is lease object ,why is formulated of a learning objectives important in term minimt an skill level of achit. - why is lesson problem import give 4 reason..-what us primary with demonstrate lesson .. - wath is importy. - during introductory phase of lesson them . - which important prerequisite applies to group ...-----______________________________ 31. Life training religious,Cristian culture, art buchellor : Explant: administration Guide master form - explain spread gospel pratical & Admnistrat Guide master form , - questt after asked about . - introduction letter church member... -suggested sheet adver,suggested 1st years scheduled (33 weeks , - application form admnistration, -student address planer, -recors of tests marks and exams ,paymet of fees register, -attandance register , assignment register. - order for code cost and note ,record of orders, -certificate warding sample in cover ,-bible school survey compus registraty. -please take book apart except the last two sheet important documents read, certificate sample , certificate merited , certt Christian service ,diplome in Christ lead ,certt in word minister,licenciate in Christian ministries .. ------------------.... -32.explanation: marketing reseat the research process and problem . - structural eqt models ,neural networks,social net,- analysis ,factor analyse ,cluster analysis. -cass part , winscon power,stormt equt,canopy of core ,canopy production, food ,transitional housing ,picty word megabyt of ...- equipment,fabut -research report ,fundamt criteria if form of report the oral grapt presentation. - students guidence to office autimat : . Office start four kinds of infot infirmat processt operational office ,procedure office system office, - example of an office system designing and office ,system the impact of office automation on job. -office automation hard , - computer and office how computer work disk drive,work disk driver input output ,device networks other office automation hardware. -the electronics desktop,system sittt ,operating system task operating syst command . - operating envy. -recors keeping : record keet concept ,record keet task ,record keeping application type of record keeping . - software . - choosing a package. -spreadsheets: - spread sheet and database packau ,spread sheet package other spread sheet facitie and graphs spreadshtappli a.. Item loyal customer te - 32 explain: Educational the Mrs in time perspective. Explain peadagogic and perspective history of Education development .- orientation : Greek idea sophist concepts ,Socratic idea of knowledge the platonic concept ,Aristotelian idea on the infrastructure of Education ,the stoic Telos formula , - Roman idea , earthing Christianity ,media volbidea ,humanistt ide ,pedagy becomes ,pioneer of peadagogic founder of pedagt become science of historical original and development . - methodology of the history of Education.: orientation field of reast nature of problem of research ,general methodict,post minded futt ,factuality individual b,open mind , Conte temporality , setting the regret methodology unrestrained complexity present and future ,nomothecity .. +Professional competence personal enrichment.comparaison ,method approach,basic science method of investigation,them design field ,invesy of contemporary them , hypothesis formulation, investigation ,collecting data making , established information Education ,interprefinger data writing, approach for research, problem historical problem historical anthropology approach Mets bletic , history. - explain : development of higher education in general.comment , concept higher education a time instituts history functioning ,modern ..-explain college university criticism , justice. - established ,some .. - English education system ,control Education used ,aim content , - note ,th the act preamble to the act ..some stipulation-- Aspect of the provincial Education system : - Education control , religious instruction,teaching medium . - a natit Education dispensation coordination uniform in education matter , preliminary work for new Education dispensation .. - policy keep with policy principles : change in some important Education matter , preliminary Education primary and secondary , division to schools course , the grouping of school , provincial Education , -- - 35 .explanation :General psychology low - the identification of psychopedagogie two , -method of psychopedagogie test nationalism the experimental testing the experimental method the clinak methods, naturalism observations testing ,the functy of theory test verification , modification form of modern theory . - explanation of behaviour reductions, explanation pattern , psychopedagogie influenced school of psychopedagogie present phylosophie - motivation , : explain motivation questions acquired classifying working . - biological energy recurring need measure activai stimulus transaction - discrimination conditions: other classically conditions response , instrumental learning and operant conditioning..- - reward and principal of reinforcement three learnings situation narration rewards non continouse extinction, stimulus generation learner reward negotivr reinforcement and motivation. .-learning : selective discrimination learning ,trial and error multimensionaliry learning.. - motor skills learnings motor skills task distribution of , transfer of training feedbay knowledge. - verbal learning : general procedure verbal rate presentation vfactor some interpretation in verbal learning transfer of learning concept.. -cognition memory: Measurements of two factor of retention,short term memory information processing memory control language, development, hereditary some genetic principle . - maturation: patterns of development maturation and experience. - some devely topics : perceptual development language development of intelligence development of socisk . - sociality interiors change communication society .. -consumer psychology: attention getting methods effective of advy other aspects of , structure,purpose Personal patter animal socisk manipulation social acquisition. -motion : emotional in history analyse Lyman emotion physiology functionalite, facial expressions. - acquisition emotional: limitations emotional conditions, learning developing and maturation of emotional,theory.. -psychologicsl stress: selyes ,systt stress psychological stress psychomat. Perception : receptor function:vision audition ,faction and skin sense kinds, - psychophysic : detectsbily low sublimation perceptions scaling ,.- - organization's : reception audition faction the skin equilibrium. - origin perception: development perception at distance visual depth movement perception,sound locaty colour perception colour their.... - subjective color after effect illusion. - attention : matter orientation Tracy passive stimulation select. -attentiin analyse : neurological attention negotivr didactt listening institute , attention brief stability. - conditioning : the learning concept classical conditioning ,temporal relation extincty recovered higer order classical response .. motivation .. _________&&_&& - learning and memory at school in Learning psychopedagogie persscpectuve perspectt components of the learning memory. - model , - the affective level of the learning memory process sensory memory. -the cognitive level of t learning memory process Short term memory -the normative level in the memory process long term memory Long term memory epis and semantic memory why do pupils forget learnings . -learning subject content school -ainm ,learning model for subject content planning phase , planning and preparing subject content effective learn ,planing execution phase.. - step in the learnerinf process with reference to learning pattern level of drilling reinforcement and competency , -product phase ,level of proficiency,level of structure complex , monitoring the prodtphase. - communication the teacher as the exponey Education in transition teacher communicayteach ,communicat process ,general process. Communicator style noise , - Educationak medit for effective teaching media practice subject : teach computer in education class PC Education use for teaching - learning purpose :.computer aide instruction single PC managed available and placement of teacher : - social aspect of classroom practice Communication classroom , emotional aspect authority flexibility. - acknowledge of father people motional encounter ,transfer of value personal aspect distance. -function of teacher task directed functionalite of the teacher the social emoy group . - life orit: explanation competency life skill ,type of skill life orientation study research in respect.- -role : of the the church in realisation the role society . - the role of occupy life in the realisation of wath do emplot exception terrait planing for life skill trait. - explain definition terrain delimitation,the desit of programmtfor skill training a primary or secondary,CVS develot ,life skill modej ,religit Education theory and Irat. Agraindinf of the subjey ...- - handling of pupils of : Motional assisted.. - benefits the individual , orthopaedic they ______________________________ Explanation: teacing the practice of nursing a text nursing didactic th. - nursing educst the phylosophie of nursing ,nursing educst . -the scope of practice of a registered nurse . - the scope of the role nurse. - the scope of pratice of enrollment nurse . - the independent and dependent of nurse ..the independent functy of nurse . Phylosophie of nurse ...- the historical of nursing education outline ,:introduy , nights syst, amercain system ,conbtini. - purpose : and object nursing education.: selected of Education object in nursing ,decide what student ,plan implementation plan , evaluation. - authoritie responsible for providing education . -regulatiin affecting nursi Education: Regulation country council ,RSA ,training registration and enrollment ,types course a Aila le registration, --_------------------ Safety health aid tools hand ,,,. Education safety health occupation,security. ,, ... Explain: what is pedagy importance of pedagogy in teaching and learning process , - what is pedagogy, - what is the pedagy in teaching, - difference between a pedagogical approach pedagogical technical. - type of peadagogic, - role of pedagogie, - pedagogie is method of teaching in theory pratical understanding student. - pedagogie in teaching in refer educator student lead ,LMS , construction. - teaching quality of teaching, encourage cooperation learn , eliminate mono learning. - pedagical technique ,a pedagogical technique. : defines a set of action performance by the teacher in the classe for teaching include flipped learn learning computational thing and stepped learning it is more granular Thant . - technological pedagical content knowledge understand of how teaching learning can participate framework an education. - technologiCal pedagogical content knowledge framework integrating knowledge record. ______________________________ - Engineering pedagogie educating ,focus if view of engineering pedagy is the development teaching concept creation for the preparation of further Engineering leadership roles changing . - explain problem base learning TVET engineering electrical, ______________________________ - explain ,educare qualifications has been designed for people love work with children be able growth development child phrase .. ______________________________ -explanation psychotechnique ,: system of actor training preparatory Deve theatre practical test measurement large verbal numerique ,test permis, suspension, permit v. QI. = Quotient intellectual ,age mental /age chronological . recruitment test suit logic. Is used to determine the degree of extrave Ce emotional stability professionalism ,as employment,is concerned accord board dimensions psychopedagogie. -______________________________ Psychometric test : the main goal of an aptitude test is to ensure that a candidate passes the amount of skill and cognitive ability to perform the duties of job role the common skill set measure test numerical verbal and non verbal rea ... 39.Explain: pratical school , orientation industrial trade Pratical nated , - promote standardisation in trade and industry is one the objective of council ,CSIR -orientation industrial in electrotechnology.standard industrial draw and label gate by EIC system gate output,,explain neer . orientation industrial : in electrical trade theory ,domestic appliances: type machine washer , ,,- maintenance out replace element tasg ,replace ,stei pannej ,, - orientation industrial in plant operations theory ,chemestrt and chemical processing ,cellulose fibre material ,manonr,readrvcombustion fuel and thermal insuy,,transfer heat pump, mechanism , convection. - orientation industrial advantage close cooperation compagny ,industry ,, Functionalite supervisor control responsibility,the aspect to prevent is to teach workers not tact :teach work Teach worker. Discuss different between Education and training .. government institutts. - a supervisor realise account organisation position direction tools ,, - importance diRectiob stragie ,operationel ,, - supervisor selection worker job tools need , employees training performance - operator is need mechanical workshop machine operator for stocking material - industrial orientation in trade electrical Operator stock material orientation, By protection ,heart, illumination. Application , equation AC ,DC - ______________________________,_ -In dbe to isita project to teach workers In dbe teaching worker training direction practice workshop dbe ..compagny corporation City power Eskom : exam national DBE ... Explanation , orientation industrial vs manage supervisor,vs management system information vs manage system information in education key challenge n Career posting time table counseling: trademarks industrial compagny trade theory license and trade pratical license. Orientation industrial Teach sork disciplinaire work communication skill team study team operational discipline teach counselor assessment and facilitate team value Journal classwork average score Counselor statement ,by psychometric goal work counselor conduct misconduct coursework engineering Counselor engineering studies creation Portofolio assessment,and planing by ruling courtesy low common . In dhet ,,in DBE workshop technologie Counseling project by orientation checking low outcome workers project isita umalusi electrotech EIC commissioner in job experience -Minister creation secret arrested ministerial letter appeal step. Minister dhet and DST building infrastructure government system careers creation authoritie building creation, counselor conductor, complain compliance duty Orientation industrial guidelines project workplace disciplinaire, questions number of task number job project marktrad licensed , -appeal release result irregularity,non accreditation school instituts research trade training to minister ucpd , development isita creating DST ,supplier profile , regulation,minister irregularity creating diploma technologie system DBE and recreating system backlog ista Teach appeal low Education processing learn ,by abscent Clauseoffice ucpd record learner orientation ministers teaching students practice counseling orientation industrial and marking process presentation ucpd and DBE system was learn job in trainer training . - explain: isita project orientation industrial counseling experiemental - pratical experiemental irregularity assessment. back log ,,time table n4 ,,and time table n3 trade theory examination .. Irregularite suspension 12month ,n4 rwiten final n6 ,n5 final examination,final soon n4 examin irregularity final Examination assessment years academic final , -Level 5,6 framework qualifition letter no qualifications isita back log . Irregularite: 12 additional information pratical process learner completed: Management system information Level 1,2,3,4,5 vocational principle police theory ,applied resolved Orientation: principle . information management system: Pratical 12month ,18 month pratical subject pratical exam school . Topics test n 6 .. -in high Education subject assessment moderation project: In dbe subject it orientation vocational guidance: outmark DBE filing pratical Poe s Isita project student make computer Learning lecturer computer subject , orientation skill training computer system - information system , :computer - quest operating system ,display option control panel gives , - system tool data computer . Option , change display ,system defragmentation display.. - uninstall program system programs feature ,, physical formatting Calle relative , ram room cache memory ,folder created. - Process of converting or data into prevention b, software , fraudulent vpratice email personal information ,infects . - format pictures style drop ,use ,,spread is opened ,insert formulae .- appropriate spread sheet v. - appropriate functy determinat the price contract router .. - computerised systeme Create a news set of name select file compagny , - compagny parameter , business - word processing : create services invoice ,use Arial 12 pt , all .. - leave two line space , key ,, - unit and replace word megabity ,save file A,,fibre .. - irregularity,isita project back log record complain subject .. Assessment mathematics: -Orientation industrial and trade mathematics :teach workers ,trainer workers supervisor ,standard measure -Management supervisor, :mathematics Computer system management -geometrical, algebraic ,limited , dervide function Prove ,radius area high calculate approximate change in volume: V= π.r.r.h -use partial fraction to calculate b.. -determind particular solutions integration. - sketch the graphs of , the area bounded . determine the length of curve , equation, - calculate surface the curve , x ,y is rotated-- Engineering ,orientation industrial: engineering physics T# compression : Heat heeded to bring heater , Heat gained ,heat lost - electrostatics: Power = w/t the amount of energy . - heat gained ,atom , frequently ,the energy of each ,,thermionic ,optical ------------------------------ - electrotechnical : DC : excitat motor control obtat adjust, Alternates - power 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 9 of 18 developed,rotor output ,, Power input = rotor output rotor . Energy Industrial electronics ,transient ,calcul value resistance to allow oscillation , Transducers : standard current ,step .. - ultrasonic x -rays and radii activt: the energy can transmitted the energy genert high , - electronics safety device and electronics ,regulator system. -thyristor device and scr speed . -,programmable logic controller.. Pratical industrial in dhet high irregularity regulation material project ,, Outmark .. - Counseling: project In dbe project workshop counseling Management supervisor workshop engineering,isita record academic ucpd Create diploma: certificate Counseling industrial electronic electrotechnique mathematics ,in trade theory electrical ,material irregularity DBE disciplinaire 11month suspension marking progress .appeal minister Pratical, action take occured irregularity and complain address ,, qualifications subject: 18 month technology guidence vocational module. Explanation : career vocational science ,, explanation low Portofilio. The police introduction - section Career orientation profile, - selection process ; choose career answers. -question reward live leave , professional answers occupation. -student guidance counseling police opportunity,, career understand job sleep skill , duty correlation, - peace officer preami,duty assignment case involy policing ,salary career allowance, duties securite function compagny invesy,older private police no longer existed replacement ,in function ,police minim case senior college orientation profile,psychometric , polytropic test college Deb employ , task physical , deduction probation life insurance, professional, listening ,career ,profey a matter an amateur career ,Unifor report ,court syst , division Pre trial paralegal ,, - police officer entrance exam police measure the basic skill ,exN read word duty -what is community oriented in policing range , innovation organisation police improve skill project build communy , procedure,practice , activities residents ... Explanation: irregularity Error test used for diffece between two independent sample satisfactory distributor performance: -service ranking ×1 overall,raking difference ,d1=y1-y2.(Bid sum .d.d = s data analyse invest assot agreement irregularity and back log project trademarks nated in job ,step process respond , provisional tax payer and penalty , understand and late submission,file Portofilio education trade , ,maturity date Poe s social award student , coupon rate 14%, internet,tendered bid or submitting 12%, tendered assumed accepted ,(1009),I R 709 interested,pay + c / 100×d, 3609,c = rate interested order ,d= number of day , 60 day proceed,R,1000=(1000×17,49,, denomination acceptance capital emploie, capital reserve resent taxation total assets liabilities balance sheet,manufacture -pat total retrenct , provided tax liability,salary and interest tax sum tax norm tax tax free portion award , provisional tax ,income salary overtime , allowance award irregularity plug ,equal renumeration leave,less acceptance of quotation irregularity and back log . ______________________________ 40..Management administration industrial , - products maintence tpm - H: rate of Quality products 98% ,ideal cycle time=0,8minute, f: actual processing time + j×g=0,8×400 t availability= s/c×100=400/600×100=87% -(m: operating speed rde= I / jx 100+0,5×0,8×100=6,25%,, - net operating rate = f/e ×100=(0,8×400)400×199×80%> I: performance efficiency ,+ m×n .100 +×100=(0,8×4000+80% -net operating rate = file + actual processing / operationek -process amount × actual cycle to operating+ 400 item× 0,8 % availability, Avat + operation time / loadshedding time day academic record and Pratical -net ... -time loading,400 Mon × 109+ workplace record accuracy,process running,planned down ,lost process ,time c- d ,, processing time ,, j×g operating time finished , external total, quantity processed ,total including losses memory , attander ,cycle , actually processing time - time × idee cycle actual appears= 400 item × 0,8 Min /400,, -ovarall ,, - job schedule job , production planning and control schedule date issued , relaxation total,credit 0-4 Min work earned ,1080 per× 0,4+43 Min work Min available work of 100 performance ,432 Min ,, 432/432 days of work = 90 out ,100 performance,Orla ,% is over all relaxation allowance mode rate .. ---------------------------------- B. Planned down time per day ,down time accounted for inhere proceed,-- a.manning meeting +29 minute loading time per day. A-B + 460 minute ,D ,stoppage loss per day ,break down,20 minute stop, 30 minute, adjustment -20 minute= 60 minute ,operating time per day -C-D= 400 minute ,G : output per day + 400 item file 42-Duty industrial trade college and industrial , - explanation ista project back log computer student make . -document wallet project office , appointment documents access post , -docuy wallet registration form appointment office , register documents employ, information recruitment documents Wallpaper wallet information,database stationery documents wallet ,arch office ,office size mass . - docuy wallet bank account ATM printer ,record book customer revie ,record registry I'd number system , documents wallet Portofilio job career , - database emploie system entry exhib , - emploie record trait job qualifications graduation training post advertised, - I'd register for customer entry databy job post sale reward , programme logic control custy logiy system I'd programmation language database .. - print I'd frame work student ,print I'd student information ,print I'd ,job duty post ,print task rosta ,price over time print labour .. -explanation: to -electronics digital analogic circuit: input a,b gate yes = a.B -storage : potentiometer coefficient resulted and reducing voltage integration by factor (6/12(initial ,x= 6/12 chart capacitor input , output and gate Inverter integral circuit dx/St,,6/4 ,13,, Sum,integer,summat,difference,RLC L.di/DT(R,,+2/c , integral.. -construction PC architecture design development: input unit yes mouse optical keyboard yes , card red,control unity memory RAM ,ROM yes output ,CRT didn't,CPU yes ,room ,yes I/o,year vertical ,8 bit 69 but ,64×#=655336, -memkry systt. -sequencw +3 yes ,0,25 yes ,a+b ,A,B rim , - row yes data ,yes gate output gate , transistor bibpolaire logic diagram ,static RAM ,select ,supplies logic , - booleen algorithm program read ,yes memory register , printer charge plate ,electrosty digital input ,character ,source ,Lazer mirror ,module ,ribbon tape supply. - data memory time yes, -128 sector memoire ,564 bit sector, input output devices microcomputer converter serial data , parallel decoding microspacev,ram 16×16 bineray yes -disc label plastic with write ed inde hold, - sectaire track ,2,255 but logic process read digital step motor, -ns ram yes ,ram yes ,ROM yes ,CPU semie conductor yes ,hard dic driver yes ,external yes flopy disc ,data 150 km to 12m,typical machine -3 bit /5bit/ secret,000A,/AAA@/ load AC ,oo#B/BBB - 00/ load output /001,001/ -- -pc specifications format : Intel core 7 , external 975@,3,3ghz ,Intel ,DX58SO motherboard ,6GB,g skill trident DDR-200 channel gaineard ,GTx580 sponsored by vertex ,wD 320 GB ,data iu hard drive ,Intel core ,i7870 ,Gigabyte ,P55-UD6 ,LG flatro ,a essential up grade components AMD,procedure,chip choice the starting dusk x 2550BEb, CPU ,,X4 , 646 upward faster closely processor direct conflict shoe improvement load processor specific benchmark 3 d tendered video encoder x 264 ,, - graphic upgrade ,new little graphic card up date gaming phenomenon power × 2550 choice graphic card filled card up grade ,sub R1,500 udger choice HD 5770bigger to jumping performance Dx ,10 gaming word in conflict , - platform up grade ,CPU u grade path for LGA ,775 socket mother PC 3Ghz,core ,3500 CPU ,4 GB of DDR,ram direct ,x9 tessellation performance heaven ,,2,5 / frame per second higher better ,base systeme with sapphire,HD 550/#7 - upgrade to HD 6959 -ditect ,x 9 gaming perfot.. -one the card edge graphic tracker #gb , sapphire 5850 Xtreme ,retailing R2000 ,price complain 6 pin power connector which PSU hard physical driver installed benchmark away result disappointed ,3 marks improvement word conflict did manage ,lost planet frame wallet being ,R2000 ligth completed reliable, - battery ,g ram ,slot ,#gb,systy memory sticks R150 ,ram benchmark -upgrading memory and processor GB ,test window ,CPU the HD , -weigth components for the perfect budgy building , perfect machine Mother board F#A75-M-R1.100, processor A8-3859-R1,300,, -ram ,corsair ,4 GB,,:1600mhz-R1000 -graphic ,xFx random:HD6670-R1000, -storage : 750 GB - R 619, opacity ,re R200,PSU corsair ,430w ,R470, chassis : cm elite 343/, total :R5,369 ------- Build test installation CPU Vital - compot case layer CPU guard lockdown,add cooler and fan fixing bracket underneath ,screw holes fitting connect mbod,fit the ram : open the catch snai lock. Motheboymemory Chanel ,# and 3 operator, Hook connect ,2+4 pin connector to mobo ,the 8 pin EPs cable whichever,. - test the company power that sucker uonturning , screwdriver,striking the balance corsair ,4 GB ,,1,600 MHz ,DDR3 ,liani ram share system,CPU gaming rate ,2,34 MHz ,and 1,600mhz case , - Pre the case bit ,atz mounting screws install the PSU ,bottoy cable module drop in mother remove CPU from mobo CPU - test it still works connect cable case fab ,tech analysis: 2560×1600 screen Gami surplus frame ,R14,09 flashi ,CPU rendering performance. - cindbonh ,R#1, Test ... 44.Explanation:Technologie compagny: Teasing compagny , requirements market technologie solutions customer product security surveillance network point , - mission : provide technology added value business provide quality products , - valeur accountability ,,. - LCD monitor screen size ,22,5" , 6 viewable image size : 546,86 mm display area : 476.H,,,268,2,v).. mm brightness , typical : 300 CD/mm, contrast ,ratio (typical) 600000:1(DCR) response time (typically) 5 ms , viewing angles 170/169,max ,, - resolution : 2920×1080@ ,60hz -HDCP compatible ,yes ,input signal : analogy ,RGB ,,and user control menu entry image ration source up ,consumption power ,on < 49 standard < ,wall mounted ,visa 100 mm , mechanical function tilt ,5-29 - special features : touch key USB , - type Gori - 335 case type ,ATx Min ,case motherboard : micro ATX , external up (up to 13"×9,7),(p4ready) - power supply: 400w Culp ,P/s with 22cm fan (20+4 pin socket ,775 ready,.,,5,25" drive bays : ,3,3,5" drive hidden , expansion slots: 7,I/O interfy USB × 3 mic ,1 spk ×2 cooling fans front ,80mm,×2,rear 80 mm×1, dimensions,(D×w×H): 410×182×425mm,M/t(cuft):1,73. - print mount USB audio high green LCD fan external ,= 4,5,25" and ,3×3,5" internal driver bays ,4× 3,5" HD ,system board ATX form facty ,13"×20,5 expansion slots standard ATX material steel , - dimensions: 52,25×20×45 cm - raid max modular cabling system durable , titanium mirror grade block wraps mesh cable to mention ,20 toal power connector for computer ,type ,ATX ,12 EPs ,22v maximum ,power ,fan ,135 m blue led ,PFC ,main connector , - rails PCI e connector ,2×6 pin ,,1×6+12 ,pin modular cabling support yes , energy efficiency ,up to 80 % ,over voltage , - network cable . 5 cabling : 500m,solid , 24 AWG,,0,5 mm ,pair ,grey ,305 m flex or solids ,to ,24 AWG,,05mm ,pair ,,cat 6 cable ,305 flex or solids uti,24 AWG ,0,57 mm ,4 pair Gray .. - cable tester digital tester ,cat 5. - toolkit ,j-059 long nose pliers (159,mm) by micro cutting pliers ,by ,339 cable blade trividr hyp ,5022 wire stripper , by

567 telephonic plier ,8 p8 ,/-45 punch down tape,2,mm knife , 539 soldering iron ,39 w cable tester tweezers ,125 mm ,crysty, tester , tweezers 225 mm , crystal, screwdriver,+- module plug RJ ,- 45 / 7 PC , PC plastt box ,315× 255×55mm ,crimping ,tool ,Rachel type dual crimping ,punch down tools ,walls boxry cat singltpart,45 key Stine jack , surface ,car 5 double ,RJ 45 jack ,carb , - connector ,boot sleever ,RJ45 cat micron connector , standard cable make female ,15 pin VGA,extenst available ,in 2,0 m ,,3.0,,m,5 / male 25 pin,, -1000VA/2000VA,rack mount ups, - patch panel 24 port it cat ,5 a panel ,w,t back ,bar ,48 port cat ,5 panel ,, - battery voltage ,24 VDC recharge ,8 hours to ,90% charger input voltage ,2# vac ,, - or 220VA,, output,wave from pseudo,wave protection outshort city overload protection with current limiting protection ,659 VA line interactive ups ,auto restart recover , provide ovrlot protection size ligth,b microprost control ,proviy modem phone ,line surge protector optit , equipment input ,voltage , building DC start functionalite enable ups ,input commercial power range ,145 vac ,280vac,avr range ,265 vac , frequency ,59 ,z #0% ,, output commercial power, sine shared frequence AVR voltage , 229vac ,auto sensing transfered ,b gross weight ,6,2 ,size mm,D×w×H,,,, 260×96×135.. - data manufacture data security , securite technologie PC , undertaking ,self finger printing , maximum b,test winner , antivirus program,,engine ,anti spyware,antipising, systeme tuning, firewall,internet ,award technologie,double scan outbreak shield , integration block,file archive ,formal ,heurisy detectt of virus ,client security , manager server ,agent notbooj server memory ,, - - Serie projector ,3 projection sysy ,3,LCD ,panel,2 lense projects , system ,resoloi was resolution.. ______________________________& ,- adabase ,storage data, association, emploie..file edit mask array , more, systeme, session systeme, system data. Area program ,nucleus ,buffer pool / ,I/o General,file control block field data space command is added , database, Empl modification,leave ,,name ,title ,edit-- -Triggered: gitlab,/ GitHub /azure Issue test .. -Triggered electronic elektor technologie -Circuit microcontrol ,, -Gitlab ,fail running Issue kananga ,, Engineering tshingombe Project ,commited contributing ,code source ... tshingombe fiston Sep 16, 2024, 9:29 PM (5 days ago) to tshigombekb, me Explanation: asssessment task management system information Back log isita : orientation police career Pratical Platform software engineer,policy data right met career ,detective career electronics engineering,detective met Tableaux design analyse investigation research police forensic digital print report , intelligence felonies vector design source analyse report evidence - ID submission: 22255 Your :tableau blue print assessment results thank ,completing blue print assessment:: Find everything building action plan get started tableau kit collection resource whitin organisation ,creating data culture happen by flipping a switch professional: - agility deployment monitor maintence typically,it led effort understand board technical requirements. - capabilities agility ,low high . - recommendations to building your agility capabilities,recommattiin to building server , understand hardware, network, database , application is first step in planning server installation. Review tableaux deployment section , completed the enterprise architecture in the the tableaux blueprt planner . - leverage installation can tableaux server implementation to deploy authenty and details, configuration. - manage tableau licensed: license be manage accordt softt license process allocating ,use changing tableaux analyi skill in trade , reclaiming available tableau licensed . - reviy tableaux license level for the company. - deployed client software desktop prep builders,if virtual desktop determine want to manage license. - monitor tableau server process status server process monitoring back group job runseever ,job include extra data slots admnise process fail so corrective action can be taken ,, - configuration critical information platform outage take immediate. 2 - configuy notification system alert and failure process state drive space constraints instat. - define a process how admnistration will response alerge triggered issue ,, - reviews performance thresholds Claude understand systeme proactive admnistration view. -monitor license utilisation administration monitor usage answer using if you need , - review admnistration view for monitoring. - completed loadtrst capacity planning load testing understand data work load usage capacity planning , - performance database maintence free space review database maintence.. Installation add extension on tableaux. -- -tshingombe Tshitadi - Dev Engineering south africa traiblazet profile : communauty .sale force : Rank 115 badge | 22,125 point |7trails - earn ,6,875 more point reach maintence - career mode , certificate - network security planning, application ,security basic , network care ,security ,cyber security threat and three -------------- Work book : tshingombe , executive, summary Pipe : value , discovery , negotiation,prose , qualifition,, - topics learn objective take stock of your building energy use stationnnary assets data for key field ,few calculation . -refrigerant emissions factor : global warming (GwO) Coolin create record . Auto calculated , emissions in CO2 ,scope corresponding ,entered , -:sum explored key information energy record for a stationary asset emissions ,Miami stationnnary asset envirt,fuel const details NTO headquarters Miami , monthly electricity bill ,electricity 1000kwh ,NTO diesel 1000 litre NTO headquarters ,W1 refresh bilk ,10kg ,calculation of electricity related emissions,the unite state ,us .. C02o emisst rate for location based emissions factor = 396,78 g/kWh Location - based coal -miz percentage ,20% Location based gas mix, 47% Location based nuclear. , 11% .. - scope ,2 location - base emissions (tc02)= electricity consumption (in kW) - emissions factor (g/kW) ,/ 10^6(tC02, convection factor ,100*396 .78 / 100000000= 0,3968t ,c02 ______________________ - information is calculate ,base grid mix - location based electricity from coal (kWh) 29% of 100kwh= 200kwh. - location based gaz 47%,10000=470kwh - grid mix stationary càlcul,12% of 10000kwh = 11000 - Simi core reference fuel factor record warning potential GwO of CH4:28,GEO of N2I=265,,CH4 emissions factor ,co 2 emissions factor ,C02 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 10 of 18 emissions factor ,N2I.. - diesel : 15 kWh ,, 12,45 tones / MWh,, Consumption of diesel (1000litre is first converted to is kWh , calorific value ,15 kW/ K,, - total fuel consumption = 1500kwh (1000×15) = 12,45 × 15000/1000)=186,5 Calculate refrigerant emissions are calculate fuel type is refrigeration sulfure Hexa fluoride (sf6)- IPCC ,,AR ,2007 refrigerator emissions factor record specific global warming. - scope , emissions (tc2e)= GwO)=Gwp×fuel . Green house gas emissions result on stationery asset enert. - Salesforce helo create a stationed asset environmental source record. - Map, stationnnary asset environmental record type . - create an electricity emissions factor record - create an electricity efactor record ,other emissions factor set record .. - Grid mix information : comparison data Quality metrics ,, - eisten case case predictive intellence Consol , Zero claud calculate ,daily energy consumption ,F gaos --- Action user tableau cloud . Wath is action specify user taking this site user name ,wath action user taking , Line x coordination -2 to 150;,, Access interactive action ,,0,50,1000 - published download action ,, subscription b.. - item name ,action :. opportunity tshingombe pipe ,use data source . -home ,,access view -engineering tsht : ----publish workbook Executive ,summary ---- access view - pipeline analyse ,access view - login ,access view , published workbook published data source ,user data ------------------------------------ - metropolitan: met request intellectuel property ,IP license ,date 03 July ,2024,time ,this form has been sent to metropolice police via online home report serviceuser>library tree app data >code user profi\e 1{ 2} 3 name : build , code quality 4 name build ,code quality 4. 5 job 6 build 7 8 9 run - on Ubuntu - latest 11 12 step: 13 uses : action) checkout @v1 - name : set up .JD 1.8 - uses : action / setup - with app name : Wze ba) sample token: ${{ secret.APO _ center_ Group Tate File aoo build outmname upload artefac to app center with File aoo / build) outbut) aoj - start- contribution Module Zejdu / aoo center - gthub action Report abuse Aoo center distributee update note is not certifie by GitHub On Thu, 10 Oct 2024, 20:25 tshingombe fiston, wrote: - continuing and training,act No16 of 2006 amendment,NQF ,act No 67 of 2008 ,as amended , determination phase N1-N3 term ,sect 42(1)(a) training dhet ,N1-N3 juanert ,2024 , dr zimande trade test ,trade occupation revise.. --testability checklist at the schematic level. - testability checklist at the PCB layout level , - revising design. Win existing ICT creating a test point report manufacture.,PC designer PCB relay project status information,PLC. - PLC wiring ,main breaker switch busbar circuit breaker SMP digital input output analif input terminal. -reaning PLC wiring diagram, profit bus communication PLC , digital input card diagram ,PLC digital Re: for multiple positions Inbox TSHINGOMBEKB TSHITADI Fri, Sep 20, 2:47 PM (20 hours ago) to Thandiwe, me On Thu, 19 Sep 2024, 17:15 Thandiwe at Jobrapido, wrote: Unsubscribe You've been a little distant lately. 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On Tue, 18 Oct at 1:34 PM , TSHINGOMBEKB TSHITADI wrote: I m asking if can have letter of statement for that account number card confirm saling for that saving account to confirm that balance the saling that grocery or it will be give tendered statement cashback for saling or pay back returned savings account for the accounts . On Tue, 18 Oct 2022, 13:25 TSHINGOMBEKB TSHITADI, wrote: Thank you for the clarification. On Tue, 18 Oct 2022, 11:15 MMA Support, wrote: Hi TSHINGOMBEKB TSHITADI, Please note the amount showing on your slip is to show how much you have saved on goods. This amount cannot be used to buy anything. It is just to show that you have been saving on your groceries. Best, Thelma On Mon, 17 Oct at 8:24 PM , TSHINGOMBEKB TSHITADI wrote: Hello claim extra savings money. 9710085084520751 Amount deposited money for gift receipt cash back magazine resend comments checkers Disclaimer: https://www.shopriteholdings.co.za/email-disclaimer.html Disclaimer: https://www.shopriteholdings.co.za/email-disclaimer.html Corporate Gift Cards | Website Enquiry Inbox TSHINGOMBEKB TSHITADI Oct 18, 2022, 1:58 PM (5 days ago) to giftcards Hi there, I'd like to enquire about your corporate gift cards. Below is my personal information: Name and surname: tshingombe Tshitadi Contact number:0725298946# Email address Amount of gift cards required: @100000rand to 1000rand Mart Marie Van Antwerpen Oct 18, 2022, 2:52 PM (5 days ago) to me Good day I hope you are doing well Please find attached the policies and procedures which should explain the bulk gift card process. This document also indicates the discount rates. If you are 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 12 of 18 interested in placing an order, please fill in your details below so we can create your profile for an accurate invoice: Name and surname of delivery contact :tshingombe Email address of delivery contact :tshingombekb@gmail.vom Telephone number of delivery contact :072529846 Cell number of delivery contact :0725298946 Company Name :tshingombe trade Delivery address (please include postal code) :103 Company address :rockview yeohvill jhb Postal Code : Company VAT number : Not Compulsory/ Denomination Quantity Type Total R x1200 X4 Gift Cards R x12000 12000 0 5 Gift Cards 12000 TOTAL 120000 Please ensure that the delivery contact is available to answer their phone and receive the gift cards from the couriers. Please note that we cannot take any responsibility for a delay in delivery when the delivery address or delivery contact details are incorrect. Please do not hesitate to contact me if you have any questions. Thank you Kind regards, Mart-Marié van Antwerpen Money Market Gift Cards 021 980 4727 / 021 980 4665 Request #87322: How would you rate the support you received? Inbox Support Unsubscribe Tue, Sep 17, 9:01 AM (4 days ago) to me Hello tshingombe fiston, We'd love to hear what you think of our customer service. Please take a moment to answer one simple question by clicking either link below: How would you rate the support you received? Good, I'm satisfied Bad, I'm unsatisfied Here's a reminder of what this request was about: Elektor Support Team (Elektor) 16 Sept 2024, 08:44 CEST EN0202272ID Dear Sir, Thank you for your e-mail. What's your question about the newsletter please? Hopefully we have informed you sufficiently, but if you need anything else, please do not hesitate to contact us again. Our customer service team would be glad to assist you. Kind regards, Marleen Brouwer Customer Support Elektor International Media www.elektor.com www.elektor.nl www.elektor.de www.elektor.fr Elektor is the media brand of EIM | learn, design & share electronics tshingombe fiston 14 Sept 2024, 16:47 CEST Become a Member My • • Topics • Magazine • Articles • News • Video • Projects • Newsletter • Submit • Store MyLAB EN0202272ID No bio • • • • • • • • 0 | Follow user View as visitor: My Groups Coming soon My Stats 0 Published projects Views 0 Followers 0 Star(s) on average 0 Comments 0 Comments My Projects • Letter experimental job experience: theoretical practical by EN0202272ID . requirement: .letter experimental work based log activities theoreti... 0 0 Draft • Education technology engineering electrical and trade by EN0202272ID Trade , pratical and theory ,Technologie technical electrotechnic elec... 0 0 Following Not following any project Subscribe to the e-zine Elektor is a great international source of essential electronic engineering information and innovative solutions for engineers, pro makers, startups, and the companies seeking to engage them. We helped launch the first electronics maker movement in the 1960s. Since then, our global electronics design community has expanded to include hundreds of thousands of active members and more than 1,000 contributing experts. We are proud to be growing every day as we inspire new members to design, share, and earn. Become a member • CUSTOMER SERVICE • Privacy Policy • Terms of business • Copyright • Contact us • Advertising info • ELEKTOR WORLD • Elektor MAGAZINE • Elektor LABS • Elektor STORE • Submit Your Content • Social Media • • Safe Payments • • BECOME FREE MEMBER AND RECEIVE OUR EZINE • THE ELEKTOR UNIVERSE ____ tshingombe fiston 14 Sept 2024, 16:36 CEST engineering hello my question about published Hi there, a warm welcome from our Elektor community! For your records, below is a copy of the information you submitted to us. • Email: tshingombefiston@gmail.com • First Name: fiston • Last Name: tshingombe • Birthday: • Country: South Africa • Phone: • Address: Johannesburg, South Africa • Gender: • Company: Engineering tshingombe • Elektor Store: • Elektor Editorial Newsletter: • Elektor Industry Updates: • Vertical: • Education: • Field of Studies: • Field of industry: • Elektor Editorial Newsletter: Subscribe • Elektor Store: Subscribe • Elektor Industry Updates: Subscribe • Newsletter Subscriptions: Elektor Editorial Newsletter, Elektor Store, Elektor Industry Updates If at any time you wish to stop receiving our emails, you can: unsubscribe here You have questions? Contact us at: service@elektor.com T tshingombe fiston Member since 9/17/2024 ____ Achievements To start earning badges, sign up to be a Product Expert in our Product Expert Program open_in_new . Activity Oct NovDecJanFebMarAprMayJunJulAugSep21 Community guides Community videos Questions Total replies Recommended User activity chart Post history Reply to Engineering electrical database Google Account•9/17/2024 Education technology engineering electrical and computer science data word excell windows school year vertical rising ground floor current location Engineering electrical database Google Account•9/17/2024 Engineering electrical database management system information, 1 reply Application Update Inbox Met Recruitment Team 9:35 AM (1 hour ago) to me Vacancy: 17878 - Specialist Operations Recovery Driver - Perivale Car Pound Dear tshingombe, Thank you for your application for a new position within the Met. To be eligible to apply for this new position, we have a set of criteria that applicants need to meet. Based on the information you have shared so far; we regret to inform you that you are not eligible to progress with your application. Your individual answers suggest that you do not meet the application criteria. You can read more about our eligibility criteria on our Careers Website or by reviewing information available on MyHR. We understand that this will be disappointing news for you but would like to thank you for your interest in this position and wish you all the best for the future. Shared Services Connected Ltd – Delivering services in partnership with the Metropolitan Police Service Phone: 01633 632500 Email: Enquiries.PoliceJobs@police.sscl.com Met Recruitment Team 9:40 AM (1 hour ago) Vacancy: 17952 - Student Placement - Portfolio Office Assistant - Change -2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 9:45 AM (1 hour ago) Vacancy: 17902 - LMS Administrator Met Recruitment Team 9:50 AM (1 hour ago) Vacancy: 17924 - HR Performance and Reporting Lead Met Recruitment Team 9:55 AM (1 hour ago) Vacancy: 17939 - Student Placement - Analysis & Research Assistant - Data & Analysis - 2025/2026-Counter Terrorism Policing HQ Met Recruitment Team 9:55 AM (1 hour ago) Vacancy: 17957 - Student Placement - Project Support Assistant - Change - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:00 AM (1 hour ago) Vacancy: 17951 - Student Placement - Junior DevOps Engineer - Technology - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:00 AM (1 hour ago) Vacancy: 17956 - Student Placement - Junior Service Designer - Technology - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:10 AM (1 hour ago) Vacancy: 17942- Student Placement - Borders Assistant - Borders Operations Centre - 2025/2026 Counter Terrorism Policing HQ Met Recruitment Team 10:10 AM (1 hour ago) Vacancy: 17955 - Student Placement- Junior Project Manager - Technology - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:10 AM (1 hour ago) Vacancy: 17941 - Student Placement - Project Support Assistant -Strategy, Performance, and Planning - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:15 AM (1 hour ago) Vacancy: 17908 - Business and Policy Support Officer - Data & Analysis - Counter Terrorism Policing HQ Met Recruitment Team 10:15 AM (1 hour ago) Vacancy: 17947 - Student Placement - Assurance and Standards Team Assistant - Change - 2025/2026 -Counter Terrorism Policing HQ Met Recruitment Team 10:20 AM (1 hour ago) Vacancy: 17948 - Student Placement - Associate End User Computing Engineer - Technology - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:20 AM (1 hour ago) Vacancy: 17823 - SQL Server Database Administrator - Counter Terrorism Policing HQ Met Recruitment Team 10:25 AM (1 hour ago) Vacancy: 17937 - Student Placement - Project / Research Assistant - Data & Analysis - 2025/2026 -Counter Terrorism Policing HQ Met Recruitment Team 10:25 AM (1 hour ago) Vacancy: 18030- Senior MetLaw Officer Met Recruitment Team 10:35 AM (50 minutes ago) Vacancy: 17980 - Police prosecutor Met Recruitment Team 10:35 AM (50 minutes ago) Vacancy: 17752 - Student Placement - Media and Communication Administrator 2025/2026 Met Recruitment Team 10:35 AM (50 minutes ago) Vacancy: 16279 - Experienced Intelligence Analyst Met Recruitment Team 10:40 AM (45 minutes ago) Vacancy: 17949 - Student Placement - Business Change Assistant - Change - 2025/2026 - Counter Terrorism Policing HQ Met Recruitment Team 10:40 AM (45 minutes ago) Vacancy: 17680 - Student Placement - Forensic Business Assistant 2025/2026 Met Recruitment Team 10:45 AM (40 minutes ago) to me Vacancy: 17959 - Student Placement - Communications Assistant - 2025/2026 - Communications - Counter Terrorism Policing HQ Met Recruitment Team 10:55 AM (30 minutes ago) Vacancy: 17853 - Enquiry Officer Met Recruitment Team 10:55 AM (31 minutes ago) to me Vacancy: 17830 - Programme Management Office Administrator Met Recruitment Team 10:55 AM (30 minutes ago) to me Vacancy: 16747 - 202402 - MPS Return Scheme Retired Officers Candidate added to Talent Bank Inbox Met Recruitment Team 9:35 AM (1 hour ago) to me Dear tshingombe, Thank you for registering to speak with the Outreach team. A member of the team will contact you shortly by your preferred method. If you no longer wish to speak to a member of the team, please click here to withdraw from our contact list. Many thanks, The Outreach Team Phone: 01633 632500 Email: TalkToUs@met.police.uk Outreach Live chat link: https://uk.meetandengage.com/al2rpqdab Your recent submission Inbox no-reply@service.police.uk 9:15 AM (2 hours ago) to me Thank you for completing the form, your reference is: MIP-482-24-0100-000. --- We understand how distressing being affected by crime or anti-social behaviour can be and we are committed to bringing offenders to justice and ensuring that victims of crime receive the support they need from us and from others. We have lots of crime prevention advice which you may also find useful. Consider our environment - please do not print this email unless absolutely necessary. NOTICE - This email and any attachments may be confidential, subject to copyright and/or legal privilege and are intended solely for the use of the intended recipient. If you have received this email in error, please notify the sender and delete it from your system. To avoid incurring legal liabilities, you must not distribute or copy the information in this email without the permission of the sender. MPS communication systems are monitored to the extent permitted by law. Consequently, any email and/or attachments may be read by monitoring staff. Only specified personnel are authorised to conclude any binding agreement on behalf of the MPS by email. The MPS accepts no responsibility for unauthorised agreements reached with other employees or agents. The security of this email and any attachments cannot be guaranteed. Email messages are routinely scanned but malicious software infection and corruption of content can still occur during transmission over the Internet. Any views or opinions expressed in this communication are solely those of the author and do not necessarily represent those of the Metropolitan Police Service (MPS). Find us at: Facebook: Facebook.com/metpoliceuk Twitter: @metpoliceuk no-reply@service.police.uk 9:22 AM (2 hours ago) to me Thank you for completing the form, your reference is: CNP-53345-24-0100-000. Tell us what you think of our online service Feedback on your experience of using our online services genuinely helps us to make sure they work as well as possible. If you have a couple of minutes, please complete a quick feedback survey. no-reply@service.police.uk 9:28 AM (1 hour ago) to me Thank you for completing the form, your reference is: FOI-22728-24-0100-000. This email confirms we've got your request. We'll reply within 20 working days if we can. If that's not possible we'll let you know. If you've told us we can respond by email then we'll do that unless the type of information you've asked for means we need to give it to you in a different way. If you've told us you'd prefer us to respond in a different way then we'll do our best, but if it isn't possible we'll contact you by email to explain. Application Update Inbox Met Recruitment Team Sat, Sep 21, 5:40 PM (17 hours ago) to me Vacancy: 17879 - Electronics Development Engineer Dear tshingombe, Thank you for your application for a new position within the Met. To be eligible to apply for this new position, we have a set of criteria that applicants need to meet. Based on the information you have shared so far; we regret to inform you that you are not eligible to progress with your application. Your individual answers suggest that you do not meet the application criteria. You can read more about our eligibility criteria on our Careers Website or by reviewing information available on MyHR. We understand that this will be disappointing news for you but would like to thank you for your interest in this position and wish you all the best for the future. Shared Services Connected Ltd – Delivering services in partnership with the Metropolitan Police Service Phone: 01633 632500 Email: Enquiries.PoliceJobs@police.sscl.com Met Recruitment Team Sat, Sep 21, 5:45 PM (17 hours ago) to me Vacancy: 17895 - Head of Visits and Events Met Recruitment Team Sat, Sep 21, 5:50 PM (17 hours ago) Vacancy: 17896 - Senior Media Officer Met Recruitment Team Sat, Sep 21, 5:55 PM (17 hours ago) Vacancy: 17897 - Media Officer Met Recruitment Team Sat, Sep 21, 6:00 PM (17 hours ago) Vacancy: 17912 - Communication Planning Manager Met Recruitment Team Sat, Sep 21, 6:05 PM (17 hours ago) Vacancy: 17918 - Senior Content, Channels and Engagement Officer Met Recruitment Team Sat, Sep 21, 6:05 PM (17 hours ago) Vacancy: 17927 - Head of Data Literacy and Culture Met Recruitment Team Sat, Sep 21, 6:05 PM (17 hours ago) Vacancy: 17874 - Quality Assurance Lead Met Recruitment Team Sat, Sep 21, 6:15 PM (17 hours ago) Vacancy: 17686 - Service Design and Transition Manager - Band C - Technology - Counter Terrorism Policing HQ Met Recruitment Team Sat, Sep 21, 6:15 PM (17 hours ago) Vacancy: 17844 - Senior Project Manager - Change - Counter Terrorism Policing HQ Met Recruitment Team Sat, Sep 21, 6:15 PM (17 hours ago) Vacancy: 16896 - Lead Data Analyst in the Strategic Insight Unit Met Recruitment Team Sat, Sep 21, 6:15 PM (17 hours ago) Vacancy: 17866 - Business Change Manager - Change - Counter Terrorism Policing HQ Met Recruitment Team Sat, Sep 21, 6:20 PM (17 hours ago) Vacancy: 18011 - HOLMES Typist Met Recruitment Team Sat, Sep 21, 6:30 PM (16 hours ago) Vacancy: 17862 - Junior Data Engineer Met Recruitment Team Sat, Sep 21, 6:30 PM (16 hours ago) Vacancy: 17969 - Business Assurance Junior Manager Met Recruitment Team Sat, Sep 21, 6:30 PM (16 hours ago) Vacancy: 17875 - CTSFO Tactical Advisor Met Recruitment Team Sat, Sep 21, 6:30 PM (16 hours ago) Vacancy: 17834 - Operations Manager Met Recruitment Team Sat, Sep 21, 6:35 PM (16 hours ago) Vacancy: 17877 - Infrastructure Engineer Met Recruitment Team Sat, Sep 21, 6:40 PM (16 hours ago) to me Vacancy: 18001 - Lead Dev Ops Engineer (Cloud Platform) - Technology CSC - Police Staff - Counter Terrorism Policing HQ Thank you for your Application! Inbox Microsoft Recruiting 6:44 AM (4 hours ago) to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1755381) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you're selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. ____ This message was sent to tshingombefiston@gmail.com. If you don't want to receive 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 13 of 18 these emails from this company in the future, please go to: https://ms.icims.com/icims2/?r=11B617365170&contactId=116124102 © Microsoft Corporation; One Microsoft Way; Redmond, WA 98052; USA Microsoft Recruiting 6:57 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Technology Specialist - Modern Work (Job number:1771873) position at Microsoft! We're glad you're in Microsoft Recruiting 7:02 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Software Engineering Manager (Job number:1766765) position at Microsoft! We're glad you're Microsoft Recruiting 7:06 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Applied Scientist (Job number:1762056) position at Microsoft! We're glad you're interested in Microsoft Recruiting 7:13 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Software Development Engineer (Platform Firmware & Drivers) (Job number:1738100) position at Microsoft Recruiting 7:16 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Director of Network Supply Chain (Job number:1771684) position at Microsoft! We're glad you're inter Microsoft Recruiting 7:18 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Director, Cybersecurity Business Strategy Lead (Job number:1770318) position at Microsoft! We Microsoft Recruiting 7:21 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Product Manager (Job number:1736502) position at Microsoft! We're glad you're interested i Microsoft Recruiting 7:26 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Data Center Technician (Job number:1769625) position at Microsoft! We're glad you're interested in a Microsoft Recruiting 7:28 AM (4 hours ago) Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer-Full Stack- Xbox (Job number:1771329) position at Microsoft! We're glad you're int Microsoft Recruiting 7:30 AM (3 hours ago) to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Job number:1770175) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you're selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. Your recent job application for (631) Business Analysis Competency Centre Lead - BSTD - 631 Inbox SARB Talent Acquisition Sat, Sep 21, 7:51 AM (1 day ago) to me Hello, tshitadi, We received your job application for (631) Business Analysis Competency Centre Lead - BSTD - 631. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Your recent job application for (642) SHEQ Analyst-RMCD - 642 Inbox SARB Talent Acquisition Sat, Sep 21, 7:48 AM (1 day ago) to me Hello, tshitadi, We received your job application for (642) SHEQ Analyst-RMCD - 642. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Recruiting Team Your recent job application for (649) Cloud Engineer - BSTD - 649 Inbox SARB Talent Acquisition Sat, Sep 21, 7:45 AM (1 day ago) to me Hello, tshitadi, We received your job application for (649) Cloud Engineer - BSTD - 649. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Your recent job application for (557) End-User Computing Architect - BSTD - 557 Inbox SARB Talent Acquisition Sat, Sep 21, 7:42 AM (1 day ago) to me Hello, tshitadi, We received your job application for (557) End-User Computing Architect - BSTD - 557. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Your recent job application for (630) Data Collection Administrator - 630 Inbox SARB Talent Acquisition Thu, Sep 19, 7:08 AM (3 days ago) to me Hello, tshitadi, We received your job application for (630) Data Collection Administrator - 630. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, Your recent job application for (640) Information Governance Specialist - BSTD - 640 Inbox SARB Talent Acquisition Thu, Sep 19, 7:13 AM (3 days ago) to me Hello, tshitadi, We received your job application for (640) Information Governance Specialist - BSTD - 640. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Your recent job application for (635) Reporting Systems Inspector -FinSurv - 635 Inbox SARB Talent Acquisition Thu, Sep 19, 7:06 AM (3 days ago) to me Hello, tshitadi, We received your job application for (635) Reporting Systems Inspector -FinSurv - 635. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Your recent job application for (639) Senior Economic Policy Analyst-IERP - 639 Inbox SARB Talent Acquisition Thu, Sep 19, 6:52 AM (3 days ago) to me Hello, tshitadi, We received your job application for (639) Senior Economic Policy Analyst-IERP - 639. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Your recent job application for (644) Team Leader - Food and Beverages - CSD - 644 Inbox SARB Talent Acquisition Thu, Sep 19, 6:49 AM (3 days ago) to me Hello, tshitadi, We received your job application for (644) Team Leader - Food and Beverages - CSD- 644. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Your recent job application for (643) Associate Trade Settlement Officer – Foreign Markets - FMD -643 Inbox SARB Talent Acquisition Thu, Sep 19, 6:11 AM (3 days ago) to me Hello, tshitadi, We received your job application for (643) Associate Trade Settlement Officer – Foreign Markets - FMD -643. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Recruiting Team Your recent job application for (646) Divisional Head: Security Operations -GSMD - 646 Inbox SARB Talent Acquisition Thu, Sep 19, 6:08 AM (3 days ago) to me Hello, tshitadi, We received your job application for (646) Divisional Head: Security Operations - GSMD - 646. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Update on your Job application with SARB Inbox SARB Talent Acquisition Mon, Sep 16, 11:05 AM (6 days ago) to me Dear tshitadi tshingombe, Thank you for your interest in the (616) Contractor-Building Engineer -CTC at the SARB, we regret to inform you that your application was unsuccessful. Regards Thank you for your interest in Microsoft! Inbox Microsoft Recruiting Unsubscribe Thu, Sep 12, 9:26 PM (10 days ago) to me Hi Fiston Tshingombe teodor, Thank you for your interest in a career at Microsoft. Unfortunately, we will not be moving forward with your candidacy for the position of Software Engineer II (Full stack), 1749784 at this time. However, we'd like to encourage you to continue to explore other career opportunities on Microsoft Careers as we continually update openings on a daily basis. We look forward to considering you for other positions at Microsoft! Thank you, Microsoft Recruiting Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. This mail is sent from an unmonitored mailbox. Please do not reply. Eskom Careers: Confirmation of Application Inbox sharepoint@eskom.co.za Sun, Sep 1, 1:27 PM to me Dear Tshingombe Tshitadi , Job Reference: EMTOPPMT06 Position: Technical Official PPM Mechanical X2 (Distribution) EAL Midrand Region: South Africa (Gauteng) Industry: Engineering Closing Date: 2024/09/09 Thank you for your interest in a career at Eskom. Your online application was received and will be duly actioned by the Recruitment Practitioner allocated to the position you applied for. Should you not be contacted within 28 days of the closing date of this advertisement, please accept that your application was unsuccessful Please also note that you only have to register and load your Personal History Profile (PHP) once. You may in future apply for vacancies using the PHP provided. Once the PHP has been completed for a particular vacancy, it can be saved and used for future applications. The PHP may be up-dated, when necessary, for future applications Best wishes with your future Kind Regards Recruitment Manager Shared Services (HR) FINANCE DIVISION Disclaimer NB: This Email and its contents are subject to the Eskom Holdings SOC Ltd EMAIL LEGAL NOTICE which can be viewed at https://www.eskom.co.za/about-eskom/email-legal-spam-disclaimer/ sharepoint@eskom.co.za Sun, Sep 1, 1:29 PM Dear Tshingombe Tshitadi , Job Reference: EIT X2/GX PrimaryE/MC Position: 1 Learning-Programme-Engineer-in-Training-x-2,-Generation,-Megawatt-Park Region: South sharepoint@eskom.co.za Sun, Sep 1, 1:30 PM Dear Tshingombe Tshitadi , Job Reference: GXMATL- EIT/2024 Position: Learning Programme Engineer in Trainng x17 GX Matla Power Station Region: South Africa (Mpu sharepoint@eskom.co.za Sun, Sep 1, 1:31 PM Dear Tshingombe Tshitadi , Job Reference: 50515483LM Position: Manager Site Outage Execution, Generation, Tutuka Power Station Closing Date: 2024/09/13 sharepoint@eskom.co.za Sun, Sep 1, 1:31 PM Dear Tshingombe Tshitadi , Job Reference: 50813227NLee01 Position: Re Advert Snr Technologist Electrical Engineering Substation x2 (National Transmission Compa sharepoint@eskom.co.za Sun, Sep 1, 1:32 PM Dear Tshingombe Tshitadi , Job Reference: 50813227NLee01 Position: Re Advert Snr Technologist Electrical Engineering Substation x2 (National Transmission Compa sharepoint@eskom.co.za Sun, Sep 1, 1:32 PM Dear Tshingombe Tshitadi , Job Reference: 50861481SN/GX-Koeberg Position: Senior Technician Chemistry x2 (Technical Support and Oils Micro) (Generation) Koeberg sharepoint@eskom.co.za Sun, Sep 1, 1:33 PM Dear Tshingombe Tshitadi , Job Reference: GXMedOMM04 Position: Officer Safety Health Environment X1 Generation Medupi Power Station Region: South Africa (Limpop sharepoint@eskom.co.za Sun, Sep 1, 1:34 PM Dear Tshingombe Tshitadi , Job Reference: Learners OGE Contracts Management Position: Learning Programme Outages x1 - Graduate in Training , Generation, Megawat sharepoint@eskom.co.za Sun, Sep 1, 1:35 PM Position: Learning Programme -Graduate in Training-Quantity Surveyor, Generation, Megawatt Park sharepoint@eskom.co.za Sun, Sep 1, 1:36 PM Dear Tshingombe Tshitadi , Job Reference: Snr Advisor SDL&IPL Position: Senior Advisor Supplier Development, Localisation and Industrialisation x2, Generation, sharepoint@eskom.co.za Sun, Sep 1, 1:37 PM Dear Tshingombe Tshitadi , Job Reference: DurbanvilleFXGIT2025 Position: Graduate-in-Training (Finance) Industry: Other Closing Date: 2024/09/09 sharepoint@eskom.co.za Sun, Sep 1, 1:38 PM Dear Tshingombe Tshitadi , Job Reference: 50828254NLee01 Position: Re Advert Snr Draughtsperson Draughting Electrical Substation Engineering x3 NTCSA MWP Closin sharepoint@eskom.co.za Sun, Sep 1, 1:39 PM Dear Tshingombe Tshitadi , Job Reference: PeakingTITDrakensberg2025 Position: Technician-in-Training x2 (1xC+I and 1+Mech) Region: South Africa (Kwa-Zulu Natal) sharepoint@eskom.co.za Sun, Sep 1, 1:39 PM Dear Tshingombe Tshitadi , Job Reference: GX49002630WK/TUT Position: Snr. Supervisor Tech Instrument x 2 (Generation) Tutuka Power Station Region: South Africa sharepoint@eskom.co.za Sun, Sep 1, 1:40 PM Dear Tshingombe Tshitadi , Job Reference: PeakingLearnersEIT2025 Position: Engineer-in-Training-Control and Instrumentation AND-Auxiliary and Ancillary-(Peaking sharepoint@eskom.co.za Sun, Sep 1, 1:42 PM Dear Tshingombe Tshitadi , Job Reference: GXMedSTR14.1 Position: Re Advert Senior Technician Configuration X1 (Generation) Medupi Power Station Closing Date: 20 sharepoint@eskom.co.za Sun, Sep 1, 1:43 PM Dear Tshingombe Tshitadi , Job Reference: 50817165NQ Position: Engineer Prof Eng Quality of Supply (National Transmission Company South Africa) Newscastle Indus sharepoint@eskom.co.za Sun, Sep 1, 1:45 PM Dear Tshingombe Tshitadi , Position: Learning Programme - Graduate in Training x1, Generation, Megawatt Park Region: South Africa (Gauteng) sharepoint@eskom.co.za Sun, Sep 1, 1:45 PM Dear Tshingombe Tshitadi , Job Reference: Learners OGE Environmental Management Position: Learning-Programme -Graduate-in-Training-x3,-Generation,-1Megawatt-Par sharepoint@eskom.co.za Sun, Sep 1, 1:46 PM Dear Tshingombe Tshitadi , Job Reference: Learners Gx Procurement Position: Learning Programme-Graduate in Training x 3, Generation, Megawatt Park sharepoint@eskom.co.za Sun, Sep 1, 1:47 PM Dear Tshingombe Tshitadi , Job Reference: Learners OGE Legal Position: Learning Programme-Graduate in Training x 2, Generation, Megawatt Park sharepoint@eskom.co.za Sun, Sep 1, 1:49 PM Dear Tshingombe Tshitadi , Job Reference: 50097836FN Position: Senior Supervisor Technical Projects (National Transmission Company South Africa)Northwest and sharepoint@eskom.co.za Sun, Sep 1, 1:51 PM Dear Tshingombe Tshitadi , Job Reference: 50861459SCM Position: Snr-Advisor-Applications-Support-(Group-IT-DIVISION)-Megawatt-Park Region: South Africa (Gauteng sharepoint@eskom.co.za Sun, Sep 1, 1:51 PM Dear Tshingombe Tshitadi , Job Reference: 001 EIT Position: Learning Programme - Engineer in Training x3 (Generation) Engineering MWP Region: South Africa (Gaut sharepoint@eskom.co.za Sun, Sep 1, 1:53 PM Dear Tshingombe Tshitadi , Job Reference: GXKRL-04 Position: Secretary Secretarial (Gx Kriel Power Station) Region: South Africa (Mpumalanga) sharepoint@eskom.co.za Sun, Sep 1, 1:55 PM Dear Tshingombe Tshitadi , Job Reference: Graduate in Training- Commercial Position: Graduate in Training (Commercial) x1 (Generation) Industry: Human Resources sharepoint@eskom.co.za Sun, Sep 1, 1:58 PM Dear Tshingombe Tshitadi , Job Reference: Graduate in Training- Finance Position: Graduate in Training (Finance) x1 (Generation) sharepoint@eskom.co.za Sun, Sep 1, 1:58 PM Dear Tshingombe Tshitadi , Job Reference: Engineer-in-Training Nuclear Engineering Position: Engineer in Training (Nuclear Engineering) x9-Generation Koeberg NP sharepoint@eskom.co.za Sun, Sep 1, 2:00 PM Dear Tshingombe Tshitadi , Job Reference: Learners Gx OMO/SM Position: Learning Programme - Engineer in Training x2, 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 14 of 18 Generation, Megawatt Park Region: South Afr sharepoint@eskom.co.za Sun, Sep 1, 2:01 PM Dear Tshingombe Tshitadi , Job Reference: 505571133PM/01 Position: Re Advert Senior Engineer Prof Electrical Engineering (Project Integration) NTCSA MWP Region: sharepoint@eskom.co.za Sun, Sep 1, 2:02 PM Dear Tshingombe Tshitadi , Job Reference: 50840435MIR Position: Officer Security (National Transmission Company South Africa) Bellville sharepoint@eskom.co.za Sun, Sep 1, 2:04 PM Dear Tshingombe Tshitadi , Job Reference: Gx Arn NN 23/08/24 Position: Officer catering (Generation) Arnot Power Station x1 Region: South Africa (Mpumalanga) In sharepoint@eskom.co.za Sun, Sep 1, 2:05 PM to me Dear Tshingombe Tshitadi , Job Reference: 50842085LRR Position: Re-Advert: Assistant Officer Security Operations Centre (FINANCE DIVISION) Megawatt Park Region: South Africa (Gauteng) Industry: Other Closing Date: 2024/09/06 Thank you for your Application! Inbox Microsoft Recruiting Sun, Sep 1, 8:55 AM Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Software Engineer – Teams Platform (Job number:1726871) position at Microsoft! We're glad Microsoft Recruiting Sun, Sep 1, 8:58 AM Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Machine Learning Engineer (Job number:1759775) position at Microsoft! We're glad you're inter Microsoft Recruiting Sun, Sep 1, 9:01 AM Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Security Technical Program Manager (Job number:1762424) position at Microsoft! We're glad you Microsoft Recruiting Sun, Sep 1, 9:05 AM Hi, Fiston Tshingombe teodor, Thank you for applying to the Data & AI Technical Sales Specialist (Job number:1762311) position at Microsoft! We're glad you're i Microsoft Recruiting Sun, Sep 1, 9:11 AM Hi, Fiston Tshingombe teodor, Thank you for applying to the Software Engineer II (Full stack) (Job number:1749784) position at Microsoft! We're glad you're inte Microsoft Recruiting Sun, Sep 1, 9:13 AM Hi, Fiston Tshingombe teodor, Thank you for applying to the Customer Success Account Manager (Job number:1762683) position at Microsoft! We're glad you're inter Microsoft Recruiting Sun, Sep 1, 9:16 AM Hi, Fiston Tshingombe teodor, Thank you for applying to the Principal Technical Program Manager (Job number:1736977) position at Microsoft! We're glad you're in Microsoft Recruiting Sun, Sep 1, 9:19 AM to me Hi, Fiston Tshingombe teodor, Thank you for applying to the Senior Applied AI Engineer (Job number:1762298) position at Microsoft! We're glad you're interested in a career at Microsoft and we're here to help you find a perfect fit. You may not receive feedback from us on your application directly, but please know that it's being evaluated, and you'll hear from us as soon as the review process is complete. If you're selected for an interview, you'll be notified by someone on the recruiting team. You can view your application status updates through your Action Center. If you see the job moved to an Archived state, that means the position is either no longer open, you withdrew from consideration, or you were not selected for the role. You may notice that we move your application from one role to another. This may happen a few times and is a normal part of our recruiting process. So, if you see the job you applied to in an Archived state, and a new job listed as Active, please know that this is normal and does not negatively impact your candidacy in any way. How's your profile? A key part of the review process is evaluating your profile in relation to the job requirements, so please make sure your profile is accurate and extensive – it's our first step in getting to know you! You can build your profile anyway you'd like – you can import it from LinkedIn, manually update it, or import/attach a resume. The most important thing is that your profile tells your story! We encourage you to check back frequently and continue to look for opportunities that match your interests, as new jobs are being posted regularly. Thank you, Microsoft Recruiting This mail is sent from an unmonitored mailbox. Please do not reply. Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. ____ This message was sent to tshingombefiston@gmail.com. If you don't want to receive these emails from this company in the future, please go to: https://ms.icims.com/icims2/?r=11B617365170&contactId=113826735 Your recent job application for Software Engineer FMCD - 34622 Inbox Ford Careers Sun, Sep 1, 8:45 AM to me Hello fiston, Thank you for your interest in joining the Ford Motor Company team. You've taken the first steps by completing your application and sharing your qualifications for the Software Engineer FMCD -34622 position. We will contact you if we think you're a good fit for that position. In the meantime, keep checking www.careers.ford.com for additional opportunities – we'd love to help you find your dream job. Sincerely, The Ford Talent Acquisition Team Your recent job application for Cyber Security ISP and Data Analyst - 34582 Inbox Ford Careers Sun, Sep 1, 8:40 AM to me Hello fiston, Thank you for your interest in joining the Ford Motor Company team. You've taken the first steps by completing your application and sharing your qualifications for the Cyber Security ISP and Data Analyst -34582 position. We will contact you if we think you're a good fit for that position. In the meantime, keep checking www.careers.ford.com for additional opportunities – we'd love to help you find your dream job. Sincerely, The Ford Talent Acquisition Team Your recent job application for Backend Engineer - 34857 Inbox Ford Careers Sun, Sep 1, 8:37 AM to me Hello fiston, Thank you for your interest in joining the Ford Motor Company team. You've taken the first steps by completing your application and sharing your qualifications for the Backend Engineer - 34857 position. We will contact you if we think you're a good fit for that position. In the

meantime, keep checking www.careers.ford.com for additional opportunities – we'd love to help you find your dream job. Sincerely, The Ford Talent Acquisition Team Your recent job application for Thermal Systems Integration Engineer, HVAC - 34848 Inbox Ford Careers Sun, Sep 1, 8:35 AM to me Hello fiston, Thank you for your interest in joining the Ford Motor Company team. You've taken the first steps by completing your application and sharing your qualifications for the Thermal Systems Integration Engineer, HVAC - 34848 position. We will contact you if we think you're a good fit for that position. In the meantime, keep checking www.careers.ford.com for additional opportunities – we'd love to help you find your dream job. Sincerely, The Ford Talent Acquisition Team Your recent job application for STA Site Engineer - 34645 Inbox Ford Careers Sun, Sep 1, 8:30 AM to me Hello fiston, Thank you for your interest in joining the Ford Motor Company team. You've taken the first steps by completing your application and sharing your qualifications for the STA Site Engineer - 34645 position. We will contact you if we think you're a good fit for that position. In the meantime, keep checking www.careers.ford.com for additional opportunities – we'd love to help you find your dream job. Sincerely, The Ford Talent Acquisition Team Your recent job application for Propulsion Systems Design Release Engineer - 34464 Inbox Ford Careers Sun, Sep 1, 8:28 AM to me Hello fiston, Thank you for your interest in joining the Ford Motor Company team. You've taken the first steps by completing your application and sharing your qualifications for the Propulsion Systems Design Release Engineer - 34464 position. We will contact you if we think you're a good fit for that position. In the meantime, keep checking www.careers.ford.com for additional opportunities – we'd love to help you find your dream job. Sincerely, The Ford Talent Acquisition Team Your recent job application for HV Battery Build & Test Engineer (Thermal Runaway) - 31563 Inbox Ford Careers Sun, Sep 1, 8:25 AM to me Hello fiston, Thank you for your interest in joining the Ford Motor Company team. You've taken the first steps by completing your application and sharing your qualifications for the HV Battery Build & Test Engineer (Thermal Runaway) - 31563 position. We will contact you if we think you're a good fit for that position. In the meantime, keep checking www.careers.ford.com for additional opportunities – we'd love to help you find your dream job. Sincerely, The Ford Talent Acquisition Team Your recent job application for Systems Engineering - 32712 Inbox Ford Careers Sun, Sep 1, 8:23 AM to me Hello fiston, Thank you for your interest in joining the Ford Motor Company team. You've taken the first steps by completing your application and sharing your qualifications for the Systems Engineering - 32712 position. We will contact you if we think you're a good fit for that position. In the meantime, keep checking www.careers.ford.com for additional opportunities – we'd love to help you find your dream job. Sincerely, The Ford Talent Acquisition Team Your recent job application for Systems Integration, Electrical Architecture - 32709 Inbox Ford Careers Sun, Sep 1, 8:21 AM to me Hello fiston, Thank you for your interest in joining the Ford Motor Company team. You've taken the first steps by completing your application and sharing your qualifications for the Systems Integration, Electrical Architecture - 32709 position. We will contact you if we think you're a good fit for that position. In the meantime, keep checking www.careers.ford.com for additional opportunities – we'd love to help you find your dream job. Sincerely, The Ford Talent Acquisition Team our recent job application for (602) Bank Analyst-FCSD - 602 Inbox SARB Talent Acquisition Sat, Aug 31, 2:01 PM to me Hello, tshitadi, We received your job application for (602) Bank Analyst-FCSD - 602. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Your recent job application for (608) Lead Policy Analyst - 608 Inbox SARB Talent Acquisition Sat, Aug 31, 1:57 PM to me Hello, tshitadi, We received your job application for (608) Lead Policy Analyst -608. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Recruiting Team Application acknowledgement Inbox SARS Human Capital and Development Sat, Aug 31, 8:43 AM to me Dear Tshingombe Tshitadi , Job Application: Business Area Lead: Civil Case Select Strategy Reference code: 9833 Receipt of your application for the advertised post is hereby acknowledged. It may take some time to process your application. Regards, SARS Talent Acquisition Team 31 August 2024 SARS Human Capital and Development Sat, Aug 31, 8:45 AM to me Dear Tshingombe Tshitadi , Job Application: Ops Manager: Facilities Management Reference code: 9832 SARS Human Capital and Development Sat, Aug 31, 8:46 AM to me Dear Tshingombe Tshitadi , Job Application: Specialist Developer: Information Technology (Adabas) Reference code: 9799 SARS Human Capital and Development Sat, Aug 31, 8:47 AM to me Dear Tshingombe Tshitadi , Job Application: Specialist: Systems Engineer (Mainframe) Reference code: 9804 SARS Human Capital and Development Sat, Aug 31, 8:48 AM to me Dear Tshingombe Tshitadi , Job Application: Senior Specialist: Database Administration (Adabas) Reference code: 9796 SARS Human Capital and Development Sat, Aug 31, 8:49 AM to me Dear Tshingombe Tshitadi , Job Application: Junior Specialist: Asset Management (Software) Reference code: 9791 Update Regarding Your Application Inbox Eaton TalentHub Fri, Aug 30, 3:47 PM to me Hi Fiston, Thank you for applying for the position of Senior Field Service Representative – 31188. We appreciate you considering a career at Eaton. After careful review, we have decided to move forward with other candidates who more closely match the current needs for this team and position. We know that messages like this are disappointing, but we really hope you continue to pursue other opportunities at Eaton. Be sure to check out Eaton.com/careers, where you can find all our open jobs and set up a job alert. Thank you for your interest in Eaton and wish you all the best! Eaton Talent Acquisition Team Your recent job application for (605) Financial Stability Department - Finstab - 605 Inbox SARB Talent Acquisition Sat, Aug 31, 1:45 PM to me Hello, tshitadi, We received your job application for (605) Financial Stability Department - Finstab - 605. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Recruiting Team Your recent job application for (606) Associate Macroprudential Specialist - Finstab - 606 Inbox SARB Talent Acquisition Sat, Aug 31, 1:49 PM to me Hello, tshitadi, We received your job application for (606) Associate Macroprudential Specialist -Finstab - 606. If your profile corresponds to our requirements, a member of our Recruiting team will contact you. If you were requested to provide additional info about your job application, or if you want to manage your profile, go to your candidate self service page. Sincerely, South African Reserve Bank Recruiting Team Application Unsuccessful Inbox SARS Human Capital and Development Wed, Aug 28, 2:00 PM to me Dear Tshingombe Tshitadi , Thank you for applying for Specialist: Case Selection (Transfer Pricing). After careful consideration we regret to inform you that your application was not successful. We wish you everything of the best in your future applications. Yours Sincerely, SARS Talent Acquisition Team • About Us • Our Network • Skills for Work and Life • Knowledge Resources TVET Forum - Connect With a Global TVET Community TVET Forum SDG and TVET Virtual Conferences About the TVET Forum Terms of Use Help & FAQ Manage Your Account Unsubscribe Contact TVET Forum User profile tshitadi fiston Member since 2023-10-14 5 Postings UNEVOC Centre #3043 h Contact: tshingombefiston@gmail.com User Messages: 2024-09-23 Re: Models of Institutional Effectiveness in VET () 2024-09-23 engineering qualification framework implentation tvet college , rdc and rsa record system engineering n studie () 2024-09-23 engineering qualification framework implentation tvet college , rdc and rsa record system engineering n studie () 2024-09-23 experimental workbase tvet and institut back log dhet ucpd record st peace college and sita and examination irregularity implentation () 2024-09-23 experimental career tvet college institu assessment police guidence back log sita and irregularity level 4,5,3,6 ucpd engineering studie diploma certificate () RE: CMS 221043 YS Online form submission: CNP-53345-24-0100-000 Inbox TPMailbox-CMSCCC@met.pnn.police.uk Mon, Sep 23, 12:23 PM (21 hours ago) to me Good Morning, Thank you for your online submission into the Crime Management Services. The crime reference number is showing in the system as not in existence. Are you the victim? What is the nature of the crime? Do you have a named Officer assigned to the Case? Would you like us to place an update onto the system? Kindest regards, Yvonne - Crime Management Services Should you require us in an emergency, please dial 999. If you wish to speak to the operator regarding a non-emergency, please dial 101. ***********PLEASE DO NOT REPLY TO THIS EMAIL. OUR MAILBOX CANNOT RECEIVE EMAILS DIRECTLY FROM MEMBERS OF THE PUBLIC. AS SUCH, SHOULD YOU WISH TO RESPOND TO THIS EMAIL, YOU WILL NEED TO VISIT THE FOLLOWING LINK TO RE-SUBMIT THE REPLY*********** https://www.met.police.uk/contact/af/contact-us/ -----Original Message----- From: no-reply@service.police.uk Sent: 22 September 2024 08:24 To: TP MAILBOX - CMS CCC Subject: CMS 221043 YS Online form submission: CNP-53345-24-0100-000 ** OFFICIAL - SENSITIVE ** --STEP 1 -- First name: fiston -- Surname: tshingombe -- Date of birth: 10/11/1982 -- Email address: tshingombefiston@gmail.com -- Telephone number (for international numbers include the country code): +270725298946-- Postcode: Percy street 1039, Hendrik Potgieter St Johannesburg 1030 --Origin: Form --- Crime reference number: eg 1234567/17 or 01/00000/24: 2345654/24--- When did the incident happen?: 02/09/2022 -- What is your involvement in this 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 15 of 18 case?: High court London transaction victim Edith ,Mrs basem attorney chamber affidavit Portofolio evidence low , complain incidence accident transaction money for claim bank work UK from Canada transaction made in RSA , union waster..Asia bank -- Please provide us with your update: 10/09/2024 NOTICE - This email and any attachments are solely for the intended recipient and may be confidential. If you have received this email in error, please notify the sender and delete it from your system. Do not use, copy or disclose the information contained in this email or in any attachment without the permission of the sender. Metropolitan Police Service (MPS) communication systems are monitored to the extent permitted by law and any email and/or attachments may be read by monitoring staff. Only specified personnel are authorised to conclude binding agreements on behalf of the MPS by email and no responsibility is accepted for unauthorised agreements reached with other personnel. While reasonable precautions have been taken to ensure no viruses are present in this email, its security and that of any attachments cannot be guaranteed. Application Update Inbox TalkToUs@met.police.com.uk via tal.net Mon, Sep 23, 4:15 PM (18 hours ago) to me Dear tshingombe Good Afternoon Thank you for getting in touch with the Metropolitan Police regarding career opportunities. We apologise if there has been a delay in responding to you but this is likely to be because of the large amount of interest that the campaign has generated. If you have seen it "change needs you !" We are here to help you with any enquiries or questions that you have about the job or your application form in the hope that you will complete and submit an application but please do let us know if you are no longer interested. In order to make a start of understanding how we can help you we have a few questions that we would appreciate you answering in reply to this email and if replying on another device the email address to use is TalkToUs@met.police.uk. Are you still interested in a career in the Met? What role are you interested in? What is your highest level of academic achievement? Are you currently working towards a qualification? Do you have a GCSE or equivalent in English? Have you attended or are you interested in attending an Insight Event? Is there anything that we can help with to encourage your application? Look forward to hearing from you soon Kind Regards Met Police Candidate Engagement Team. Automated Response Inbox TalkToUs@met.police.uk Mon, Sep 23, 4:25 PM (17 hours ago) to me Thank you for getting in touch to find out more about becoming a Met Police Constable. Due to the high volume of queries, we aim to contact you within 5 working days. We will do our best to reach out to you within your ideal time slot, if provided. Kindest regards, Talk to Us Team NOTICE - This email and any attachments are solely for the intended recipient and may be confidential. If you have received this email in error, please notify the sender and delete it from your system. Do not use, copy or disclose the information contained in this email or in any attachment without the permission of the sender. Metropolitan Police Service (MPS) communication systems are monitored to the extent permitted by law and any email and/or attachments may be read by monitoring staff. Only specified personnel are authorised to conclude binding agreements on behalf of the MPS by email and no responsibility is accepted for unauthorised agreements reached with other personnel. While reasonable precautions have been taken to ensure no viruses are present in this email, its security and that of any attachments cannot be guaranteed. Application Update Inbox Met Recruitment Team 1:05 AM (9 hours ago) to me tshingombe, You've started your application form, but haven't yet finished it. You haven't got much left to do in this section, and we'd love it if you had five minutes to finish this off. You'll need to log back into the system to continue – Application Centre to pick up where you left off. You can review your progress using the navigation menu on the left hand side of the application form screen – a tick means you're done in each section. If you're stuck and need help, please give us a call – our telephone details are below. Please don't worry about asking us for assistance, that's what we're here for! If you're having trouble deciding whether you want to continue or not, please do give us a call – we'll be able to help by talking this through with you. Have a great day! Yours sincerely, Shared Services Connected Ltd – Delivering services in partnership with the Metropolitan Police Service Phone: 01633 632500 Email: Enquiries.PoliceJobs@police.sscl.com Removing Barriers to Officer Accountability Inbox Google Forms 9:49 AM (4 minutes ago) to me Thanks for filling out Removing Barriers to Officer Accountability Here's what was received. Removing Barriers to Officer Accountability Section 1: Attorney Affirmation is MANDATORY if you wish to receive CLE credit. Section 2: Course Evaluation is ENCOURAGED to inform the state of New York on our program. Email * tshingombefiston@gmail.com Section 1: Attorney Affirmation NY CLE Credit for Webinar To obtain New York CLE credit, please complete and sign this form and then submit it to the Policing Project at NYU Law. Your participation must be verified by the provider. Experienced New York attorneys (attorneys who have been admitted to the New York bar for more than two years) may earn CLE credit through nontraditional formats. Newly admitted attorneys (attorneys who have been admitted to the New York Bar for two years or less) should confirm that the format is permissible for the category of credit. New York attorneys should retain a copy of this affirmation. Email * tshingombefiston@gmail.com Format: Webconference Course Code(s) During each session of the conference you will see and/or hear one or more CLE course codes. Please enter the code(s) in the fields below. If you do not enter the correct code(s), you will not be awarded New York CLE credit. If you did not attend the entire conference, you are able to receive partial credit for the individual sessions you attended in their entirety. List all code(s) for September 24, 2024 * 21-CIP-J / FFPSA & Kinship (Part 1),Date & Time Sep 24, 2024 09:00 PM Johannesburg Webinar ID 912 5168 3181,Tue Sep 24, 2024 9pm – 10pm (SAST) Where https://nyu.zoom.us /w/91251683181?tk=9vyym4gehi0cHxdYwYdOOiYbUw2lCZzZ_lKD0ceCABo.DQcAAAAVPwYvbRZjNTdyNEx1S1NaQzljV2s3NlU2SEdRAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA& uuid=WN_3jfCNZddR7iCjsRfhRXPag Who Gabby Bayness 30x30 Initiative: Advancing Women in Policing Chicago Neighborhood Policing Initiative Legislation Litigation Regulating Use of Technology in Policing ReImagining Public Safety SAJE Policing Assessment Our Mission: We Partner With Communities And Police To Promote Public Safety Through Transparency, Equity, and Democratic Engagement. Our work focuses on front-end, or democratic, accountability—meaning the public has a voice in setting transparent, ethical, and effective policing policies and practices before the police or government act. The goal is to achieve public safety in a manner that is equitable, non-discriminatory, and respectful of public values. Broadly speaking, our work is centered around three focus areas: Front-End Voice in Policing: We believe that in a democratic society, the public must have a voice in how it is policed. Regulation of Policing Technology: We believe that there must be transparency and public debate around the adoption of new policing technologies. Reimagining Public Safety: We believe it is time for a national conversation about what public safety means, and how it is best achieved. Explore our focus areas to learn more about our work.*, Name of CLE Provider: New York University School of Law - Policing Project Please confirm the following statements by checking the boxes and typing your name in the signature field below * ✓ I acknowledge receipt of the course materials for Removing Barriers to Officer Accountability ✓ I certify that I have listened to and/or viewed Removing Barriers to Officers Accountability in its entirety for the sessions for which I've entered codes. Therefore, I request that I be awarded the applicable number of New York CLE credits for this course. Signature * tshingombefiston@gmailcom Date of completion of CLE course (New York attorneys earn CLE credit as of the date they complete a CLE course): * MM 09 / DD 25 / YYYY 2024 Attorney email address to receive CLE certificate (if different from the address above): tshingombekb@gmail.com Section 2: Course Evaluation Course evaluations are optional, but must be offered to all attorneys who participated in today's course. Program Title Thank you for registering for Removing Barriers to Law Enforcement Officer Accountability. You can find information about this webinar below. Removing Barriers to Law Enforcement Officer Accountability Date MM 09 / DD 25 / YYYY 2024 Speaker(s): Removing Barriers to Law Enforcement Officer Accountability Confirmation Inbox Gabby Bayness AttachmentsSep 24, 2024, 8:15 PM (13 hours ago) to me Sep24Tue Removing Barriers to Law Enforcement … View on Google Calendar When Tue Sep 24, 2024 9pm – 10pm (SAST) Where https://nyu.zoom.us /w/91251683181?tk=9vyym4gehi0cHxdYwYdOOiYbUw2lCZzZ_lKD0ceCABo.DQcAAAAVPwYvbRZjNTdyNEx1S1NaQzljV2s3NlU2SEdRAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA& uuid=WN_3jfCNZddR7iCjsRfhRXPag Who Gabby Bayness* Agenda Tue Sep 24, 2024 No earlier events 9pm Removing Barriers to Law Enforcement … No later events Hi Tshingombe tshitadi, Thank you for registering for Removing Barriers to Law Enforcement Officer Accountability. You can find information about this webinar below. Removing Barriers to Law Enforcement Officer Accountability Date & Time Sep 24, 2024 09:00 PM Johannesburg Webinar ID 912 5168 3181 Add to: Google Calendar Outlook Calendar(.ICS) Yahoo Calendar To edit or cancel your registration details, click here. You can cancel your registration before Sep 24, 2024 09:00 PM. Please submit any questions to: gib7728@nyu.edu Thank you! WAYS TO JOIN THIS WEBINAR Join from PC, Mac, iPad, or Android Join Webinar If the button above does not work, paste this into your browser: https://nyu.zoom.us/w/91251683181?tk=9vyym4gehi0cHxdYwYdOOiYbUw2lCZzZ_lKD0ceCABo.D Please take a few moments to evaluate this course: Excellent Good Fair Poor N/A Program Content ✓ Instructor Quality ✓ Written Materials ✓ Facility ✓ Technology ✓ Relevence to my practice: assessment police engineering st peace college policing conduct , Comments: policing conduct investigate analyse design framework regulatory mendator policing portofolio eveidence low design in order to resolve in good conduct system managemnt low conduct , in court poe s, Create your own Google Form Report Abuse • Our Work • 30x30 Initiative: Advancing Women in Policing • Chicago Neighborhood Policing Initiative • Legislation • Litigation • Regulating Use of Technology in Policing • ReImagining Public Safety • SAJE Policing Assessment Our Mission: We Partner With Communities And Police To Promote Public Safety Through Transparency, Equity, and Democratic Engagement. 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RE: New WFCP Membership Application Inbox WFCP Secretariat 2:15 AM (7 hours ago) to me Hello Tshingombe, Thank you for your interest in joining the WFCP. To confirm, are you applying for institutional membership or association membership? Sincerely, Joanna Andrews Program Officer, WFCP Secretariat World Federation of Colleges and Polytechnics (WFCP) 1 Rideau Street - Suite 701, Ottawa ON K1N 8S7 Email: secretariat@wfcp.org Website: www.wfcp.org Subscribe to our Newsletter From: Tshingombe Tshitadi Sent: Tuesday, September 24, 2024 1:48 AM To: WFCP Secretariat Subject: New WFCP Membership Application About the Applicant Are you a: private institution Type of membership requested Association Membership Are you accredited? not applicable Name of Applicant (individual or institution) Tshingombe engineering/St peace college Number of students enrolled in your institution 20 Name of accrediting body St peace sasseta Please share your reasons for joining WFCP Engineering electrical assessment police officer, Contact Information Contact name Tshingombe Tshitadi Contact email tshingombefiston@gmail.com Contact telephone +270725298946 Website https://tshingombefiston.com Address 20 percy 1030 Rockview 103, Jhb Gauteng South Africa Map It Application Update Inbox Met Recruitment Team Tue, Sep 24, 2:15 PM (19 hours ago) to me Vacancy: 18023 - Intelligence Manager – Public Order & Public Safety Intelligence - Inspector – MO2 Dear tshingombe, Thank you for your application for a new position within the Met. To be eligible to apply for this new position, we have a set of criteria that applicants need to meet. Based on the information you have shared so far; we regret to inform you that you are not eligible to progress with your application. Your individual answers suggest that you do not meet the application criteria. You can read more about our eligibility criteria on our Careers Website or by reviewing information available on MyHR. We understand that this will be disappointing news for you but would like to thank you for your interest in this position and wish you all the best for the future. Shared Services Connected Ltd – Delivering services in partnership with the Metropolitan Police Service Phone: 01633 632500 Email: Enquiries.PoliceJobs@police.sscl.com Met Recruitment Team Tue, Sep 24, 2:20 PM (19 hours ago) Vacancy: 18028 - Intelligence Manager - Public Order & Public Safety Intelligence - Detective Inspector - MO2 Met Recruitment Team Tue, Sep 24, 2:20 PM (19 hours ago) Vacancy: 17954 - PA to DCS Band E Met Recruitment Team Tue, Sep 24, 2:25 PM (19 hours ago) Vacancy: 17991 - Detective Constable - DASO - Professional Standards Met Recruitment Team Tue, Sep 24, 2:25 PM (19 hours ago) Vacancy: 17874 - Quality Assurance Lead Met Recruitment Team Tue, Sep 24, 2:30 PM (19 hours ago) Vacancy: 17915 - Complaint Resolution Unit (CRU) - Complaint handler Met Recruitment Team Tue, Sep 24, 2:30 PM (19 hours ago) Vacancy: 17879 - Electronics Development Engineer Met Recruitment Team Tue, Sep 24, 2:35 PM (19 hours ago) Vacancy: 18014 - Developing Threats Team – PC Met Recruitment Team Tue, Sep 24, 2:35 PM (19 hours ago) Vacancy: 17806 - Licensing Admin Support Officer Met Recruitment Team Tue, Sep 24, 2:40 PM (19 hours ago) Vacancy: 17978 - Professional Standards Unit (MO12/MO4/CRIB) Band D Met Recruitment Team Tue, Sep 24, 2:40 PM (19 hours ago) Vacancy: 18051 - Operations Lead - Superintendent Met Recruitment Team Tue, Sep 24, 2:45 PM (19 hours ago) Vacancy: 17990 - MO2 Met Intel - ANPR Auditor - Innovation Deployment & Compliance Team Met Recruitment Team Tue, Sep 24, 2:45 PM (19 hours ago) Vacancy: 18033 - Police Constable DPS - Professional Standard Unit Met Recruitment Team Tue, Sep 24, 2:55 PM (19 hours ago) Vacancy: 18008 - CSC - Offender Management - Central Orders Team Police Constable Met Recruitment Team Tue, Sep 24, 2:55 PM (19 hours ago) Vacancy: 17775 - PSO - Threat Assessment & Intelligence Unit - Intelligence Officer – Researcher Met Recruitment Team Tue, Sep 24, 2:55 PM (19 hours ago) Vacancy: 18048 - Met Intel PC ANPR Investigations Met Recruitment Team Tue, Sep 24, 3:00 PM (18 hours ago) Vacancy: 18047 - Met Intel DS ANPR Investigations Met Recruitment Team Tue, Sep 24, 3:00 PM (18 hours ago) Vacancy: 17922 - Intelligence Officer -Bomb Data Centre - FMT - SO15 Met Recruitment Team Tue, Sep 24, 3:10 PM (18 hours ago) Vacancy: 17223 - Digital Engagement Officer Met Recruitment Team Tue, Sep 24, 3:10 PM (18 hours ago) Vacancy: 18042 - Covert Admin (COVAD) Deputy Manager Met Recruitment Team Tue, Sep 24, 3:10 PM (18 hours ago) Vacancy: 17823 - SQL Server Database Administrator - Counter Terrorism Policing HQ Met Recruitment Team Tue, Sep 24, 3:10 PM (18 hours ago) Vacancy: 18005 - PC - MO6 Public Order Crime Team Met Recruitment Team Tue, Sep 24, 3:15 PM (18 hours ago) Vacancy: 17986 - Driver Assistance Centre Team Leader Met Recruitment Team Tue, Sep 24, 3:15 PM (18 hours ago) Vacancy: 18006 - DS - Public Order Crime Team Met Recruitment Team Tue, Sep 24, 3:30 PM (18 hours ago) Vacancy: 18050 - Resource Management Office Manager Met Recruitment Team Tue, Sep 24, 3:30 PM (18 hours ago) Vacancy: 17925 - Digital Project Officer - 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 16 of 18 NDES Service 3 - SO15 Met Recruitment Team Tue, Sep 24, 3:30 PM (18 hours ago) Vacancy: 18059 - Detective Sergeant - Complex Investigation Team (CIT) Met Recruitment Team Tue, Sep 24, 3:30 PM (18 hours ago) Vacancy: 18078 - National Counter Terrorism Security Office (NaCTSO) – Venues and Public Spaces Unit- Detective Inspector - Counter Terrorism Policing HQ Met Recruitment Team Tue, Sep 24, 3:35 PM (18 hours ago) Vacancy: 18015 - Safety Camera Processing Clerk Met Recruitment Team Tue, Sep 24, 3:40 PM (18 hours ago) Vacancy: 18026 - Health & Safety/Accommodation Manager - Band D - Counter Terrorism Policing HQ Met Recruitment Team Tue, Sep 24, 3:40 PM (18 hours ago) Vacancy: 18081 - MO19 Specialist Firearms Command – Development, Delivery, Equipment & Finance Sergeant Met Recruitment Team Tue, Sep 24, 3:45 PM (18 hours ago) Vacancy: 18095 - Complaint Handler Met Recruitment Team Tue, Sep 24, 3:50 PM (18 hours ago) Vacancy: 17848 - MBS Reporting Senior Analyst Met Recruitment Team Tue, Sep 24, 3:50 PM (18 hours ago) Vacancy: 18067 - Dev Ops Engineer (Cloud Platform) - Technology CSC - Police Staff - Counter Terrorism Policing HQ Met Recruitment Team Tue, Sep 24, 3:55 PM (18 hours ago) Vacancy: 17977 - MetCC Centre Facilities Support Staff Met Recruitment Team Tue, Sep 24, 4:00 PM (17 hours ago) Vacancy: 17872 - BCU Learning and Development Lead Met Recruitment Team Tue, Sep 24, 4:05 PM (17 hours ago) Vacancy: 17923 - Business Analyst – Strategy, Planning and Performance (SPP) Counter Terrorism Policing HQ Met Recruitment Team Tue, Sep 24, 4:05 PM (17 hours ago) Vacancy: 17987 - Character Enquiry Centre Team Leader Met Recruitment Team Tue, Sep 24, 4:10 PM (17 hours ago) Vacancy: 18086 - MO7 Taskforce TSG -Police Sergeant Met Recruitment Team Tue, Sep 24, 4:15 PM (17 hours ago) Vacancy: 17229 -Higher Computer Aided Surveyor / 3D Specialist Met Recruitment Team Tue, Sep 24, 4:20 PM (17 hours ago) Vacancy: 18065 - Counter Weapons Threat Team Officer - PC - Counter Terrorism Policing HQ Met Recruitment Team Tue, Sep 24, 4:25 PM (17 hours ago) Vacancy: 18063 - MO19 Specialist Firearms Command - Tactical Firearms Commander Inspector (UNARMED) Met Recruitment Team Tue, Sep 24, 4:40 PM (17 hours ago) Vacancy: 18064 - MO19 Specialist Firearms Command - Tactical Firearms Commander Detective Inspector (UNARMED) Met Recruitment Team Tue, Sep 24, 9:30 PM (12 hours ago) to me Vacancy: 18085 - Royalty and Specialist Protection - RaSP 400 Inspector Met Recruitment Team Tue, Sep 24, 9:35 PM (12 hours ago) to me Vacancy: 18009 - MO7 Taskforce Mounted Branch Inspector Met Recruitment Team Tue, Sep 24, 9:35 PM (12 hours ago) to me Vacancy: 16708 - 202402 - MPS Return Scheme Approaching Retirement Met Recruitment Team Tue, Sep 24, 9:40 PM (12 hours ago) to me Vacancy: 18004 - Digital Forensic Manager Met Recruitment Team Tue, Sep 24, 9:45 PM (12 hours ago) to me Vacancy: 17666 - Motor Vehicle Technician Met Recruitment Team Tue, Sep 24, 9:55 PM (12 hours ago) to me Vacancy: 17392 - Volunteer Police Cadet Leader Google Forms Thu, Sep 26, 9:28 AM (1 day ago) to me Thanks for filling out Removing Barriers to Officer Accountability Here's what was received. Removing Barriers to Officer Accountability Section 1: Attorney Affirmation is MANDATORY if you wish to receive CLE credit. Section 2: Course Evaluation is ENCOURAGED to inform the state of New York on our program. Email * tshingombefiston@gmail.com Section 1: Attorney Affirmation NY CLE Credit for Webinar To obtain New York CLE credit, please complete and sign this form and then submit it to the Policing Project at NYU Law. Your participation must be verified by the provider. Experienced New York attorneys (attorneys who have been admitted to the New York bar for more than two years) may earn CLE credit through nontraditional formats. Newly admitted attorneys (attorneys who have been admitted to the New York Bar for two years or less) should confirm that the format is permissible for the category of credit. New York attorneys should retain a copy of this affirmation. Email * tshingombefiston@gmail.com Format: Webconference Course Code(s) During each session of the conference you will see and/or hear one or more CLE course codes. Please enter the code(s) in the fields below. If you do not enter the correct code(s), you will not be awarded New York CLE credit. If you did not attend the entire conference, you are able to receive partial credit for the individual sessions you attended in their entirety. List all code(s) for September 24, 2024 * Model statute: An Act to Removing Barriers to Accountability and Facilitate Robust Oversight Our model statute gives states guidance on how to remove barriers to law enforcement officer accountability and oversight commonly found in state or local laws, and/or in police collective bargaining agreements. Advocacy Toolkit: Community Oversight of Police Union Contracts This toolkit by the Legal Defense Fund breaks down accountability-impeding provisions in over 100 police union contracts, providing a resource for advocates and community members engaging in police collective bargaining agreement reform efforts. Journal Article: Stephen Rushin, Police Union Contracts, 66 Duke Law Journal 1191-1266 (2017) This article collects and analyzes more than 170 police union contracts, showing how provisions in these agreements serve as barriers to officer accountability. Journal Article: Kevin M. Keenan & Samuel Walker, An Impediment to Police Accountability - An Analysis of Statutory Law Enforcement Officers' Bills of Rights, 14 B.U. PUB. INT. L.J. 185 (2005) This law review article identifies provisions in Law Enforcement Bills of Rights (LEOBORs) from 14 different states that are impediments to holding officers accountable, focusing on five kinds of provisions that are particularly harmfulVictor Dempsey, Community Organizer, Legal Defense Fund Victor Dempsey is a community organizer at the NAACP's Legal Defense Fund (LDF). Mr. Dempsey has devoted his career to ending police violence through community organizations, eventually founding his own organization to support and advocate for impacted families called Families are the Frontlines. Reneé Hall, former Chief of the Dallas Police Department Reneé Hall is the former Chief of the Dallas Police Department, the first woman to lead the department. Chief Hall has worked to bridge communities with law enforcement through the implementation of a civilian oversight board and has been a champion of accountability by establishing a duty to intervene policy when officers witness excessive force. She graduated with masters degrees from the University of Detroit Mercy (M.S.) and Grambling State University (B.S.). Stephen Rushin, Professor of Law at Loyola University Chicago School of Law Stephen Rushin is the Associate Dean of Faculty Research and the Judge Hubert Louis Will Professor of Law at Loyola University of Chicago School of Law. He has published a series of articles on police unions and the officer internal disciplinary procedures. His research interests include policing, criminal procedure, and criminal sentencing. His work has recently appeared in the Stanford Law Review, the University of Pennsylvania Law Review, the California Law Review, the Cornell Law Review, the Duke Law Journal, the Vanderbilt Law Review, the Texas Law Review, the Iowa Law Review, the Minnesota Law Review, the George Washington Law Review, the Fordham Law Review, the Boston College Law Review, and the Florida Law Review, among other journals. He published the premier article on police union contracts in the Duke Law Journal in 2017. Rushin graduated from Berkeley (J.D. and PhD) and the University of Texas (B.A.). HOST Josh Parker, Deputy Director of Legislative Policy, Policing Project at NYU Law Josh Parker is the Deputy Director of Legislative Policy at the Policing Project. He is a policing policy and legal expert who co-drafted the Removing Barriers to Accountability model statute and has counseled legislators and agency leaders across the country on how to reform their laws to better address police misconduct. Given his expertise, Josh is often sought for legislative testimony, media interviews, and public comment on a number of police misconduct topics. He graduated from the University of Chicago Law School (J.D.), where he served as an Articles Editor of the University of Chicago Law Review, and Duke University (B.A.).21-CIP-J / FFPSA & Kinship (Part 1),Date & Time Sep 24, 2024 09:00 PM Johannesburg Webinar ID 912 5168 3181,Tue Sep 24, 2024 9pm – 10pm (SAST) Where https://nyu.zoom.us /w/91251683181?tk=9vyym4gehi0cHxdYwYdOOiYbUw2lCZzZ_lKD0ceCABo.DQcAAAAVPwYvbRZjNTdyNEx1S1NaQzljV2s3NlU2SEdRAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA& uuid=WN_3jfCNZddR7iCjsRfhRXPag Who Gabby Bayness 30x30 Initiative: Advancing Women in Policing Chicago Neighborhood Policing Initiative Legislation Litigation Regulating Use of Technology in Policing ReImagining Public Safety SAJE Policing Assessment Our Mission: We Partner With Communities And Police To Promote Public Safety Through Transparency, Equity, and Democratic Engagement. Our work focuses on front-end, or democratic, accountability—meaning the public has a voice in setting transparent, ethical, and effective policing policies and practices before the police or government act. The goal is to achieve public safety in a manner that is equitable, non-discriminatory, and respectful of public values. Broadly speaking, our work is centered around three focus areas: Front-End Voice in Policing: We believe that in a democratic society, the public must have a voice in how it is policed. Regulation of Policing Technology: We believe that there must be transparency and public debate around the adoption of new policing technologies. Reimagining Public Safety: We believe it is time for a national conversation about what public safety means, and how it is best achieved. Explore our focus areas to learn more about our work.*,. 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Program Title 21-CIP-J / FFPSA & Kinship (Part 1),Date & Time Sep 24, 2024 09:00 PM Johannesburg Webinar ID 912 5168 3181,Tue Sep 24, 2024 9pm – 10pm (SAST) Where https://nyu.zoom.us /w/91251683181?tk=9vyym4gehi0cHxdYwYdOOiYbUw2lCZzZ_lKD0ceCABo.DQcAAAAVPwYvbRZjNTdyNEx1S1NaQzljV2s3NlU2SEdRAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA& uuid=WN_3jfCNZddR7iCjsRfhRXPag Who Gabby Bayness 30x30 Initiative: Advancing Women in Policing Chicago Neighborhood Policing Initiative Legislation Litigation Regulating Use of Technology in Policing ReImagining Public Safety SAJE Policing Assessment Our Mission: We Partner With Communities And Police To Promote Public Safety Through Transparency, Equity, and Democratic Engagement. Our work focuses on front-end, or democratic, accountability—meaning the public has a voice in setting transparent, ethical, and effective policing policies and practices before the police or government act. 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Explore our focus areas to learn more about our work.*, Please take a few moments to evaluate this course: Excellent Good Fair Poor N/A Program Content ✓ Instructor Quality ✓ Written Materials ✓ Facility ✓ Technology ✓ Relevence to my practice: engineering project assessment police low enforcement portfolio discipline quality management evidence low in order police design thing resolve order in gov system orientation Comments: god thing on disciplinary conduct code police Job Description Schneider Electric's EcoStruxure™ Automation Expert (EAE) is a software-centric industrial automation system that creates successive improvements throughout your operational lifecycle. The EcoStruxure team supports countries globally in deploying this solution. Your role: Reporting to the EcoStruxure EMEA Manager (Francisco) and as part of a team of 7 Project Managers, you will participate in the deployment of the EAE automation solution in Europe. You will support our clients (internal and external) during pre-sales and project execution phases. Your main missions: • Promote the technical benefits of the EAE solution in Europe with Schneider Electric entities in the relevant countries (joint visits, presentations, demonstrations) • Provide technical support to Schneider's local pre-sales teams • Assist in creating technical documents, technical guides, white papers, knowledge base articles, etc. • Support pilot project execution and execution of key projects for clients (direct and indirect) • Train internal teams in different countries using Schneider's local technical resources • Develop the autonomy of each country in deploying EAE Your profile: • Master's degree in Engineering or equivalent in automation • 3 years of minimum experience in design and automation Your skills: • Understanding of OT (Operational Technology) and IT (Information Technology) convergence to address client sustainability challenges • Understanding of DCS (Distributed Control Systems) concept and implementation • Mastery of secure, open, interoperable, and scalable control systems • Appreciated knowledge of the IEC61499 standard • Aptitude for assembling software components to meet customer requirements • Software integration experience • Commercial aptitude, good communication skills, relationship building, collaboration, and teaching • Curiosity, organizational skills, and autonomy • Fluent in English and French We know that skills manifest in many ways and can be based on your life experience. If you do not necessarily meet all the requirements listed, we still encourage you to apply. We offer you: Our offer includes an attractive remuneration and goes well beyond. If you join Schneider Electric, here's an idea of all that we can offer you to live the best possible experience: • A competitive salary, individual bonus, as well as profit-sharing and participation bonuses rewarding everyone's efforts • A range of social benefits that make life easier: from CSE to rich catalogs, health insurance that meets all needs, generous savings and retirement plans, an advantageous employee share ownership program • Professional development through training, mobility and internal promotion (local and international), skills sharing, etc. • An integration journey from your first day 10/27/2024, 12:52 PM Request an intellectual property (IP) licence | Metropolitan Policehttps://www.met.police.uk/rqo/request/ipl/request-intellectual-property-ip... 17 of 18 to give you the keys to success at Schneider Electric within a culture that promotes diversity, professional fulfillment, and inclusion • Work-life balance through our telecommuting policy (up to 48% telecommutable time, equipment included), support for parenthood, inter-company childcare facilities, etc." About Our Company Why us? Schneider Electric is leading the digital transformation of energy management and automation. Our technologies enable the world to use energy in a safe, efficient and sustainable manner. We strive to promote a global economy that is both ecologically viable and highly productive ob Description Schneider Electric's purpose is to empower all to make the most of our energy and resources, bridging progress and sustainability - we call this Life Is On. Our mission is to be the digital partner for sustainability and energy efficiency: https://www.youtube.com/watch?v=VbldHPFltQQ Great people make Schneider Electric a great company - and we are currently recruiting for a Budapest-based, Italian speaking Energy Sourcing Analyst to support the sourcing activity in the Italian market. You will be an active member of our energy and sustainability services group, vital to the future success of the business, and you will play a key role in assisting the team facilitate the delivery of our services to clients across Europe. Please note, this is an Entry level role within the team and this will be a Maternity Cover, starting out as a 2-year-long fixed-term contract with the possibility to extend. Purpose of the job: Deliver effective and efficient energy procurement services (for electricity and natural gas) for our Clients. Maintain effective working relationships at an operational level with key Internal (Client Management, Data, Solutions, Risk Management) and External Stakeholders (Energy Suppliers). Drive operational excellence by participating in process and service improvements in response to market developments and business targets. What you will do: • Analyze energy supply contract prices and terms and negotiate with energy suppliers to ensure optimal contracts are secured • Manage client and supplier relationships through excellent formal and informal communication • Work closely with the Client Management and other internal teams to deliver an exceptional level of service to our clients • Develop and maintain a deep understanding of the Italian energy markets and legislation • Maintain regular contact with energy suppliers in order to ensure flawless service delivery to our client • Effectively create/communicate regional market opinions and knowledge to internal/external clients • Manage pre-tender activities through collecting data, invoices, contracts, etc. • Manage the tendering, analysis and subsequent contract award and placement processes relating to complex energy supply contracts • Negotiate and utilise quantitative and qualitative techniques to deliver optimal energy supply contract terms and prices for our clients through regular interaction with the energy suppliers on the related markets • Collaborate with Sourcing leadership to identify, evaluate, and incorporate efficiencies, new services, and innovative ideas/concepts • Participate in budget forecast creation process What we need from you: • Excellent knowledge of MS Excel is a must • University/College degree preferably in Finance/Economics/Maths/Science or Energy related studies or equivalent experience in energy procurement / client or supplier management / contract management / negotiations • Fluency in English AND Italian is a must • Experience of the energy industry gained either at a supplier or an energy consultancy is a big advantage • Experience in multinational environment is an advantage Skills, competencies that can make you the successful candidate: • Strong analytical and logical skills • Be an excellent influencer, negotiator and collaborator, forming effective relationships with demanding stakeholders • Great communication skills, capablility of engaging people of varying levels in seniority and experience • Strong time management and organisational skills • Results focused and self-directed mindset What we offer: • Life, Accident and Health insurance packages (Medicover White Spring) • Cafeteria allowance • Home Office and Utility allowances • Yearly bonus • Global Family Leave • Flexible and hybrid working model • WESOP (World Employee Share Ownership Plan) to become a shareholder in the company • Engagement groups within the company: get a sneak peek to our company life at https://download.schneider-electric.com/files?p_Doc_Ref=Engagement_groups_HU • Working at the company that ranked #1 in TIME Worlds' Most Sustainable Companies in 2024 • International, diverse environment and a company culture that encourages raising questions and ideas - to make an impact • Real future career building opportunities locally & globally • Working directly with international customers dustrial / Manufacturing senior Engineering - 00934K • Manage the process flow and qualification in collaboration with BU and GSC to prepare a successful industrial transfer • Lead the deployment on NPI and capacity increase projects at the facility ensuring consistency between BU & GSC • Work with cross-functional and remote teams to guarantee the deployment of industrial processes • Accountable for decision making and project execution in compliance with project goals, business, industrial y customer requirements • Accountable for projects requirements: resources, product cost fie, planning & schedule, capacity, SPS and other deliverables • Decision making based on priorities and risk assessment • Ensure the capacities adaptation according to the dedicated tools (CAMA, CORIM, Bridge ..), internal or external • Perform regular Queue Simulations, using the waiting queue design tool, in order to optimize Lead Times and assure capacity of the lines. • Define & maintain a referential operating time based on measurement tools adapted (MTM-UAS-timer-video analysis.) • Ensure the profitability of investments adapted to the needs of optimization and development process Guide the choice of designers by providing industrial and logistical requirements • Is the "Time determination & Ergonomics Specialist/Referent" within his perimeter. • Responsible for Productivity action plan in his perimeter (define, implement) • Implement adaptation on the processes and manufacturing workstation for existing products by improving the industrial performance, in manual process, automatic process & PLC (Programmable Logic Control) using SPS techniques and tools. • Involved in the specifications and quotation of new line architectures and industrial scenarios in order to meet Safety/Quality/Lead Times and productivity requirements. • Optimize Lead Times and assure capacity of the lines. • Write operator work instructions for training • Study the feasibility & profitability of investments adapted to the needs. • Qualifies means and processes, in plant but also at suppliers' location. Application Update Inbox Met Recruitment Team Sat, Oct 26, 7:40 PM (16 hours ago) to me Vacancy: 18130 - National Referral Mechanism Coordinator Dear tshingombe, Thank you for your application for a new position within the Met. To be eligible to apply for this new position, we have a set of criteria that applicants need to meet. Based on the information you have shared so far; we regret to inform you that you are not eligible to progress with your application. Your individual answers suggest that you do not meet the application criteria. You can read more about our eligibility criteria on our Careers Website or by reviewing information available on MyHR. We understand that this will be disappointing news for you but would like to thank you for your interest in this position and wish you all the best for the future. Shared Services Connected Ltd – Delivering services in partnership with the Metropolitan Police Service Phone: 01633 632500 Email: Enquiries.PoliceJobs@police.sscl.com Incomplete Application Inbox Met Recruitment Team Thu, Oct 24, 10:15 PM (3 days ago) to me Vacancy: 14783 - 202305- Police Community Support Officer (PCSO) tshingombe, We don't think you want to continue with your application, and are sorry to see you go. We've closed down your application for now, so that we don't keep bothering you if you've decided this isn't the opportunity for you. If we've got this wrong, and you want to carry on, please get in touch and we'll open your application form back up. Our contact details are below if you want to give us a call. Being a Police Constable isn't for everybody, so we understand that sometimes applicants change their mind. If you've decided this isn't the role for you, but you're still interested in joining the Met, please take a look at the other opportunities we've currently got available - you can view our careers website here. Have a great day tshitadi! Yours sincerely Shared Services Connected Ltd – Delivering services in partnership with the Metropolitan Police Service Phone: 01633 632500 Email: Enquiries.PoliceJobs@police.sscl.com HCP Open Day with the MPS Inbox Dawn.James@met.police.uk Thu, Oct 24, 3:09 PM (3 days ago) to Dear Healthcare Professional, Thank you for registering your interest to attend our Healthcare Professional Open Day today at Charing Cross Police Station. Unfortunately you didn't attend, you can however still apply for the role by clicking on the link below, remember to attach a CV and personal statement. Become a custody healthcare practitioner | Metropolitan Police Please do contact me if you have any queries. Kind Regards Dawn Dawn James | Deputy Healthcare Director (Acting) Met Detention (M09) 07917 586675 | dawn.james@met.police.uk Lambeth HQ, 109 Lambeth Road, London, SE1 7LP NOTICE - This email and any attachments are solely for the intended recipient and may be confidential. If you have received this email in error, please notify the sender and delete it from your system. Do not use, copy or disclose the information contained in this email or in any attachment without the permission of the sender. Metropolitan Police Service (MPS) communication systems are monitored to the extent permitted by law and any email and/or attachments may be read by monitoring staff. Only specified personnel are authorised to conclude binding agreements on behalf of the MPS by email and no responsibility is accepted for unauthorised agreements reached with other personnel. While reasonable precautions have been taken to ensure no viruses are present in this email, its security and that of any attachments cannot be guaranteed. to me Dear Fiston, Thank you for applying for the position of Service Centre Helpdesk Coordinator - 33335. We appreciate the opportunity to consider you for employment with Eaton. This communication is to let you know that this job has been filled. We invite you to visit www.eaton.com/careers and apply to other opportunities that match your current career aspirations. Thank you for your continued interest in Eaton. Best regards, Tshingombe, will you answer a question for us? Inbox Schneider Electric Sat, Oct 26, 2:30 PM (21 hours ago) to me Hello Tshingombe, Recently, you applied and were considered for a position with Schneider Electric. While the outcome has not resulted in an offer of employment, we would appreciate your time in answering one final question which will help us understand your lasting impression of Schneider Electric. Our goal is to treat all candidates with fairness and respect and your lasting impression helps us understand if we have achieved our goal. Pulse - One Question Survey Thank you. We look forward to hearing from you! *Please note that all feedback is confidential and is not associated with any application. Any feedback gathered will not impact any potential employment with Schneider Electric. This email is being sent from an unmonitored email address. Schneider Electric can be reached at the following: 800 Federal Street North Andover, MA 01810 https://www.se.com/us/en/ / (978) 975-9600 Survale sends surveys on behalf of Schneider Electric at their request and has no involvement with employment decisions. We can be reached at contactus@survale.com. To unsubscribe click here Powered by Survale In Automatic reply: letter explanation theoretical pratical base work , n diplomat award engineering electrical Inbox CallCentre via dhetgovza.onmicrosoft.com 9:16 AM (8 hours ago) to me Please note that this is an automated response, do not reply to it. Thank you for contacting the Department of Higher Education and Training Call Centre. We appreciate your inquiry. Regarding NN Diploma, Nated, and NCV certificate enquiries: • All applications for new issues, replacements, or combination requests must be submitted directly to the relevant college. • Please note that there is a minimum waiting period of 3-6 months for diploma applications. • The issuance of NN Diploma is currently paused. We have communicated this to all colleges. • In the meantime, students whose diplomas are finalized but awaiting printing can obtain a confirmation letter from their college. We apologize for any inconvenience this may cause and appreciate your understanding. MMA support Inbox MMA Support via freshdesk.com Mon, Oct 21, 8:41 AM (2 days ago) to me Hi Tshingombe Thanks so much for reaching out! We know there's nothing worse than sending an email and getting no response. So, to make sure that you know that we are aware of your email, we have created this handy auto-reply just to let you know that we have your email and we are assigning it to the best person to help you! We like to be quite speedy on our replies, so you should get a response soon. Your experience is our first priority and our agents are here from Monday to Saturday between 08h00 and 20h00 and on Sundays between 08h00 and 19h00. You can also chat with our agents directly using our live chat on the Shoprite app. In the meantime, if you have general questions about the Money Market Account, check out our website for some handy walk-throughs and answers to some questions you may have. We have also created some useful videos on how to use the Money Market Account, please click here to view them. If you have any additional information that you think will help us to assist you, please feel free to reply to this email. We look forward to chatting soon! Money Market Account Services Team (no subject) Inbox Ahmed Abdelmonem (International Supplier) Tue, Oct 22, 1:52 PM (1 day ago) to me Hi Tshingombe, I trust this email finds you in good health. My name is Ahmed Abdelmonem, and I serve as a Customer Lifecycle Manager for Microsoft. My responsibilities include overseeing the SMB segment in the South African market. Within my role, I manage various Microsoft workloads, including: • Microsoft Azure: Our expansive cloud platform that provides an array of services tailored for the development, deployment, and management of applications. • Microsoft Dynamics: An integrated suite of ERP and CRM software applications designed to streamline business processes. • Modern Workplace: A collection of solutions aimed at enhancing collaboration and productivity within today's digital-first work environment. • Copilot: Our latest AI-driven platform that assists in code generation and other complex tasks, ensuring efficiency and innovation. I would like to connect with you to discuss your needs and explore the best possible solutions for your organization. Please let me know a convenient time for us to connect. Thank you for your attention, and I look forward to connecting with you soon. Regards, Ahmed Abdelmonem Customer Lifecycle Manager | SMB South Africa | MEA v-ahmabdelmo@microsoft.com Application Unsuccessful Inbox SARS Human Capital and Development Sat, Oct 26, 9:00 AM (1 day ago) to me Dear Tshingombe Tshitadi , Thank you for applying for Specialist Advisor: Direct Tax (Legal and Domestic Tax). After careful consideration and review of your profile against the minimum requirements (qualifications and work experience) of the job, we regret to inform you that your application was not successful. We encourage you to visit our career site and search other available opportunities. Thank you for showing interest and we wish you all the best in your job search. Thank you for applying to Schneider Electric! Inbox Schneider Electric Unsubscribe Sat, Oct 26, 5:22 AM (1 day ago) to me Hi Tshingombe, We appreciate your interest in career opportunities at Schneider Electric! Thank you for taking the time to apply for the Senior Power Electronics Architect position we have posted online. One of our Talent Acquisition Professionals will review your submission and contact you either by phone or email if you are selected to move forward in the process. We will make every attempt to complete this initial review within 10 – 15 business days; however, we ask for your understanding if it takes slightly longer due to high volumes. At Schneider Electric, we desire to provide reasonable transparency throughout the process. During the application process, you created an account in which you can log-in to check the status of your application at any time. You can also use this account to update and strengthen your profile. Thank you, The Schneider Electric Talent Acquisition Team Access My Career Portal Search for Jobs It is the policy of Schneider Electric to provide equal employment and advancement opportunities in the areas of recruiting, hiring, training, transferring and promoting all qualified individuals regardless of race, religion, color, gender, disability, national origin, ancestry, age, military status, sexual orientation, marital status, or any other legally protected characteristic or conduct. ____ This message was sent to tshingombefiston@gmail.com. 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At Schneider Electric, we desire to provide reasonable transparency throughout the process. During the application process, you created an account in which you can log-in to check the status of your application at any time. You can also use this account to update and strengthen your profile. Thank you, The Schneider Electric Talent Acquisition Team Access My Career Portal Search for Jobs It is the policy of Schneider Electric to provide equal employment and advancement opportunities in the areas of recruiting, hiring, training, transferring and promoting all qualified individuals regardless of race, religion, color, gender, disability, national origin, ancestry, age, military status, sexual orientation, marital status, or any other legally protected characteristic or conduct. ____ This message was sent to tshingombefiston@gmail.com. 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We will make every attempt to complete this initial review within 10 – 15 business days; however, we ask for your understanding if it takes slightly longer due to high volumes. At Schneider Electric, we desire to provide reasonable transparency throughout the process. During the application process, you created an account in which you can log-in to check the status of your application at any time. You can also use this account to update and strengthen your profile. Thank you, The Schneider Electric Talent Acquisition Team Tshingombe Tshitadi Dashboard | Log Out My Career Account Options shown include to update your full profile (helps get important information to our recruiting team), current and past application submissions with current status as well as managing subscription preferences to our talent communities. How can I correct my Personal Information? No need to wait for us, you own and are empowered to correct your data at any time. Just click on 'Update My Profile' and correct the information. Options Update My Profile View Current Job Opportunities Manage My Interests My Rights Submissions All times are in Eastern European Standard Time. Each row is an application to a Job. The last column contains buttons for actions such as withdrawing or continuing an application if applicable. ID Title Status Last Update Actions 2023-62576 Energy Sourcing Analyst (Italian speaking) - Maternity Cover Received Submission 10/25/2024 2023-55706 EcoStruxure Automation Expert Regional Consultant Received Submission 10/25/2024 2024-79748 Digital Power Inside Sales Manager Received Submission 10/25/2024 2024-79405 Senior Power Electronics Architect Received Submission 10/25/2024 2024-79092 Power Systems Medium Voltage Intern Not Selected 10/23/2024 Privacy Notice Schneider Electric Community About Fiston Tshingombe Fiston Company : Tshingombe Engineering engineering electrical st peace college diploma , Cadet Online Community Badges View All 2 Posts 0 Likes Received 0 Likes Given 0 Solutions MY ACTIVITY BOOKMARKS SUBSCRIPTIONS DRAFTS Go to mySchneider Translate to: Please select 1 Help Feedback About Fiston - Schneider Electric Community https://community.se.com/t5/user/viewprofilepage/user-id/153387 1 of 3 10/17/2024, 12:05 PM No Content Available My Content Likes Given Latest Contributions Activity Feed 0 0 0 0 0 0 0 2 My Moderated Posts Understanding Our Pre-Moderation Process: Fostering a Positive Community Environment -@ ë ' > My Photos Upload An Image Top Tags english scada SCADA software SCADA tutorial SCADA app Telemetry and SCADA ups apc battery smart-ups PowerChute back-ups turkish power shutdown firmware bug Indonesian modbus spacelynk management network software beeping edc communication homelynk NMC network_management_card problem View All Feedback About Fiston - Schneider Electric Community https://community.se.com/t5/user/viewprofilepage/user-id/153387 2 of 3 10/17/2024, 12:05 PM Terms & Conditions Privacy Notice Change your cookie settings © 2024 Schneider Electric, Inc FORUMS KNOWLEDGE CENTER EVENTS & WEBINARS IDEAS BLOGS GET STARTED | | Feedback About Fiston - Schneider Electric Community https://community.se.com/t5/user/viewprofilepage/user-id/153387 3 of 3 10/17/2024, 12:05 PM Thank you for your interest in Microsoft! Inbox Microsoft Recruiting Unsubscribe Fri, Oct 25, 5:10 PM (2 days ago) to me Hi Fiston Tshingombe teodor, Thank you for your interest in a career at Microsoft. Unfortunately, we will not be moving forward with your candidacy for the position of Software Engineer II, 1755381 at this time. However, we'd like to encourage you to continue to explore other career opportunities on Microsoft Careers as we continually update openings on a daily basis. We look forward to considering you for other positions at Microsoft! Thank you, Microsoft Recruiting Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. This mail is sent from an unmonitored mailbox. Please do not reply. Your Application to Schneider Electric - Tshingombe Tshitadi Inbox Schneider Electric Unsubscribe 2:17 PM (2 hours ago) to me Hi Tshingombe, Thank you again for your interest in Schneider Electric and the Power Systems Medium Voltage Intern role we have on our team. We wanted to follow-up on the status of your candidacy. Your application was impressive; however, you were not selected to continue forward in the process. Please do not take this decision to mean we have no interest in you as a candidate. We will keep your resume in our system and share opportunities that fit your skills and experience. New positions are posted daily, so we encourage you to continue visiting our career website but also sign-up for our talent pool emails to receive notification of the latest roles that match your profile. We wish you success in your job search and hope we will have the chance to consider you for another role in the future. Best regards, Brock Coffey The Schneider Electric Talent Acquisition Team Access My Career Portal Search for Jobs ____ This message was sent to tshingombefiston@gmail.com. If you don't want to receive these emails from this company in the future, please go to: https://se.icims.com/icims2/?r=6EA61614346&contactId=5716766 © Schneider Electric Update on Your Job Application for (644) Team Leader - Food and Beverages - CSD Inbox SARB Talent Acquisition 2:30 PM (2 hours ago) to me Dear tshitadi tshingombe, Thank you for your application to (644) Team Leader - Food and Beverages - CSD (644). Kindly note that this requisition hiring process currently on hold. Hence selection process will be paused temporarily, we will notify you as soon as we resume this process. Regards, SARB Talent Acquisition Team Update on your Job application with SARB SARB Talent Acquisition 2:35 PM (2 hours ago) Dear tshitadi tshingombe, Thank you for your interest in the (644) Team Leader - Food and Beverages - CSD at the SARB, we regret to inform you that your application was unsuccessful. Thank you for your interest in Microsoft! Inbox Microsoft Recruiting Unsubscribe 9:29 AM (7 hours ago) to me Hi Fiston Tshingombe teodor, Thank you for your interest in a career at Microsoft. Unfortunately, we will not be moving forward with your candidacy for the position of Senior Applied AI Engineer , 1762298 at this time. However, we'd like to encourage you to continue to explore other career opportunities on Microsoft Careers as we continually update openings on a daily basis. We look forward to considering you for other positions at Microsoft! Thank you, Microsoft Recruiting Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. This mail is sent from an unmonitored mailbox. Please do not reply. 11 of 8,039 Application Unsuccessful Inbox SARS Human Capital and Development 8:30 AM (8 hours ago) to me Dear Tshingombe Tshitadi , Thank you for applying for Researcher: Tariff X2. After careful consideration and review of your profile against the minimum requirements (qualifications and work experience) of the job, we regret to inform you that your application was not successful. We encourage you to visit our career site and search other available opportunities. Thank you for showing interest and we wish you all the best in your job search. Best Regards, SARS Talent Acquisition Team 23 October 2024 SARS Human Capital and Development 10:30 AM (6 hours ago) to me Dear Tshingombe Tshitadi , Thank you for applying for Technical Officer: Tariff Classification. After careful consideration and review of your profile against the minimum requirements (qualifications and work experience) of the job, we regret to inform you that your application was not successful. SARS Human Capital and Development 10:30 AM (6 hours ago) to me Dear Tshingombe Tshitadi , Thank you for applying for Investigator: Digital Fraud. After careful consideration and review of your profile against the minimum requirements (qualifications and work experience) of the job, we regret to inform you that your application was not successful. Update Around Your Application Inbox Eaton TalentHub Tue, Oct 22, 2:43 PM (1 day ago) to me Dear Fiston, Thank you for applying for the position of Commercial Finance Manager - 31056. We appreciate the opportunity to consider you for employment with Eaton. This communication is to let you know that this job has been filled. We invite you to visit www.eaton.com/careers and apply to other opportunities that match your current career aspirations. Thank you for your continued interest in Eaton. Best regards, Eaton TalentHub Tue, Oct 22, 3:47 PM (1 day ago) to me Dear Fiston, Thank you for applying for the position of Service Centre Helpdesk Coordinator - 33335. We appreciate the opportunity to consider you for employment with Eaton. This communication is to let you know that this job has been filled. We invite you to visit www.eaton.com/careers and apply to other opportunities that match your current career aspirations. Thank you for your continued interest in Eaton. Best regards, Please tell us the name of the officer or member of staff you are working with in relation to this request Become a Member My Elektor Topics Magazine Articles News Video Projects Newsletter Submit Store You are now logged in. MyLAB EN0202272ID No bio 0 | Follow user View as visitor: My Groups Coming soon My Stats 0 Published projects Views 0 Followers 0 Star(s) on average 0 Comments 0 Comments My Projects No projects Following Not following any project Subscribe to the e-zine Elektor is an international platform for applied electronics, providing engineers, makers, and startups with expert content, practical knowledge, and industry insights. Since the 1960s, we've empowered a global community to design, build, and share real-world solutions. Members get exclusive project access, store discounts, and opportunities to collaborate with top innovators. Whether you're learning, designing, or scaling a business, Elektor helps you connect, create, and grow. 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Gender First Name Last Name Nickname Date of Birth My DVD settings Email address tshingombefiston@gmail.com Primary Add email address Invoice emailaddress Phone numbers Add phone number Change password Subscribe to the e-zine Elektor is an international platform for applied electronics, providing engineers, makers, and startups with expert content, practical knowledge, and industry insights. Since the 1960s, we've empowered a global community to design, build, and share real-world solutions. Members get exclusive project access, store discounts, and opportunities to collaborate with top innovators. Whether you're learning, designing, or scaling a business, Elektor helps you connect, create, and grow. Become a member CUSTOMER SERVICE Privacy Policy Terms of business Copyright Contact us Advertising info ELEKTOR WORLD About Elektor Elektor MAGAZINE Elektor LABS Elektor STORE Submit Your Content Social Media Safe Payments BECOME FREE MEMBER AND RECEIVE OUR EZINE THE ELEKTOR UNIVERSE ____ Mains Power Outages Monitor Is Your Grid Supply Steadily Available? 8-Bit Companion for the Raspberry Pi Power Saving Made Easy Mercury Rectifiers PECULIAR Infographics Power & Energy Speed Control of a Brushed DC Motor EMF Measurement Instead of Tachogenerator 535B JANUARY & FEBRUARY BONUS EDITION 2025 | ELEKTORMAGAZINE.COM EDITION DIGITAL FOCUS ON Power & Energy 1 9 6 1 100k S I N C 240210-002 PIC GND OPI EXT D7a BZX84C2V7-TP C13 100n D1a BAS21 R9 4k7 R7 1k R8 EOne partner, unlimited technology solutions. fortec-integrated.de fortec-power.de • Embedded • HMI systems • Power supplies • Displays and TouchCONTENTS Elektor January/February 2025 Bonus Edition Elektor Magazine is published 8 times a year by Elektor International Media b.v. 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The article, "Mains Power Outages Monitor," details a circuit that constantly monitors mains power and signals outages. Before high-power semiconductor-based rectifiers, converting AC to DC in industrial and transportation applications was a significant challenge. Devices were bulky, fragile, used polluting materials, and demanded frequent maintenance. Check out the article, "Mercury Rectifiers," to learn about mercury arc rectifiers and more. Brush-type DC motors are often replaced by brushless (BLDC) and stepper motors, but their simpler control still has advantages. The article, "Speed Control of a Brushed DC Motor," explores maintaining constant speed regardless of torque — without a tachometer generator. We hope you enjoy these articles and rest of the content in the Bonus edition. As you work on your own projects, be sure to document your progress on the Elektor Labs platform (www.elektormagazine.com/labs)! International Editor-in-Chief: Jens Nickel | Content Director: C. J. Abate | International Editorial Staff : Asma Adhimi, Roberto Armani, Eric Bogers, JanBuiting, Rolf Gerstendorf (RG), Ton Giesberts, Saad Imtiaz, Alina Neacsu, Dr. Thomas Scherer, Jean-Francois Simon, Clemens Valens, Brian Tristam Williams | Regular Contributors: David Ashton, Stuart Cording, Tam Hanna, Ilse Joostens, Prof. Dr. Martin Ossmann, Alfred Rosenkränzer | Graphic Design & Prepress: Harmen Heida, Sylvia Sopamena, Patrick Wielders | Publisher: Erik Jansen | Technical questions: editor@elektor.com The Team COLOPHON EDITORIAL The January/ February 2025 edition of ElektorMag is available at newsstands and in the Elektor Store. 3 Colophon 4 Speed Control of a Brushed DC Motor EMF Measurement Instead of Tachogenerator 10 8-Bit Companion for the Raspberry Pi Power Saving Made Easy 12 From Life's Experience Micromanagement 14 Peculiar Parts Mercury Rectifiers 16 Infographics: Power and Energy 18 Mains Power Outages Monitor Is Your Grid Supply Steadily Available? January & February 2025 3 One partner, unlimited technology solutions. fortec-integrated.de fortec-power.de • Embedded • HMI systems • Power supplies • Displays and Touchgenerator unit is larger and more expensive than a tacholess version of a motor. If the motor is operated with a pulsed voltage (PWM), however, the speed is proportional to the duty cycle. At the same time, the motor operates as a generator in the off-phase of the PWM voltage so that its speed can be measured in this phase. In the past, in the analog age, the electronic effort for such a control was not insignificant, as can be seen from the schematic diagram in Figure 5. A rectangle generator, a voltage-controlled pulse width modulator, a sample-and-hold circuit to measure the actual speed value, and a PI controller were required. In the digital world, the principle remains the same, but the effort required is considerably reduced thanks to the use of a microcontroller. By Rainer Schuster (Germany) Brush-type DC motors are increasingly being replaced by their brushless (BLDC) and stepper motor competitors. However, their use still makes some sense, as the control effort is considerably lower. This article shows how to keep the speed of a DC motor with brushes constant regardless of the torque – and without a tachometer generator. In the simplest case, a DC motor is connected to a variable voltage supply, as shown in Figure 1. The speed is (theoretically) proportional to the supply voltage VM, but only as long as the torque is constant. Unfortunately, the equivalent circuit diagram of the DC motor looks like Figure 2. The motor winding not only has an inductance LM, but also an ohmic resistance of the copper wire, which is designated by RM. The higher the torque, the more voltage drops across RM, until finally there is no more voltage across the inductance LM and the motor stops (Figure 3). Control with Tachogenerator or EMF Measurement To compensate for these torque-dependent speed fluctuations, the motor was once usually coupled to a tachogenerator, which in turn supplied a voltage proportional to the speed (Figure 4). However, a motor-tacho Speed Control of a Brushed DC Motor EMF Measurement Instead of Tachogenerator basics 4 Bonus Edition January & February 2025 www.elektormagazine.comRPM ~ VM M VM Figure 1: In an ideal world, the speed is proportional to the motor voltage. I ~ N V = V – R x I RPM ~ V L RM M M M M M M M M VM Figure 2: In practice, the ohmic resistance of the motor winding joins its inductance. U/min I M NM Figure 3: The higher the torque, the slower the motor turns. Rev. target value Differential amplifier Tacho generator Motor Voltage regulator Power supply M Figure 4: Block diagram of a motor control system with tachogenerator. PI-Regler Drehzahl Sollwert Sample & Hold-Schaltung MOSFET-Schalter Spannungsgesteuerter Pulsbreitenmodulator NF-Rechteck Generator Strom versorgung Motor M Figure 5: Block diagram of a motor control with EMF measurement. January & February 2025 5 Practical Implementation of an EMF Control As the complete circuit diagram in Figure 6 shows, an ATtiny45 microcontroller from Microchip with 4 kB of flash memory is used for control. The controller has only eight pins, but is perfectly suited for this application. It can be programmed "in system" via SV2 using an ISP programming device. The microcontroller is supplied with 5 V by the voltage regulator IC2, which is why the input voltage (and thus the motor voltage) must not exceed 24 V. Q1 and Q2 control the motor. Q2 is a PMOS transistor of the type IRF4905, which can theoretically handle a motor current of 74 A, but only if a sufficiently dimensioned heat sink is used. Figure 7 shows what happens at the motor terminals during the different phases of the PWM signal: After the ON phase of the PWM signal, a demagnetization period follows in the OFF phase; then the motor generates an EMF voltage that is proportional to the speed. This voltage is fed to the ADC2 analog-to-digital converter of the microcontroller via the R4/R5 voltage divider. R5 should be dimensioned so that the voltage at ADC2 does not exceed 5 V. VB R5 12 V 4k7 24 V 2k2 The setpoint speed, which is set by the RPM potentiometer or an external voltage of 0…5 V at X6, is sent to ADC1 of the micro controller. Diode D1 is absolutely necessary because when the control voltage is switched off, the inductance of the motor discharges, which results in a negative voltage spike that D1 limits to about 0.7 V. Figure 8 shows a suggested printed circuit board layout for the motor control with EMF measurement; the required components are listed in the Component List. Software I The software for the ATtiny45 was written in BASCOM. The controller is operated internally at 8 MHz. Timer0 is operated as a PWM timer in Phase Correct PWM Timer mode. Demagnetization Switch-o¬ phase Switch-on phase Figure 7: The speed is measured in the switch-off phase after demagnetization. EMF = actual motor speed 240486-009 see text ISP RPM +5V +5V MOSI GND Reset SCK MISO +5V +24V max. +24V max. X2 Power PB5(RESET/ADC0) PB3(ADC3) PB2(SCK-ADC1) PB4(ADC2) PB1(MISO) PB0(MOSI) IC1 ATtiny45 GND VCC 4 1 2 3 8 7 6 5 1 3 5 2 4 6 SV1 C1 1n X1 C2 100n C3 100n Motor D1 1N4004 Q2 IRF4905 G D S R1 R2 47k R3 1M Q1 G S D BS170 R4 R5 IC2 78L05 C4 100n C5 100µ 35V R6 10k X3 C6 10µ 16V R7 Figure 6: Practical circuit of the EMF motor control. 6 Bonus Edition January & February 2025 www.elektormagazine.com 10k 10k 10kWith a prescaler of N = 64, the PWM frequency is: At 8 MHz, this results in a frequency of 245 Hz. The pulse width is set via register PWM0A from 0 to 255. Depending on the motor type, the prescaler may need to be set to 256, for example if the induction phase is longer than or the same length as the switch-off phase. This results in a PWM frequency of approximately 60 Hz. In the main program loop, the speed setpoint is constantly read in at ADC1. The actual value is read in at ADC2 during the off-phase (Pwm_Pin=0) and summed up. When the motor is switched on again, the average of the actual value is calculated. To implement the PI controller, there is the constant Ti (integration time), together with the time constant of Timer1 and Kp (proportional gain), which must be adapted to the motor used. The interrupt time of Timer1 is set using the TCCR1 register: TCCR1 Timer1 Interrupt 4 250 µs 5 500 µs 6 1 ms 7 2 ms When Ti has expired (Timer1-Interrupt × Ti), the speed deviation is calculated, added to the previous value (taking into account the sign) and multiplied by Kp. The result is output directly as the new switch-on duration. Control Using RI Compensation Another practical solution can be what is known as RI compensation. As mentioned at the beginning, the speed fluctuation of a DC motor is due to the ohmic resistance of its copper winding. If the current through the motor is measured, this resistance can be compensated. To do this, only the coil resistance of the motor needs to be known, which can be easily measured. The circuit in Figure 9 is similar to that in Figure 6, except that the motor current is measured as a voltage drop across R5. R5 is to be dimensioned so that a maximum of 0.5 V is dropped across R5 at maximum motor current. The power dissipation in watts must be equal to R5 × motor current squared. Figure 10 shows a suggested layout for the motor control with RI compensation. 1 6 C1 C2 C3 C4 R3 R4 R5 SV1 C5 C6 R1 R7 1 n 1 00n 1 00n 1 00n 1 M 1 0k TINY45 1 00u/35 1 0u/1 6 1 0k 1 0k Figure 8: Proposal for a circuit board layout for the EMF control. 1 6 C1 C2 C3 C4 R1 R3 R5 SV1 C5 C6 R7 1 n 1 00n 1 00n 1 00n 1 0k 1 M TINY45 1 00u/35 1 0u/1 6 1 0k Figure 10: Proposed circuit board layout for the control with RI compensation. Figure 9: The motor control with RI compensation differs only in one detail. 240486-009 see text ISP RPM +5V +5V MOSI GND Reset SCK MISO +5V +24V max. +24V max. X2 Power PB5(RESET/ADC0) PB3(ADC3) PB2(SCK-ADC1) PB4(ADC2) PB1(MISO) PB0(MOSI) IC1 ATtiny45 GND VCC 4 1 2 3 8 7 6 5 1 3 5 2 4 6 SV1 C1 1n X1 C2 100n C3 100n Motor D1 1N4004 Q2 IRF4905 G D S R1 R2 47k R3 Q1 G S D BS170 R4 R5 IC2 78L05 C4 100n C5 100µ 35V R6 10k X3 C6 10µ 16V Software II The software for the RI compensation is also written in BASCOM. Timer0 is configured as a PWM timer with a frequency of 245 Hz. In contrast to the EMF control, the control here is designed as a pure P controller. To do this, the coil resistance of the motor and the supply voltage must be known and specified as constants RM and U0 in the program. The motor current is now measured during the switch-on phase of the PWM signal. The effective value of the current is calculated from the switch-on duration: The duty cycle is then increased by the corresponding value. Two Options There are several ways to control a DC motor without a tachogenerator. Each of these options has different advantages and disadvantages: > For the EMF control, a PI controller is required, the parameters of which January & February 2025 7 A1 7,5mm 1 2 1 2 - OI 1 2 3 D1 IC2 Q1 Q2 R2 X1 X2 X3 IC1 R6 1 N4004 78L05 BS1 70 IRF4905 47k 1 0k A1 7,5mm 1 2 1 2 - OI 1 2 3 D1 IC2 Q1 Q2 R2 X1 X2 X3 IC1 R4 1 N4004 78L05 BS1 70 IRF4905 47k 1 0k 10k 10k 10kmust be adapted to the motor used in order to optimize over- and under shoot. To do this, voltage fluctuations in the supply voltage are compensated. > With RI compensation, there are no overshoots or undershoots, but voltage fluctuations in the supply voltage are not compensated. The schematics, layouts, and software for both controllers can be downloaded from the Elektor Labs project page at [1]. Translated by Jörg Starkmuth — 200486-01 About the Author Rainer Schuster 's fascination with electronics began at the age of 13, when he received the Philips EE1 electronics experiment kit from his parents for Christmas in 1970. In September 1971, he bought his first issue of Elektor magazine and has remained loyal to it to this day. After studying electrical engineering at the Munich University of Applied Sciences, he worked for 37 years as an engineer in electronics development at Agfa in Munich. He has been writing articles for Elektor since 2009. Now that he is retired, he also has his own YouTube channel (www.youtube. com/@rainerschuster5722), where he posts his projects. Questions or Comments? Do you have questions or comments about this article? Email the author at rainerschuster@mnet-mail.de, or contact Elektor at editor@elektor.com. Related Product > Motor Control Development Bundle www.elektor.com/20534 [1] Elektor Labs page about this project: https://tinyurl.com/200486-01 [2] YouTube video: https://www.youtube.com/watch?v=6IEVBQyKIF4 WEB LINKS Component List for RI Compensation Controller Resistors: R1, R6, R7 = 10 kΩ R2 = 47 kΩ R3 = 1 MΩ R5 = see text Capacitors: C1 = 1 nF C2…C4 = 100 nF C5 = 100 µF/35 V C6 = 10 µ/16 V Semiconductors: D1 = 1N4004 Q1 = BS170 Q2 = IRF4905 IC1 = ATtiny45 IC2 = 78L05 Miscellaneous: SV1 = 2 × 3-pin header X1,X2 = 2-pin PCB terminal, 5 mm pitch X3 = 3-pin PCB terminal, 5 mm pitch Component List for EMF Controller Resistors: R1, R4, R6, R7 = 10 kΩ R2 = 47 kΩ R3 = 1 MΩ R5 = see text Capacitors: C1 = 1 nF C2…C4 = 100 nF C5 = 100 µF/35 V C6 = 10 µF/16 V Semiconductors: D1 = 1N4004 Q1 = BS170 Q2 = IRF4905 IC1 = ATtiny45 IC2 = 78L05 Miscellaneous: SV1 = 2 × 3-pin header X1, X2 = 2-pin PCB terminal, 5 mm pitch X3 = 3-pin PCB terminal, 5 mm pitch 8 Bonus Edition January & February 2025 www.elektormagazine.com January & February 2025 9 LUCKY YOU! Not a subscriber yet? Sign up for our free e-zine newsletter at elektormagazine.com/ezine-24 LUCKY YOU! An e-zine subscriber never misses the monthly 'reverse project' GET FREE DOWNLOADDEVELOPER ZONE The MCU obviously requires a separate power supply that is independent of the EN input; due to the low-energy requirement, a linear regulator is the most economical solution here. In general, the concept is completely component-agnostic; the author likes to use modern PIC16F derivatives from Microchip. Figure 2 shows the sub-circuit that informs the PIC when the SBC (OPI = Orange Pi) is supplied by the external switching regulator (EXT). D1a, R9 and D7a implement a more or less "classic" attenuator, which breaks down input voltages in the range of up to 20 V to a value that is "manageable" for the inputs of process computer and microcontroller. Splitting the series resistor into the values R7 and R9 is necessary because single board computers sometimes become a low-impedance load or have a residual voltage when they are switched off — without the resistor, this Single-board computers with Unix capability facilitate the development of complex control systems. Especially in scenarios with high demands on GUI and data processing, they are superior to microcontrollers (MCUs). Unfortunately, power consumption and real-time capability leave some room for improvement. But why not combine the best of both worlds? If you want to trim an off-the-shelf single-board computer to be economical, you can achieve this with an eight-bitter as a partner. As an example, we want to implement a system that adheres to programmed downtimes and carries out an "alarm start" in response to a specific external event. The Circuit Concept In principle, the circuit works as shown in the flowchart (Figure 1). The voltage regulator acting as the main supply for the process computer (usually a switching regulator) is controlled by the microcontroller via its Enable input (EN). By Tam Hanna (Hungary) Raspberry Pis and other SBCs are ideal for sophisticated process control, but require significantly more power than microcontrollers. Why not combine the best of both worlds? Here we show you how to get an 8-bit PIC to switch on a Raspberry Pi whenever it is needed. 8-Bit Companion for the Raspberry Pi Power Saving Made Easy Figure 1: This circuit design significantly reduces energy consumption in stand-by mode. Figure 2: The R7 resistor can save both costs and headaches. 240210-002 PIC GND OPI EXT D7a BZX84C2V7-TP C13 100n D1a BAS21 R9 4k7 R7 1k R8 10 Bonus Edition January & February 2025 www.elektormagazine.com 100kwould cause the power management microcontroller (connected via the PIC terminal) to see strange or invalid values. R7 is an additional protective element — the inputs of the process computer are connected to the supply voltage and ground via protective diodes. When very high voltage levels occur, R7 ensures that the current flowing into these diodes is limited and the process computer is not damaged — C13 and R8 provide a small additional debouncing function. It should be noted that the circuit shown here with its EXT input was connected "directly" to the vehicle electrical system in various school buses. As there are now several thousands of such systems on the market without failures, it has been proven to work. The role of diode D1a as reverse polarity protection is also helpful — please believe the author, who also works in the logistics sector, that connecting batteries the wrong way round is one of the classic "sports" of a mechanic. The Software Is the Key Communication via I2C is generally unproblematic (but don't forget the necessary pull-ups). The "secret" of this system lies in the software. The PIC implements a kind of state machine that is based on the states shown in Figure 3. The implementation of the shutdown process is of particular importance. Unixoid operating systems tend not to react very kindly to rough shutdowns. A convenient and practical way to solve the problem is to implement a countdown timer: The SBC activates this countdown and then starts the shutdown of the operating system. After the (generously dimensioned) period of time has elapsed, the process computer is "inertialized" and can be disconnected from the power supply. Of course, the PIC can also perform other tasks. In addition to storing serial numbers and other information (in order to make it harder to manipulate), it is also possible, for example, to perform basic control tasks on the PIC. Of course, more complex implementations are also possible: A complex MSR task, for example, would make a 32-bit MCU appear reasonable as the second ary controller. Practical Experience Trackers based on the circuit concept shown here are now being used in tens of thousands by one of the author's customers, demonstrating the practical value of the design. Instead of a stand-by power consumption of around 200 mA, the system now gets by with just a few milliamperes. The author's AN4121, published by Microchip, is available at [1] and provides further information on the topic. Translated by Jörg Starkmuth — 240210-01 Questions or Comments? Do you have questions or comments about this article? Email the author at tamhan@tamoggemon.com or contact Elektor at editor@elektor.com. Figure 3: Also helpful in the embedded sector: the state machine. [1] Usha Ganesh and Tam Hanna, "Using PIC16F Microcontrollers for System Power Supply Control," Microchip Application Note AN4121, 2021: https://www.microchip.com/en-us/application-notes/an4121 WEB LINK About the Author Ing. Tam Hanna has been working with electronics, computers, and software for more than 20 years; he is a freelance developer, book author, and journalist (www.instagram.com/tam.hanna). In his spare time, Tam's interests include 3D printing and the distribution of cigars. January & February 2025 11DEVELOPER'S ZONE installation on the roof or engage in energy sharing with the owner of an installation at another location. For a communal installation, you need a two-thirds majority of the co-owners, good luck with that, I would say; as a tenant, you should try to convince your landlord eventually. And regarding energy sharing, that is hardly appealing because it is complex, cumbersome and above all expensive. It is possible to have a small PV installation in Belgium, but you have to follow the same procedures as for traditional larger installations. With a "fixed connection to a separate group in the distribution cabinet, the necessary inspections and bureaucracy, the costs rise considerably, and your profits melt like snow in the sun. However, there is light at the end of the tunnel and from May 2025, plug-in solar panels would — "finally — be allowed in Belgium after all. The question, of course, is how strict the conditions and modalities will be. With a bit of bad luck, you will have to be able to present an inspection report of your electrical installation, and you run the risk of having a "smart" meter shoved down your throat. Belgians are rather risk-avoiding, and this is also reflected at the policy and regulatory level. In my opinion, it would be better to ban extension cords with a power strip, electric bikes, electric scooters and hover boards. These have been in the news several times in the context of house "res and with the last two devices, you can have serious accidents too. I was reminded of this after last summer's commotion around a well-known Belgian DIY store that had offered plug-in solar panels with the best of intentions but had to remove them from its shelves again, to its shame. Speed Camera While in neighbouring countries "plug-in solar panels" have been used trouble-free for years (Figure 1), a Belgian user organization and sector federation for renewable energy ODE — apart from the fact that it is forbidden — seem to be particularly disliking of balcony PV installations [3]. According to them, these are potentially unsafe, which may have a short lifespan, and hardly financially interesting. They have a clear preference for larger PV installations, including for flat dwellers. The latter should just install a communal By Ilse Joostens (Belgium) I have read with interest the Elektor articles from 2021 and 2024 on balcony PV installations by Dr. Thomas Scherer [1] [2], and I am entirely convinced by the idea of covering your home's "quiescent power consumption" with solar energy. In Germany, you even get a subsidy for this; but unfortunately, I live in Belgium where this kind of installation is strictly forbidden by Synergrid technical regulation C10/11 due to — alleged — "re and electrocution danger. From Life's Experience Micromanagement Source: Adobe Stock / EtiAmmos. developer's zone 12 Bonus Edition January & February 2025 www.elektormagazine.com Tips & Tricks, Best Practices and Other Useful InformationDEVELOPER'S ZONE heating systems and which car we drive. Similarly, the sale of numerous "hazardous" substances to individuals has been restricted. Even lead-based solder is becoming harder and harder to "nd, and there are already suppliers in Europe that no longer sell this stuff to individuals because it contains lead. Just imagine working on older electronic equipment for the hobby. This kind of micromanagement also curtails entrepreneurship because many companies start small, perhaps as a few students who have discovered a gap in the market and are working on a product in a garage (Figure 2). Even giants like Microsoft, Google [6], HP and Amazon once started this way [7]. The website "Nanny State Index" [8] charts the patronization by various governments when it comes to eating, drinking, smoking, and vaping and, as far as I am concerned, may be expanded to include more criteria. I dare to plead for less interference, fewer and clearer regulations and, above all, more juridical certainty. Nobody can be against that. Translated by Hans Adams — 240608-01 Politicians usually have a legal background and within that education one apparently sees no point in ill-considered ad hoc legislation. They just act according to the delusion of the day or based on flash politics, resulting in unclear "flip-flop legislation." Premiums for electric cars have already been introduced and abolished twice, and because of twists and turns in the law, users of electric company cars who charge them at home will soon be allowed to pay a lot more taxes. Belgium does not have a monopoly on absurdities, and in the Netherlands I hear rumours about grid operators secretly increasing the voltage taps on district transformers to limit feed-in from solar panels. In Zeeland, an experiment has even started where homeowners are asked to switch off their solar panels on sunny days for a fee. It shouldn't get any crazier after years of pushing people to install solar panels anyway. Patronizing The government is increasingly interfering in all aspects of our lives, and unfortunately this goes beyond energy, our home, That smart meter hasn't been out of the news recently, "rst because of the virtual rollback or not for solar panel owners and later in the context of the introduction of the capacity tariff . With that tariff , your smart meter becomes more like a speed camera that mercilessly charges you every time you have a few too many devices powered on at once in a moment of inattention. And the regulation on the roll-back counter, from which owners with solar panels could benefit for another 15 years, was rejected by the Constitutional Court in 2021 because the Flemish government had gone beyond its authority. After "erce protests, the same government was obliged to compensate the duped owners of solar panels. Flipflop You will no doubt be familiar with mathematician and computer scientist Edsger Dijkstra [4] who took issue with the excessive use of goto instructions in higher programming languages [5]. During my training, the ban on goto instructions was enforced to avoid an untidy "spaghetti code." [1] Dr. Thomas Scherer, "Balcony Power Plant," Elektor 9-10/2021: https://www.elektormagazine.com/magazine/elektor-183/59831 [2] Dr. Thomas Scherer, "Optimizing Balcony Power Plants," Elektor 1-2/2024: https://www.elektormagazine.com/magazine/elektor-324/62631 [3] VRT nws: Are solar panels on your balcony a good idea?: https://www.vrt.be/vrtnws/en/2022/10/18/are-solar-panels-on-your-balcony-a-good-idea/ [4] Wikipedia: Edsger Dijkstra: https://en.wikipedia.org/wiki/Edsger_W._Dijkstra [5] Mathematics & Computer Science Centre: Edsger Dijkstra: Go To Statement Considered Harmful: https://homepages.cwi.nl/~storm/teaching/reader/Dijkstra68.pdf [6] Inside Google's original garage, 1998-style: https://blog.google/products/maps/inside-googles-original-garage-1998-style/ [7] Business Pundit: 11 famous garage startups that now rule the world: https://www.businesspundit.com/11-famous-garage-startups-that-rule-the-world/ [8] The Nanny State Index: https://nannystateindex.org/ WEB LINKS Figure 2: Even large companies once started small. Source: Adobe Stock / Gorodenkoff . Figure 1: Balcony PV power plant — banned in one country, subsidized in another. Source: Adobe Stock / Ronald Rampsch. January & February 2025 13PECULIAR THE SERIES Rectifiers — those are like diodes, right? Well, yes. But these are not the kind of diodes you'd use in your crystal radio. Or even for your Raspberry Pi power supply. Or even for that super-duper 200 W per channel amplifier you've been building. Think electric trains, subway systems, broadcast transmitters. BIG stuff . As Crocodile Dundee might say, "That's not a rectifier, THIS is a rectifier!" Liquid Mercury Mercury-Arc rectifiers make use of the fact that if a pool of liquid mercury with some mercury vapor is used as a cathode, an arc can be drawn from a carbon anode above it, but the process does not work the other way around. Hence, rectification. This is sufficiently electronic to justify their inclusion in this column, even though they're not the kind of component that's ever been used in an Elektor project. Mercury-arc rectifiers were invented in 1902 by Peter Cooper Hewitt, an American electrical engineer who had invented mercury vapor lamps (the forerunners of our fluorescent lamps) in 1901. They were developed in the early 1900s and rapidly became the go-to solution for high-voltage, high current rectification. The arc voltage is around 20…30 V, and the simplicity of their construction makes them efficient and reliable. They were used up to the 1970s, when semiconductor rectifiers and thyristors that were up to the same job became available. Some were used until 2012. A typical 6-phase rectifier operating is shown in Figure 1. Mercury Rectifiers By David Ashton (Australia) Before the advent of high-power semiconductor-based rectifiers, transforming alternating current to DC in industrial and transportation fields was no mean task! The devices were huge, fragile, contained highly polluting materials, and required frequent maintenance. Figure 1: A 6-phase, high-power mercury-arc rectifying tube at work. (Source: Wikimedia Commons, https://commons.wikimedia.org/wiki/ File:Quecksilberdampfgleichrichter_in_Betrieb.JPG) Ignitor Electrode Ignition has to be started by an ignitor electrode, which usually has to briefly come into contact with the mercury. This is done by a number of means, including electromagnets, bimetallic strips, etc. Once the arc has been struck to cause mercury vapor to form, rectification can take place. Most mercury-arc rectifiers were 3 or 6-phase, but single-phase rectifiers needed an excitation electrode to keep the process going. The whole assembly is built within a large glass bulb, which allows the 14 Bonus Edition January & February 2025 www.elektormagazine.comFigure 2: Functional schematic of a mercury-arc rectifying tube (Source: Wikimedia commons, https://commons.wikimedia.org/w/index. php?curid=4577899) mercury vapor to condense and flow back to the cathode pool. The construction of a typical rectifier is shown in Figure 2. A typical 6-phase, 150 A rectifier was around 600 mm tall and about 300 mm round. Above 500 A steel tanks were used with ceramic insulators for the electrodes, and these were rated up to several thousand amps. Ratings up to several kV were available, higher with special construction techniques, but these required frequent maintenance. The mercury arcs emit a lot of ultraviolet light, you could get sunburned while working around them. Additionally, the noise from them and the associated transformers was considerable. Mercury is highly toxic and extensive clean-up work is often needed to remove traces of mercury when decommissioning them. 240624-01 Questions or Comments? If you have technical questions or comments about this article, feel free to contact the Elektor editorial team by email at editor@elektor.com. About the Author David Ashton was born in London, grew up in Rhodesia (now Zimbabwe), lived and worked in Zimbabwe, and now lives in Australia. He has been interested in electronics since he was "knee-high to a grasshopper." Rhodesia was not the center of the electronics universe, so adapting, substituting, and scrounging components were skills he acquired early (and still prides himself on). He has run an electronics lab, but has worked mainly in telecommunications. They trust us, do you? We love electronics and projects, and we do our utmost to fulfill the needs of our customers. The Elektor Store: 'Never Expensive, Always Surprising!' Check out more reviews on our Trustpilot page: www.elektor.com/TP/en Or make up your own mind by visiting our Elektor Store, www.elektor.com January & February 2025 15 elektor.comPower and Energy Elektor infographic Smart Grids: Enabling the Energy Transition Solar Energy: Innovations Shaping the Future The global solar energy market is on a positive growth trajectory as the solar energy industry is in a constant state of evolution. By 2030, installed renewable electricity generation capacity under the IRENA 1.5°C Scenario (see textbox on next page) is expected to more than double, with solar PV contributing 49% of the total capacity compared to 40% in 2023 [1]. This translates to an increase from 4,085 GW in 2023 to 11,173 GW by 2030, driven by annual additions averaging 558 GW per year. Challenges and Opportunities Achieving the 2030 targets will require robust innovation and investment. The solar sector's ability to sustain its current momentum hinges on continued advancements in technologies like bifacial panels, floating solar farms, and AI-optimized energy systems. These innovations will enhance efficiency and integration, ensuring solar's key role in a clean energy future. > Perovskite Solar Cells: These affordable and efficient alternatives to silicon cells are transforming solar accessibility. Lab efficiencies of up to 25% suggest they could become a cornerstone of future solar technologies. > Transparent Solar Panels: Integrating photovoltaics into windows offers a revolutionary way to harvest energy without compromising aesthetics. Early-stage transparent panels are achieving efficiencies around 10%. > Floating Solar Farms: By utilizing water surfaces, floating solar farms optimize land use while benefiting from natural cooling, which enhances panel efficiency. > AI-Optimized Energy Systems: AI is transforming solar operations, helping precise energy prediction, smarter grid integration, and real-time optimization. > Solar Skins: Customizable appearances for solar panels allow ideal integration into residential and commercial designs, addressing aesthetic concerns [5]. Global Solar Market: A Bright Outlook to 2030 Source: SolarPower Europe (2024), IRENA (2024) Source: Bartz/Stockmar (M), CC BY 4.0 Global Installed Renewable Electricity Generation Capacity in the 1.5°C Scenario, 2023 and 2030 [1]. • Solar PV • Hydro • Wind • Other RE 2023 4,085 GW 2030 11,173 GW 40% 25% 4% 6% 31% 13% 49% 32% Yesterday few large power plants production market transmission distribution consumer centralized, mostly national based on large power lines and pipelines top to bottom passive, only paying Tomorrow many small power producers decentralized, ignoring boundaries including small-scale transmission and regional supply compensation both directions active, participating in the system 16 Bonus Edition January & February 2025 www.elektormagazine.com[1] SolarPower Europe, "Global Market Outlook," June 2024: https://tinyurl.com/solar-outlook-2024 [2] IRENA, "World Energy Transitions Outlook 2024: 1.5°C Pathway," November 2024: https://www.irena.org/Publications/2024/Nov/World-Energy-Transitions-Outlook-2024 [3] IRENA, Hydrogen: https://www.irena.org/Energy-Transition/Technology/Hydrogen [4] Zurich, "How blue and green hydrogen can help solve the climate crisis," July 2024: https://www.zurich.com/media/magazine/2022/is-hydrogen-the-fuel-that-can-save-our-planet [5] Tamesol, "The Future of Solar Energy," January 2024: https://tamesol.com/future-of-solar-energy/ WEB LINKS 240640-01 Green hydrogen production, conversion, and end uses. [3] Another critical enabler has emerged for sectors that are challenging to electrify, such as heavy industry and long-haul transport, and that one is hydrogen. According to IRENA, hydrogen could fulfill 12% of global energy demand under the 1.5°C Scenario [3], with applications spanning transport, power generation, and heating. However, its production methods vary widely in environmental impact, earning the labels grey, blue, and green depending on the CO2 emissions involved. Currently, 96% of global hydrogen production relies on fossil fuels (grey hydrogen), underscoring the need for a rapid transition to cleaner methods [4]. The high costs of production for green hydrogen, and substantial energy losses during production, storage, and conversion make it less efficient than alternatives like batteries, while increasing blue hydrogen depends on costly carbon capture technologies. Hydrogen: Main Ingredient for Decarbonization 12% of global energy demand could be fulfilled by hydrogen under the 1.5°C Scenario. 96% of current share of hydrogen is produced from fossil fuels (grey hydrogen). What Is IRENA's 1.5°C Scenario? IRENA stands for the International Renewable Energy Agency, an intergovernmental organization that promotes the adoption and sustainable use of renewable energy worldwide. The IRENA 1.5°C Scenario in the World Energy Transitions Outlook presents a pathway to achieve the 1.5°C climate target by 2050 [2]. Achieving this target requires substantial investments in clean energy technologies, such as solar, wind, and storage, to decarbonize global energy systems. PRODUCTION TRANSFORMATION TRANSPORT END USE Renewable energy Electrolysis Shipping Trucks Pipeline Storage Sustainable CO2 capture Synthetic Fuels* TRANSFORMATION NO TRANSFORMATION Green ammonia + H2 H2 H2 INDUSTRY H2 HEATING H2 POWER GENERATION H2 CO2 + H2 N2 NH2 TRANSPORT H2 NH2 Chemical industry Shipping Refineries Trucks Aviation Cars Rail Buses Steel industry January & February 2025 17This design addresses the need to monitor service interruptions, whether caused by technical issues — such as infrastructure maintenance — or by malicious intruders tampering with the external meter switch to disconnect the power supply. Such an action could deplete the alarm system's backup batteries, leaving the home vulnerable. Triggering an alarm as soon as a disconnection is detected enhances overall home security. To prevent unnecessary activations, a delay (or tolerance) time of a few seconds has been implemented. This helps avoid false alarms caused by brief interruptions. In addition to the basic version (see Table 1), the digital version offers enhanced features: it tracks mains voltage drop events, allows adjustment of alarm and delay times, and automatically deactivates the signal once the preset alarm duration has elapsed. Furthermore, by configuring two DIP switches on the PCB, you can enable a beep function and a power-restoration notification. These additional features will be discussed in detail later. Differences Between the Analog and Digital Versions Analog Version As can be seen from the diagram in Figure 1, the power supply section has no transformer, which we will find in the digital version instead. Therefore, greater care must be taken during testing, since the whole circuit is connected to the mains voltage, with danger of electrocution in case of contact! In the case of the digital version, this danger is limited to the small part of the circuit connected to the primary of the transformer, which nevertheless requires a high level of attention during the testing phases! After the AC rectification and 24 V DC limiting section, consisting of diodes D1…D4 diodes and Zener diode D5, we note the split of that voltage source into two leads. One heads to the D6-C2 series, the other goes to the base of Q1. The D6-C2 series network produces a stabilized PROJECT By Stefano Purchiaroni (Italy) In areas where mains power is unstable and/or there may be safety issues, it may be useful to have a circuit that constantly monitors its presence and signals the outages in a timely manner to an external system. In this article, two design solutions are presented: one basic analog and a digital, microcontroller-based version, to monitor the presence of the power grid voltage at home and also perform the outages count. Mains Power Outages Monitor Is Your Grid Supply Steadily Available? Table 1: Available Functions in analog and digital Version. Function Analog Digital Delay (tolerance time) against short interruptions × × Delay time adjustment - × Alarm stop after a preset time - × Alarm time adjustment - × Counting and display of outages number - × Selectable pulse or permanent activation × × Signaling of mains power return - × 18 Bonus Edition January & February 2025 www.elektormagazine.comwill have to be implemented downstream of the circuit, or it must be part of the siren or other controlled device of choice. In addition to permanent signaling, the Pulse Mode of about 2 s can be selected through the other position of switch SW1 (closed contacts 5-2 and 4-3). In the absence of mains voltage, C3 gradually discharges, reducing the voltage across the base of Q1 until it is brought into conduction. Q1 thus lets current flow from C2 to the relay, passing through C4. The relay is energized, activating the alarm. After about half a second, C4 is fully charged, reducing the current flow on the relay coil until the relay is de-energized, approximately 2 s later. The values of the capacitors and resistors are already calculated to make sure that the charge of C2 can sustain the whole cycle. When the power returns, Q1 will go off again, the relay will not change its state, and C2 will be charged once more and will be able to support new cycles. Note the important function of diode D6 in this mode, which acts as a "check valve" preventing the base of Q1 from remaining high due to the accumulated charge in C2, and the relay from staying off . Digital Version The digital version's greater complexity is immediately apparent from the schematic in Figure 2. The circuit is supplied through a transformer with a 6 V output, which feeds two rectifier bridges, BR1 and BR2. The latter, followed by the stabilization section — consisting of C3, a small, 5 V linear voltage regulator U1 and C4 at the output — provides power for microcontroller U2, a versatile PIC16F1827 by Microchip. In the event of no mains voltage, 1.5 F supercapacitor C5 will continue to provide enough power to the PIC for a considerable time. Management of the supercapacitor is achieved by blocking diodes D2, D3 and D4, which isolate it during ordinary operation but ensure its charge. 23.3 V output, used to activate the relay via path 4-6 (steady mode) of the DPDT switch SW1. When the mains voltage fails, the relay returns to the off position, thus closing the COM-NC contact. Please note: In the circuit diagram, the relay is drawn in its de-energized state, which means the alarm is on. This is valid only when SW1 is in Steady Mode, in the position represented on the schematic. In the other position of the switch (4-3/5-2/Pulse Mode) the relay gets energized just for 1 to 2 seconds (which means then the alarm is on). When the mains voltage fails in Steady Mode, the alarm is activated with about a 3-to-4-second delay, due to the energy stored by the large electrolytic capacitor C2 being discharged. When power comes back on, the deactivation of the alarm will occur with about a 2 s delay, the time it takes C2 to charge and provide a high enough voltage to activate the relay again. Capacitor C5, initially discharged, allows the relay to be instantaneously activated at full voltage, but once charged, the current to keep it activated is supplied through R5, and reduced slightly, yet remaining at a level more than enough to hold the relay contacts in the closed position. This technique greatly extends the life of the relay, which remains slightly underpowered most of the time. The relay should be a DPDT type, with a 24 V coil and an internal resistance of 1,600 Ω. Any mains disconnection that lasts less than the delay time mentioned earlier will not produce an alarm activation, since C2 will not have discharged enough to drop the voltage supplied to the relay below its Vo" , measured experimentally at around 4 V. This delay avoids unnecessary alarms in case short interruptions might occur. In this analog version, the delay time is not adjustable. Another down side concerns the alarm time: Once C2 is discharged — and still no mains voltage is present at the input — the relay goes off permanently, leaving the alarm active indefinitely. Management of a maximum time 240559-003 RL1 24V Alarm Mains 0W5 1W 4x 1N4007 0W5 0W5 D3 D2 D1 D4 D5 24V R1 1M R2 820Ω C1 470n D6 1N4007 C2 2200µ 35V C3 100µ 35V C4 100µ 35V C5 100µ 35V R3 R4 4k7 R5 680Ω Q1 BC557 D7 5V1 D8 1N4148 J2 J1 SW1 6 3 4 5 1 2 Figure 1: Schematic of the mains power outage analog version. January & February 2025 19 18kThe interrupts then wake the microcontroller for program execution every second, basically to count the seconds elapsed and decide if it is time to act on the relay — comparing the second counter with the reading of the two resistive trimmers RV1 and RV2. A further reduction in power consumption is made possible by connecting the hot side of the two trimmers not directly to the supply voltage, but to digital output pin RA2, which will be set to logic high level only during the reading of the two trimmers, taken via analog inputs AN3 and AN4 (pin 2 and 3 of U1, RA3, and RA4, respectively). Mains voltage drop detection is done by the section starting at BR1, which has no high capacitance downstream, but is equipped with a circuit that generates 5.1 V when mains power is present. Note jumper JP1, provided for removing and reprogramming of the PIC without it being powered by the supercapacitor. To avoid excessive voltage drops, diodes D2 and D4 were chosen to be Schottky types, with a direct threshold voltage VDS as little as 0.2 V. This allows C5 to be charged up to 4.8 V, and to get 4.6 V for the backup power supply to the PIC, which has a minimum operating voltage of only 2.8 V for the chosen model. When the supercapacitor supplies the circuit, the reduction of the microcontroller's power consumption is achieved by software-enabling the "Nanowatt" mode, introduced by Microchip on most of its micro controllers. It sends the controller into a low-power state, where only the 32,768 Hz oscillator remains on, reactivating the code execution only at the interrupts coming from the timer associated with that oscillator. X1 = 26+] 240559-007 TOL ALM BKBP RESET OnOff Stat +V1 +V2 6(16(0W5 Mains W04G Alarm +V1 3V TP1 +V2 6(16(+V1 RA5/MCLR RA0 RA1 RA2 RA3 RA4 RA6 RA7 VSS VDD RB0 RB1 RB2 RB3 RB4 RB5 RB6 RB7 17 18 15 16 14 10 11 12 13 1 2 3 4 5 6 7 8 9 U1 U1 = PIC16F1827 C6 100n RV1 22k RV2 22k DSW1 SW1 C7 22p C8 22p X1 R5 D5 Yellow R7 D7 Red R9 D9 Green R6 4k7 Q1 BC547 R8 4k7 Q2 BC547 RL1 D8 1N4148 J2 BR2 W04G BR1 TR1 J1 R1 R2 1k R3 R4 22Ω C1 47µ 16V C2 100n C3 1000µ 16V C4 47µ 16V C5 15) 5V5 D1 5V1 U2 78L05 D4 SB140 D2 SB140 D3 1N4007 JP1 D6 1N4148 Figure 2: Schematic of the microcontroller-based, digital design. 20 Bonus Edition January & February 2025 www.elektormagazine.com 470Ω 470Ω 6V, 1VA5 22k 10k 470Ωvoid SetAlm() { // Activate the alarm and count the event in EEPROM // Activate the alarm ALMOFF=0; ALMON=1; delay_ms(RlyTim); ALMON=0; curs = 0; // Reset the second counter } The following interrupt() function constitutes the entry-point of the PIC's interrupt service routine, ISR. It is invoked by the interrupt generated by Timer1 when the second expires, even in low-power mode. An output is provided on the circuit board on test point TP1 to verify with a frequency meter or oscilloscope the operation of the oscillator. TP1's level toggles every second, producing a 0.5 Hz signal. The ground for the measurement is available on the respective GND-labeled test point. The main purpose of the interrupt procedure is to count the elapsed seconds using the 32-bit variable, curs. The interrupt for the next cycle is enabled again downstream of the function: void interrupt() { // Interrupt Service Routine. // It is called every second by Timer1 overflow. // --------- TMR1 --------- // Manage Timer1 overflow (each 1s) // to count seconds if (PIR1.TMR1IF == 1) { CLKOUT ^= 1; // Provide 0.5 Hz to Pin 1 // for checks curs++; // Update the current // second counter TMR1H = TMR1H_INI; // Reload counter high byte TMR1L = TMR1L_INI; // Reload counter low byte PIR1.TMR1IF = 0; // Clear TMR1 Interrupt flag } } After hardware setup and initialization of variables, main() function handles events according to the logic of a finite-state automaton. The current state of the automaton is set in the Mode variable. First, pressing on the SW1 button is verified, to reset the event counter and for restarting the microcontroller via the reset assembler instruction. At the first power-up with a blank microcontroller, and only then, it will be necessary to press the SW1 button to set the alarm count in EEPROM to zero. At the execution of setup(), following the button press, it will also be forced to turn o" the alarm control relay, in case (for any reason) it had remained active. In the event of an outage, the SENSE-tagged output voltage drops quickly, communicating the event to digital input pin RB1 (AN11), which interprets a voltage less than 0.8 V as a binary "0"; with the component values in this section, this threshold is reached about half a second after the mains voltage drop. By mounting optional resistor R3, this delay can be further reduced. Based on the high or low level of pin RB1, the management software activates the alarm, according to the settings of the two potentiome ters RV1 and RV2, which allow you to adjust the delay time between 0…10 s, and the alarm time from 0…2 min. As mentioned earlier, second-counting is handled by the PIC's internal low-power oscillator, fitted with the small external 32,768 Hz watch crystal, X1. Again, to minimize power consumption, the relay chosen is a bistable, 3 V, double-coil DPDT type. The two sets of contacts are connected in parallel to increase the current carrying capacity, which, however, may not exceed 5 A. The two turn-on and turn-o" coils are driven by Q1 and Q2 transistors, whose bases head to the PIC's RA6 and RA7 pins. The microcontroller will thus be able to turn the relay on and o" with short positive pulses on those pins. This chip is also connected to a dual DIP switch, which enables the two optional functions, Beep and Back. The former limits the alarm on to about one second, to provide a brief but intense warning to those in the house, for example, alert ing them to the voltage drop without disturbing the neighborhood. The Back function provides two short pulses to indicate the return of mains voltage. However, this function is limited by the maximum energy delivery time provided by supercapacitor C5, which is about a couple of hours. Finally, we note button SW1 and LED D5. The latter has the task of using short flashes to indicate the drop events that have occurred. If, for example, a power failure has occurred twice, D5 will cycle two flashes, followed by a pause of about 3 s. To reset the count, simply press the Reset button SW1. This switch also performs a full restart of the PIC, and a forced disable of the relay, which is useful in case of problems. The two LEDs, D7 and D9, indicate the output of the short command to enable and disable the relay, which, if not followed by the clicking sound of the relay, help to identify a failure of this electromechanical component. Software Let us focus on the main functions, SetAlm(), interrupt(), and main(). The SetAlm function shown below provides for the activa tion of the alarm device connected to J2 output terminals by direct pulses to the bistable relay. The persistence time of the pulse to the relay control coils is defined by the constant RlyTim, currently set to 200 ms. The coils head to pins RA6 and RA7 of the microcontroller, which energizes them through Q1 and Q2 transistors. January & February 2025 21 // the MCU is powered just by supercap! curs = 0; // Start seconds count STSLED = 0; // Force Ststus Led off Mode = Mode_TOL; // Enter the Tolerance Mode } break; In the Mode_TOL state handled by the following section, one of two possible events is awaited: the return of mains voltage before the delay time expires, to return again to the Mode_SBY state, or the overrun of that time. The condition to be met for the latter case is slightly complicated by the management of the optional Beep mode activated via the first of the two DIP switches. Depending on the state of this switch, either the ttol limit time defined first by the RV1 trimmer reading, or the MinTol time set by the initial code definitions, corresponding to 2 s, will be selected. Exceeding the limit time brings the automaton into the Mode_ALM state. The continuation of the code is always bound to the Timer1 interrupt, since it continues to operate in low-power mode: case Mode_TOL: // Waiting ttol time // before activating the alarm if (POWER == 1) { // Mains is back // before the alarm activation Mode = Mode_SBY; // Just go // back to Standby Mode } else { // Check end // of Tolerance time if (((BeepMode==FALSE)&&(curs>=ttol)) ||((BeepMode==TRUE)&&(curs>=MinTol))) { SetAlm(); // Start the // alarm, IncAlm(); // Increment // the alarms counter, Mode = Mode_ALM; // Enter in // the Alarm Mode } } break; This part handles the Mode_ALM state. It waits for the mains voltage to return, to reset the alarm and return to Standby by permanently exiting the low-power mode. Or one waits for the exhalation of the maximum alarm time, chosen from the talm value set by the analog reading of the RV2 trimmer, or from the MinAlm value preset to 1 s at the beginning of the program. It remains in low power in that case, to handle the return of the line voltage to the Mode_BACK state: case Mode_ALM: // Wait talm seconds before Alarm activation events are counted in the AlmCnt variable. Note that — in case the return of mains voltage is very late and the capacity to support operations provided by supercapacitor C5 is exceeded — in order not to lose the alarm count, the value of AlmCnt is saved in EEPROM. The setup() function requires it to be read again when the microcontroller is restarted: void main() { setup(); // Initialization while(1) { // Forever Loop if (Button(&PORTB,4,1,0)){ // Reset button pressed STSLED = 1; Delay_ms(500); STSLED = 0; AlmCnt = 0; EEPROM_Write(CNTADDR, AlmCnt); // Raz the Alarms counter in EEPROM curms = 0; // Raz the elapsed ms for Blink cycle BlkSts = 0; // Reset the Blink automaton {asm{reset}}; // Reset the MCU // (the program will restart) } In the following excerpt, the voltages on the analog pins connected to the slider of the two resistive trimmers are read; they are dedicated to adjusting the delay and alarm times. The reading is made possible by activating the hot side of the two trimmers via the digital output pin RA2, referred to here as DIVPOW. Since the microcontroller has a 10-bit A/D converter, the two readings will consist of a value between 0 and 1,023, between limits defined by configurable parameters that by default limit the delay time to between 0…10 seconds, and the alarm time to between 0…2 minutes. In default state Mode_SBY, managed by the block that follows, the automaton waits for the mains voltage drop event, communicated by the SENSE line through pin RB1 (AN11) referred to here using the POWER definition. If it goes to logic level 0, then second-counting will start, setting the PIC to low-power mode. Please keep in mind that from then on, power is provided solely by supercapacitor C5. The new state is Mode_TOL: // Automaton switch (Mode) { case Mode_SBY: // Nominal Mode. // Wait for a Power Down event if (POWER == 0) { // The Main power gone down, 22 Bonus Edition January & February 2025 www.elektormagazine.com if (((BeepMode==FALSE)&&(curs>=talm)) || ((BeepMode==TRUE)&&(curs>=MinAlm))) { ResetAlm(); // Suspend the alarm Mode = Mode_BACK; // Wait for the // Power Up event } } break; // to stop the alarm if (POWER == 1) { // Mains is back during Alarm ResetAlm(); // Stop the alarm if (BackMode==TRUE) Signal(); // Signal "Mains is back" if requested Mode = Mode_SBY; // Manage the Power Up event } else { // Check end of Alarm time Listing 1: Main Blink Sequence and Mains Monitoring Routine. // On power presence, signal the occurred alarms (one blink per each alarm) if ((POWER == 1) && (AlmCnt > 0)) { switch (BlkSts) { case 0: // Initialize a new Blinks cycle n = AlmCnt; STSLED=1; curms = 0; // Start ms counting BlkSts = 1; // Go to "Wait to turn off the LED" break; case 1: // Wait CNTBLINK ms to turn off the LED if (curms >= CNTBLINK) { STSLED=0; n--; // Decrement residual Blinks counter curms = 0; // Start ms counting if (n > 0) BlkSts = 2; // Go to "Wait to turn on the LED" else BlkSts = 3; // Go to "Wait for next Blinks cycle" } break; case 2: // Wait CNTBLINK ms to turn on the LED if (curms >= CNTBLINK) { STSLED=1; curms = 0; // Start ms counting BlkSts = 1; // Go to "Wait to turn off the LED" } break; case 3: // Wait CNTINTERV for next Blinks cycle if (curms >= CNTINTERV) { curms = 0; // Start ms counting BlkSts = 0; // Initialize a new cycle } break; } if (BlkSts > 0) curms += TIC; // Increment the elapsed time counter (ms) } #ifdef LOWPOW // If no external power is present, go in Low Power Mode if (POWER == 0) {asm{sleep};} // Sleep. Awake on Timer1 interrupt. #endif Delay_ms(TIC); // Introduce a cycle delay January & February 2025 23The 1.5 F supercapacitor is a special component, but nevertheless readily available. In this version, the alarm output is provided via a three-way terminal, which allows the user to choose NC or NO activa tion type, depending on the intended use. This is not possible in the analog version, due to circuit limitations. The digital version thus o" ers greater versatility and ease of use than the analog one, thanks to the ability to configure the alarm output according to one's needs. However, the analog version retains a struc tural simplicity that may be advantageous in some specific applica tions. The choice between the two versions will therefore depend on the user's needs and the features of the signaling system to which the device will be connected. 240559-01 Questions or Comments? Do you have technical questions or comments about this article? You may write to the author at info@purchiaroni.com or to Elektor's editorial team at editor@elektor.com. About the Author Passionate about electronics and programming, Stefano Purchiaroni shares his works by publishing projects, and also o" ers free robotics lessons for teens at a popular school. He is currently employed in Telespazio and works in a satellite center near the Italian capital. Related Product > OWON XDM1141 Multimeter www.elektor.com/20671 In Mode_BACK, it waits for the mains voltage to return and signals the event by triggering the alarm for two short consecutive pulses if provided by the Back DIP switch. Until the grid returns, the PIC is left in low-power mode: case Mode_BACK: // Waiting for the mains power // to come back again if (POWER == 1) { // Mains // is back: exit to Standby mode ResetAlm(); // Force // alarm off if (BackMode==TRUE) Signal(); // Signal "Mains is back" if requested Mode = Mode_SBY; } break; After the main automaton, a second four-state automaton was imple mented just to manage D5 connected to RA0. This LED is intended to show the current count of voltage drop events of duration longer than the delay time. The AlmCnt counter is reset table by pressing SW1, managed in the first lines of code of the main cycle, seen above. The handling of flashes by an automaton is dictated by the need to not interrupt the main cycle with simple delays, which would block any other actions during their execution. Flashing times are defined by the constants CNTBLINK set to 200 ms, and CNTINTERV, which defines the pause between two blocks of flashes, set to 3 s (Listing 1). Printed Circuit Boards For both the analog and digital versions, two single-sided, jumperless printed circuit boards have been designed. This will undoubtedly facil itate their creation using the classic methods of photoengraving, or hot transfer. You can download the Gerber files needed for DIY from the Elektor Labs page for this article [1]. Assembly In the analog version shown in the assembly plan, the SW1 switch for mode selection is wired to a six-way connector on the printed circuit board. You can connect a lever switch to it, or any DPDT switch. The digital version of the device, which can be seen in the mounting plan, involves socket-mounting the microcontroller, two miniature-type trimmers, a two-way dip-switch, and a jumper. [1] Elektor Labs page for this article: https://elektormagazine.com/labs/mains-power-outages-monitor WEB LINK 24 Bonus Edition January & February 2025 www.elektormagazine.comlektorstore www.elektor.com www.elektor.com/21074 FNIRSI GC-02 Nuclear Radiation Detector (Geiger Counter) M5Stamp Fly Quadcopter (with M5StampS3) www.elektor.com/21014 www.elektor.com/21046 www.elektor.com/21008 Price: €104.95 Douk Audio P6 mini Tube Preamplifier Elevate your audio experience with the Douk Audio P6 mini Tube Preamplifier, a perfect blend of modern connectivity, HiFi sound quality, and vintage charm. Whether you're an audiophile or just starting your journey into high-quality audio, this compact yet powerful preamp offers everything you need. Raspberry Pi 500 (US) The Raspberry Pi 500 (based on the Raspberry Pi 5) features a quad-core 64-bit Arm processor, RP1 I/O controller, 8 GB RAM, wireless networking, dual display output, 4K video playback, and a 40-pin GPIO header. It's a powerful, compact all-in-one computer built into a portable keyboard. Price: €74.95 Special Price: €59.95 Price: €49.95 Member Price: €44.96 Price: €79.95 Member Price: €71.96 January & February 2025 25www.elektormagazine.com/member Also available The Elektor web archive from 1974! 8x Elektor Magazine (print) 8x Elektor Magazine (digital) 10% discount in our web shop and exclusive off ers Access to more than 5,000 Gerber fi les The Digital membership! Join the Elektor C mmunity Take out a membership! The Elektor web archive from 1974! 8x Elektor Magazine (digital) 10% discount in our web shop and exclusive off ers Access to more than 5,000 Gerber fi les 10% discount in our web shop and exclusive off ers GOLD membership membership GREEN Power Electronics & Energy Interested in power electronics and energy-related technologies? 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____________________________________ · · Badge Enable reliable messaging for Big Data applications using Azure Event Hubs Completed on 11/20/2023 · ____________________________________ · · Badge Communicate between applications with Azure Queue storage Completed on 11/20/2023 · ____________________________________ · · Badge Work with Azure Blob storage Completed on 11/20/2023 · ____________________________________ · · Badge Manage the Azure Blob storage lifecycle Completed on 11/20/2023 · ____________________________________ · · Badge Explore Azure Blob storage Completed on 11/20/2023 · ____________________________________ · · Badge Explore Azure App Service deployment slots Completed on 11/20/2023 · ____________________________________ · · Badge Scale apps in Azure App Service Completed on 11/20/2023 · ____________________________________ · · Badge Configure web app settings Completed on 11/20/2023 · ____________________________________ · · Badge Explore Azure App Service Completed on 11/20/2023 · ____________________________________ · · Badge Design a solution for backup and disaster recovery Completed on 11/19/2023 · ____________________________________ · · Badge

Describe high availability and disaster recovery strategies Completed on 11/19/2023 · ________ · · Badge Implement canary releases and dark launching Completed on 11/19/2023 · ________ · · Badge Implement blue-green deployment and feature toggles Completed on 11/19/2023 · ________ · · Badge Introduction to deployment patterns Completed on 11/19/2023 · ________ · · Badge Manage application configuration data Completed on 11/19/2023 · ________ · · Badge Integrate with identity management systems Completed on 11/19/2023 · ________ · · Badge Implement A/B testing and progressive exposure deployment Completed on 11/19/2023 · ________ · · Badge Manage alerts, blameless retrospectives and a just culture Completed on 11/19/2023 · ________ · · Badge Design processes to automate application analytics Completed on 11/19/2023 · ________ · · Badge Share knowledge within teams Completed on 11/19/2023 · ________ · · Badge Develop monitor and status dashboards Completed on 11/19/2023 · ________ · · Badge Implement tools to track usage and flow Completed on 11/19/2023 · ________ · · Badge Manage Git repositories Completed on 11/19/2023 · ________ · · Badge Plan foster inner source Completed on 11/19/2023 · ________ · · Badge Explore Git hooks Completed on 11/19/2023 · ________ · · Badge Identify technical debt Completed on 11/19/2023 · ________ · · Badge Collaborate with pull requests in Azure Repos Completed on 11/19/2023 · ________ · · Badge Manage Git branches and workflows Completed on 11/19/2023 · ________ · · Badge Structure your Git Repo Completed on 11/19/2023 · ________ · · Badge Introduction to data protection and privacy Completed on 11/19/2023 · ________ · · Badge Discover the potential of Azure for government Completed on 11/19/2023 · ________ · · Badge Support data classification with private and hybrid clouds Completed on 11/19/2023 · ________ · · Badge Safeguard public sector data with Azure Completed on 11/19/2023 · ________ · · Badge Describe the identity protection and governance capabilities of Microsoft Entra Completed on 11/19/2023 · ________ · · Badge Describe access management capabilities of Microsoft Entra ID Completed on 11/19/2023 · ________ · · Badge Describe the authentication capabilities of Microsoft Entra ID Completed on 11/19/2023 · ________ · · Badge Describe the function and identity types of Microsoft Entra ID Completed on 11/19/2023 · ________ · · Badge Describe identity concepts Completed on 11/19/2023 · ________ · · Badge Describe security and compliance concepts Completed on 11/19/2023 · ________ · · Badge Describe analytics capabilities of Microsoft 365 Completed on 11/19/2023 · ________ · · Badge Describe endpoint modernization, management concepts, and deployment options in Microsoft 365 Completed on 11/19/2023 · ________ · · Badge Describe collaboration solutions of Microsoft 365 Completed on 11/19/2023 · ________ · · Badge Describe productivity solutions of Microsoft 365 Completed on 11/19/2023 · ________ · · Badge What is Microsoft 365? Completed on 11/19/2023 · ________ · · Badge Use Azure AI Services for Language in a Microsoft Copilot Studio bot Completed on 11/19/2023 · ________ · · Badge Set up a Microsoft Copilot Studio bot for voice Completed on 11/19/2023 · ________ · · Badge Manage Power Virtual Agents Completed on 11/19/2023 · ________ · · Badge Build effective bots with Microsoft Copilot Studio Completed on 11/19/2023 · ________ · · Badge Enhance Microsoft Copilot Studio bots Completed on 11/19/2023 · ________ · · Badge Work with entities and variables in Microsoft Copilot Studio Completed on 11/19/2023 · ________ · · Badge Manage topics in Microsoft Copilot Studio Completed on 11/19/2023 · ________ · · Badge Get started with Microsoft Copilot Studio bots Completed on 11/19/2023 · ________ · · Badge Create calculation groups Completed on 11/19/2023 · ________ · · Badge Use DAX time intelligence functions in Power BI Desktop models Completed on 11/19/2023 · ________ · · Badge Create Power BI model relationships Completed on 11/19/2023 · ________ · · Badge Use tools to optimize Power BI performance Completed on 11/19/2023 · ________ · · Badge Enforce Power BI model security Completed on 11/19/2023 · ________ · · Badge Publish and share in Power BI Completed on 11/19/2023 · ________ · · Badge Explore data in Power BI Completed on 11/19/2023 · ________ · · Badge Use visuals in Power BI Completed on 11/19/2023 · ________ · · Badge Model data in Power BI Completed on 11/19/2023 · ________ · · Badge Get started building with Power BI Completed on 11/19/2023 · ________ · · Badge Discover data analysis Completed on 11/19/2023 · ________ · · Badge Operate a guide in Dynamics 365 Guides Completed on 11/19/2023 · ________ · · Badge Author a guide in Dynamics 365 Guides Completed on 11/19/2023 · ________ · · Badge Dynamics 365 Guides for administrators Completed on 11/19/2023 · ________ · · Badge Get started with Dynamics 365 Guides Completed on 11/19/2023 · ________ · · Badge Embed 21st century skills with 21st century learning design Completed on 11/19/2023 · ________ · · Badge Deepen educational experiences with the 21CLD ICT for learning dimension Completed on 11/19/2023 · ________ · · Badge Develop learner executive function with the 21CLD self-regulation dimension Completed on 11/19/2023 · ________ · · Badge Improve communication skills with the 21CLD skilled communication dimension Completed on 11/19/2023 · ________ · · Badge Innovate learning with the 21CLD real-world problem solving and innovation dimension Completed on 11/19/2023 · ________ · · Badge Practice collaborative skills with the 21CLD collaboration dimension Completed on 11/19/2023 · ________ · · Badge Develop critical thinking skills with the 21CLD knowledge construction dimension Completed on 11/19/2023 · ________ · · Badge Transform learning with 21st century learning design Completed on 11/19/2023 · ________ · · Badge Set up number series and trail codes in Dynamics 365 Business Central Completed on 11/18/2023 · ________ · · Badge Set up general ledger configuration options in Dynamics 365 Business Central Completed on 11/18/2023 · ________ · · Badge Set up inventory replenishment in Dynamics 365 Business Central Completed on 11/18/2023 · ________ · · Badge Plan items in Dynamics 365 Business Central Completed on 11/18/2023 · ________ · · Badge Set up inventory planning in Dynamics 365 Business Central Completed on 11/18/2023 · ________ · · Badge Demand Driven Material Requirements Planning in Dynamics 365 Supply Chain Management Completed on 11/18/2023 · ________ · · Badge Use master planning in Dynamics 365 Supply Chain Management Completed on 11/18/2023 · ________ · · Badge Set up Master Planning in Dynamics 365 Supply Chain Management Completed on 11/18/2023 · ________ · · Badge Create bill of materials in Dynamics 365 Supply Chain Management Completed on 11/18/2023 · ________ · · Badge Create products and product masters in Dynamics 365 Supply Chain Management Completed on 11/18/2023 · ________ · · Badge Use inventory reports in Dynamics 365 Supply Chain Management Completed on 11/18/2023 · ________ · · Badge Configure and work with inventory management in Dynamics 365 Supply Chain Management Completed on 11/18/2023 · ________ · · Badge Get started with Dynamics 365 Supply Chain Management Completed on 11/18/2023 · ________ · · Badge Introduction to scripting in PowerShell Completed on 11/18/2023 · ________ · · Badge Write your first PowerShell code Completed on 11/18/2023 · ________ · · Badge Connect commands into a pipeline Completed on 11/18/2023 · ________ · · Badge Discover commands in PowerShell Completed on 11/18/2023 · ________ · · Badge Introduction to PowerShell Completed on 11/18/2023 · ________ · · Badge Write your first program in C++ Completed on 11/18/2023 · ________ · · Badge Create a Bot with the Bot Framework Composer Completed on 11/17/2023 · ________ · · Badge Create a bot with the Bot Framework SDK Completed on 11/17/2023 · ________ · · Badge Deploy Azure AI services in containers Completed on 11/17/2023 · ________ · · Badge Monitor Azure AI services Completed on 11/17/2023 · ________ · · Badge Secure Azure AI services Completed on 11/17/2023 · ________ · · Badge Create and consume Azure AI services Completed on 11/17/2023 · ________ · · Badge Prepare to develop AI solutions on Azure Completed on 11/17/2023 · ________ · · Badge Understand the MySQL storage engine Completed on 11/17/2023 · ________ · · Badge Understand client-server communication in MySQL Completed on 11/17/2023 · ________ · · Badge Explore MySQL Architecture Completed on 11/17/2023 · ________ · · Badge Understand concurrency in MySQL Completed on 11/17/2023 · ________ · · Badge Secure MySQL Completed on 11/17/2023 · ________ · · Badge Beneath the surface: Device details for IT administrators Completed on 11/17/2023 · ________ · · Badge Analyze DevOps Continuous Planning and Continuous Integration Completed on 11/15/2023 · ________ · · Badge Route system feedback to development teams Completed on 11/15/2023 · ________ · · Badge Explain DevOps Continuous Delivery and Continuous Quality Completed on 11/15/2023 · ________ · · Badge Characterize DevOps Continuous Collaboration and Continuous Improvement Completed on 11/15/2023 · ________ · · Badge Introduce the foundation pillars of DevOps: Culture and Lean Product Completed on 11/15/2023 · ________ · · Badge Assess your existing software development process Completed on 11/15/2023 · ________ · · Badge Manage Agile software delivery plans across teams Completed on 11/15/2023 · ________ · · Badge Choose an Agile approach to software development Completed on 11/15/2023 · ________ · · Badge Introduction to Azure DevOps Completed on 11/15/2023 · ________ · · Badge Introduction to Git Completed on 11/15/2023 · ________ · · Badge Edit code through branching and merging in Git Completed on 11/15/2023 · ________ · · Badge Collaborate with Git Completed on 11/15/2023 · ________ · · Badge How to create and modify a Git project Completed on 11/15/2023 · ________ · · Badge Enhance creativity to advance learning with Windows 11 and Microsoft 365 tools Completed on 11/14/2023 · ________ · · Badge Increase productivity with Office, OneNote, and Edge browser in Windows 11 Completed on 11/14/2023 · ________ · · Badge Build community with Teams and OneNote Completed on 11/14/2023 · ________ · · Badge Transition to and prepare for fundamentals-level security, compliance, and identity course Completed on 11/14/2023 · ________ · · Badge Develop search strategies with Search Coach and Search Progress Completed on 11/14/2023 · ________ · · Badge Perform hyperparameter tuning with Azure Machine Learning Completed on 11/14/2023 · ________ · · Badge Track model training with MLflow in jobs Completed on 11/14/2023 · ________ · · Badge Run a training script as a command job in Azure Machine Learning Completed on 11/14/2023 · ________ · · Badge Deploy a model to a batch endpoint Completed on 11/14/2023 · ________ · · Badge Deploy a model to a managed online endpoint Completed on 11/14/2023 · ________ · · Badge Run pipelines in Azure Machine Learning Completed on 11/14/2023 · ________ · · Badge Find the best classification model with Automated Machine Learning Completed on 11/14/2023 · ________ · · Badge Make data available in Azure Machine Learning Completed on 11/14/2023 · ________ · · Badge Build a machine learning model Completed on 11/14/2023 · ________ · · Badge Data collection and manipulation Completed on 11/14/2023 · ________ · · Badge Introduction to rocket launches Completed on 11/14/2023 · ________ · · Badge Digital citizenship: Prepare today's learners for online success Completed on 11/14/2023 · ________ · · Badge Extract invoice data with AI Builder's prebuilt model Completed on 11/14/2023 · ________ · · Badge Automate the processing of documents with the AI Builder prepackaged solution Completed on 11/14/2023 · ________ · · Badge Manage models in AI Builder Completed on 11/14/2023 · ________ · · Badge Get started with AI Builder Completed on 11/14/2023 · ________ · · Badge Use text generation in AI Builder Completed on 11/14/2023 · ________ · · Badge Introduction to expressions in Power Automate Completed on 11/14/2023 · ________ · · Badge Upload, download, and manage data with Azure Storage Explorer Completed on 11/13/2023 · ________ · · Badge Control access to Azure Storage with shared access signatures Completed on 11/13/2023 · ________ · · Badge Configure Azure Storage with tools Completed on 11/13/2023 · ________ · · Badge Configure Azure Files and Azure File Sync Completed on 11/13/2023 · ________ · · Badge Configure Azure Storage security Completed on 11/13/2023 · ________ · · Badge Find commands and Get-Help in Windows PowerShell Completed on 11/13/2023 · ________ · · Badge Understand the command syntax in Windows PowerShell Completed on 11/13/2023 · ________ · · Badge Review Windows PowerShell Completed on 11/13/2023 · ________ · · Badge Manage mail flow rules Completed on 11/13/2023 · ________ · · Badge Troubleshoot mail flow Completed on 11/13/2023 · ________ · · Badge Manage mail flow Completed on 11/13/2023 · ________ · · Badge Troubleshoot audio, video, and client issues Completed on 11/13/2023 · ________ · · Badge Configure auto attendants and call queues Completed on 11/13/2023 · ________ · · Badge Configure and manage voice users Completed on 11/13/2023 · ________ · · Badge Configure and deploy Teams Phone Completed on 11/13/2023 · ________ · · Badge Plan for Teams Phone Completed on 11/13/2023 · ________ · · Badge Configure, deploy, and manage Teams devices Completed on 11/13/2023 · ________ · · Badge Plan for Microsoft Teams Rooms and Surface Hub Completed on 11/13/2023 · ________ · · Badge Manage meetings and events experiences Completed on 11/13/2023 · ________ · · Badge Introduction to Teams meetings and calling Completed on 11/13/2023 · ________ · · Badge Monitor your Microsoft Teams environment Completed on 11/13/2023 · ________ · · Badge Implement lifecycle management and governance for Microsoft Teams Completed on 11/13/2023 · ________ · · Badge Plan and deploy Microsoft Teams Completed on 11/13/2023 · ________ · · Badge Explore Microsoft Teams Completed on 11/13/2023 · ________ · · Badge Examine Azure Identity Protection Completed on 11/13/2023 · ________ · · Badge Examine Privileged Identity Management Completed on 11/13/2023 · ________ · · Badge Examine Microsoft Secure Score Completed on 11/13/2023 · ________ · · Badge Explore security solutions in Microsoft 365 Defender Completed on 11/13/2023 · ________ · · Badge Explore the Zero Trust security model Completed on 11/13/2023 · ________ · · Badge Examine threat vectors and data breaches Completed on 11/13/2023 · ________ · · Badge Use OneDrive in Microsoft 365 Completed on 11/13/2023 · ________ · · Badge Configure client connectivity to Microsoft 365 Completed on 11/13/2023 · ________ · · Badge Add a custom domain in Microsoft 365 Completed on 11/13/2023 · ________ · · Badge Manage groups in Microsoft 365 Completed on 11/13/2023 · ________ · · Badge Manage users, licenses, and mail contacts in Microsoft 365 Completed on 11/13/2023 · ________ · · Badge Configure your Microsoft 365 experience Completed on 11/13/2023 · ________ · · Badge Implement compliance for Microsoft Teams Completed on 11/13/2023 · ________ · · Badge Implement security for Microsoft Teams Completed on 11/13/2023 · ________ · · Badge Manage access for external users Completed on 11/13/2023 · ________ · · Badge Plan and configure network settings for Microsoft Teams Completed on 11/13/2023 · ________ · · Badge Support social and emotional learning with Microsoft tools Completed on 11/12/2023 · ________ · · Badge Keep students engaged: Build strong student/teacher connections in a remote learning environment Completed on 11/12/2023 · ________ · · Badge Stay connected with remote learning through Microsoft Teams and Office 365 Completed on 11/12/2023 · ________ · · Badge Hybrid learning in the primary classroom Completed on 11/12/2023 · ________ · · Badge Hybrid learning: A new model for the future of learning Completed on 11/12/2023 · ________ · · Badge Hybrid learning for the adolescent learner Completed on 11/12/2023 · ________ · · Badge Hybrid learning in the intermediate classroom Completed on 11/12/2023 · ________ · · Badge Accessibility, special education, and online learning: Supporting equity in a remote learning environment Completed on 11/12/2023 · ________ · · Badge Differentiation in the classroom using the built-in tools in Office 365 and Windows Completed on 11/12/2023 · ________ · · Badge Simplify cloud procurement and governance with Azure Marketplace Completed on 11/12/2023 · ________ · · Badge Design a program launch strategy Completed on 11/12/2023 · ________ · · Badge Prepare for a program approval event Completed on 11/12/2023 · ________ · · Badge Design degree program curricula that implement certification Completed on 11/12/2023 · ________ · · Badge Define academic and industry requirements for implementing certifications in degree programs Completed on 11/12/2023 · ________ · · Badge Work with data source limits (delegation limits) in a Power Apps canvas app Completed on 11/11/2023 · ________ · · Badge Work with relational data in a Power Apps canvas app Completed on 11/11/2023 · ________ · · Badge Use custom connectors in a Power Apps canvas app Completed on 11/11/2023 · ________ · · Badge Connect to other data in a Power Apps canvas app Completed on 11/11/2023 · ________ · · Badge Use and understand Controls in a canvas app in Power Apps Completed on 11/11/2023 · ________ · · Badge Document and test your Power Apps application Completed on 11/11/2023 · ________ · · Badge Build a mobile-optimized app from Power Apps Completed on 11/11/2023 · ________ · · Badge Manage apps in Power Apps Completed on 11/11/2023 · ________ · · Badge Navigation in a canvas app in Power Apps Completed on 11/11/2023 · ________ · · Badge How to build the UI in a canvas app in Power Apps Completed on 11/11/2023 · ________ · · Badge Customize a canvas app in Power Apps Completed on 11/11/2023 · ________ · · Badge Get started with Power Apps canvas apps Completed on 11/11/2023 · ________ · · Badge How to build your first model-driven app with Dataverse Completed on 11/11/2023 · ________ · · Badge Configure forms, charts, and dashboards in model-driven apps Completed on 11/11/2023 · ________ · · Badge Get started with model-driven apps in Power Apps Completed on 11/11/2023 · ________ · · Badge Create tables in Dataverse Completed on 11/11/2023 · ________ · · Badge Validation of Teams apps extensible across Microsoft 365 Completed on 11/10/2023 · ________ · · Badge Add significant value to your Teams app Completed on 11/10/2023 · ________ · · Badge Publish Teams apps in Microsoft Teams store Completed on 11/10/2023 · ________ · · Badge Azure Health Bot built-in scenarios Completed on 11/10/2023 · ________ · · Badge Language understanding in Azure Health Bot Completed on 11/10/2023 · ________ · · Badge Azure Health Bot case studies Completed on 11/10/2023 · ________ · · Badge Basic Azure Health Bot Completed on 11/10/2023 · ________ · · Badge Introduction to Azure Health Bot Completed on 11/10/2023 · ________ · · Badge Channelized Azure Health Bot Completed on 11/10/2023 · ________ · · Badge Integrate Azure Health Bot with a database Completed on 11/10/2023 · ________ · · Badge Enhanced Azure Health Bot Completed on 11/10/2023 · ________ · · Badge Azure Health Bot scenario templates Completed on 11/10/2023 · ________ · · Badge Deploy a customer service bot Completed on 11/10/2023 · ________ · · Badge Create a chatbot to help students learn geography Completed on 11/10/2023 · ________ · · Badge Introduction to responsible bots Completed on 11/10/2023 · ________ · · Badge Detect objects in images with Azure AI Custom Vision Completed on 11/10/2023 · ________ · · Badge Translate text and speech with Azure AI services Completed on 11/10/2023 · ________ · · Badge Classify images with Azure AI Custom Vision Completed on 11/10/2023 · ________ · · Badge Challenge project - Add image analysis and generation capabilities to your application Completed on 11/10/2023 · ________ · · Badge Challenge project - Work with variable data in C# Completed on 11/10/2023 · ________ · · Badge Guided project - Work with variable data in C# Completed on 11/10/2023 · ________ · · Badge Modify the content of strings using built-in string data type methods in C# Completed on 11/10/2023 · ________ · · Badge Format alphanumeric data for presentation in C# Completed on 11/10/2023 · ________ · · Badge Perform operations on arrays using helper methods in C# Completed on 11/10/2023 · ________ · · Badge Convert data types using casting and conversion techniques in C# Completed on 11/10/2023 · ________ · · Badge Choose the correct data type in your C# code Completed on 11/10/2023 · ________ · · Badge Challenge project - Create a mini-game Completed on 11/10/2023 · ________ · · Badge Guided project - Plan a Petting Zoo Visit Completed on 11/10/2023 · ________ · · Badge Create C# methods that return values Completed on 11/10/2023 · ________ · · Badge Create C# methods with parameters Completed on 11/10/2023 · ________ · · Badge Write your first C# method Completed on 11/10/2023 · ________ · · Badge Challenge project - Debug a C# console application using Visual Studio Code Completed on 11/10/2023 · ________ · · Badge Guided project - Debug and handle exceptions in a C# console application using Visual Studio Code Completed on 11/10/2023 · ________ · · Badge Create and throw exceptions in C# console applications Completed on 11/10/2023 · ________ · · Badge Implement exception handling in C# console applications Completed on 11/10/2023 · ________ · · Badge Implement the Visual Studio Code debugging tools for C# Completed on 11/10/2023 · ________ · · Badge Review the principles of code debugging and exception handling Completed on 11/10/2023 · ________ · · Badge Evaluate Boolean expressions to make decisions in C# Completed on 11/10/2023 · ________ · · Badge Challenge project - Develop branching and looping structures in C# Completed on 11/10/2023 · ________ · · Badge Guided project - Develop conditional branching and looping structures in C# Completed on 11/10/2023 · ________ · · Badge Add looping logic to your code using the do-while and while statements in C# Completed on 11/10/2023 · ________ · · Badge Iterate through a code block using for statement in C# Completed on 11/10/2023 · ________ · · Badge Control variable scope and logic using code blocks in C# Completed on 11/10/2023 · ________ · · Badge Branch the flow of code using the switch-case construct in C# Completed on 11/10/2023 · ________ · · Badge Get started with Jupyter notebooks for Python Completed on 11/9/2023 · ________ · · Badge Python error handling Completed on 11/9/2023 · ________ · · Badge Python functions Completed on 11/9/2023 · ________ · · Badge Manage data with Python dictionaries Completed on 11/9/2023 · ________ · · Badge Use 'while' and 'for' loops in Python Completed on 11/9/2023 · ________ · · Badge Introduction to lists in Python Completed on 11/9/2023 · ________ · · Badge Use mathematical operations in Python Completed on 11/9/2023 · ________ · · Badge Use strings in Python Completed on 11/9/2023 · ________ · · Badge Use Boolean logic in Python Completed on 11/9/2023 · ________ · · Badge Create and manage projects in Python Completed on 11/9/2023 · ________ · · Badge Write your first Python programs Completed on 11/9/2023 · ________ · · Badge Get started with Python in Visual Studio Code Completed on 11/9/2023 · ________ · · Badge Using GitHub Copilot with Python Completed on 11/9/2023 · ________ · · Badge Using GitHub Copilot with JavaScript Completed on 11/9/2023 · ________ · · Badge Introduction to GitHub Copilot for Business Completed on 11/9/2023 · ________ · · Badge Introduction to GitHub Copilot Completed on 11/9/2023 · ________ · · Badge Deploy a model with GitHub Actions Completed on 11/9/2023 · ________ · · Badge Work with environments in GitHub Actions Completed on 11/9/2023 · ________ · · Badge Work with linting and unit testing in GitHub Actions Completed on 11/9/2023 · ________ · · Badge Trigger GitHub Actions with feature-based development Completed on 11/9/2023 · ________ · · Badge Trigger Azure Machine Learning jobs with GitHub Actions Completed on 11/9/2023 · ________ · · Badge Use an Azure Machine Learning job for automation Completed on 11/9/2023 · ________ · · Badge Train and evaluate regression models Completed on 11/9/2023 · ________ · · Badge Explore and analyze data with Python Completed on 11/9/2023 · ________ · · Badge Train and evaluate deep learning models Completed on 11/9/2023 · ________ · · Badge Train and evaluate clustering models Completed on 11/9/2023 · ________ · · Badge Train and evaluate classification models Completed on 11/9/2023 · ________ · · Badge Measure and optimize model performance with ROC and AUC Completed on 11/9/2023 · ________ · · Badge Confusion matrix and data imbalances Completed on 11/9/2023 · ________ · · Badge Select and customize architectures and hyperparameters using random forest Completed on 11/9/2023 · ________ · · Badge Create and understand classification models in machine learning Completed on 11/9/2023 · ________ · · Badge Refine and test machine learning models Completed on 11/9/2023 · ________ · · Badge Train and understand regression models in machine learning Completed on 11/9/2023 · ________ · · Badge Introduction to data for machine learning Completed on 11/9/2023 · ________ · · Badge Build classical machine learning models with supervised learning Completed on 11/9/2023 · ________ · · Badge Introduction to machine learning Completed on 11/9/2023 · ________ · · Badge Create a clustering model with Azure Machine Learning designer Completed on 11/9/2023 · ________ · · Badge Create a classification model with Azure Machine Learning designer Completed on 11/9/2023 · ________ · · Badge Create a regression model with Azure Machine Learning designer Completed on 11/9/2023 · ________ · · Badge Use Automated Machine Learning in Azure Machine Learning Completed on 11/9/2023 · ________ · · Badge Explore developer tools for workspace interaction Completed on 11/9/2023 · ________ · · Badge Explore Azure Machine Learning workspace resources and assets Completed on 11/9/2023 · ________ · · Badge Explore Azure Storage for non-relational data Completed on 11/8/2023 · ________ · · Badge Explore fundamentals of Azure Cosmos DB Completed on 11/8/2023 · ________ · · Badge Explore relational database services in Azure Completed on 11/8/2023 · ________ · · Badge Explore fundamental relational data concepts Completed on 11/8/2023 · ________ · · Badge Fundamentals of Azure AI services Completed on 11/8/2023 · ________ · · Badge Fundamentals of machine learning Completed on 11/8/2023 · ________ · · Badge Fundamental AI Concepts Completed on 11/8/2023 · ________ · · Badge Fundamentals of Knowledge Mining with Azure Cognitive Search Completed on 11/8/2023 · ________ · · Badge Fundamentals of Azure AI Document Intelligence Completed on 11/8/2023 · ________ · · Badge Introduction to Computer Vision with PyTorch Completed on 11/8/2023 · ________ · · Badge Introduction to PyTorch Completed on 11/8/2023 · ________ · · Badge Introduction to audio classification with PyTorch Completed on 11/8/2023 · ________ · · Badge Introduction to Natural Language Processing with PyTorch Completed on 11/8/2023 · ________ · · Badge Transcribe large amounts of audio data with Batch Transcription Completed on 11/8/2023 · ________ · · Badge Fundamentals of optical character recognition Completed on 11/8/2023 · ________ · · Badge Fundamentals of Facial Recognition Completed on 11/8/2023 · ________ · · Badge Fundamentals of Computer Vision Completed on 11/8/2023 · ________ · · Badge Introduction to Azure Bot Service and Bot Framework Composer Completed on 11/8/2023 · ________ · · Badge Fundamentals of question answering with the Language Service Completed on 11/8/2023 · ________ · · Badge Fundamentals of Text Analysis with the Language Service Completed on 11/8/2023 · ________ · · Badge Fundamentals of Azure AI Speech Completed on 11/8/2023 · ________ · · Badge Fundamentals of conversational language understanding Completed on 11/8/2023 · ________ · · Badge Use your own data with Azure OpenAI Service Completed on 11/8/2023 · ________ · · Badge Generate images with Azure OpenAI Service Completed on 11/8/2023 · ________ · · Badge Generate code with Azure OpenAI Service Completed on 11/8/2023 · ________ · · Badge Apply prompt engineering with Azure OpenAI Service Completed on 11/8/2023 · ________ · · Badge Build natural language solutions with Azure OpenAI Service Completed on 11/8/2023 · ________ · · Badge Get started with Azure OpenAI Service Completed on 11/8/2023 · ________ · · Badge Fundamentals of Responsible Generative AI Completed on 11/8/2023 · ________ · · Badge Fundamentals of Azure OpenAI Service Completed on 11/8/2023 · ________ · · Badge Fundamentals of Generative AI Completed on 11/8/2023 · ________ · · Badge Describe monitoring tools in Azure Completed on 11/8/2023 · ________ · · Badge Describe features and tools for managing and deploying Azure resources Completed on 11/8/2023 · ________ · · Badge Describe features and tools in Azure for governance and compliance Completed on 11/8/2023 · ________ · · Badge Describe cost management in Azure Completed on 11/8/2023 · ________ · · Badge Align requirements with cloud types and service models in Azure Completed on 11/8/2023 · ________ · · Badge Move Azure resources to another resource group Completed on 11/8/2023 · ________ · · Badge Control and organize Azure resources with Azure Resource Manager Completed on 11/8/2023 · ________ · · Badge Create custom roles for Azure resources with role-based access control (RBAC) Completed on 11/8/2023 · ________ · · Badge Manage access to an Azure subscription by using Azure role-based access control (Azure RBAC) Completed on 11/8/2023 · ________ · · Badge Secure your Azure resources with Azure role-based access control (Azure RBAC) Completed on 11/8/2023 · ________ · · Badge Create Azure users and groups in Microsoft Entra ID Completed on 11/8/2023 · ________ · · Badge Configure role-based access control Completed on 11/8/2023 · ________ · · Badge Configure Azure Policy Completed on 11/8/2023 · ________ · · Badge Configure subscriptions Completed on 11/8/2023 · ________ · · Badge Configure user and group accounts Completed on 11/8/2023 · ________ · · Badge Configure Microsoft Entra ID Completed on 11/8/2023 · ________ · · Badge Allow users to reset their password with Microsoft Entra self-service password reset Completed on 11/8/2023 · ________ · · Badge Manage device identity with Microsoft Entra join and Enterprise State Roaming Completed on 11/8/2023 · ________ · · Badge Secure Microsoft Entra users with multifactor authentication Completed on 11/8/2023 · ________ · · Badge Implement and manage hybrid identity Completed on 11/8/2023 · ________ · · Badge Implement and manage external identities Completed on 11/8/2023 · ________ · · Badge Create, configure, and manage identities Completed on 11/8/2023 · ________ · · Badge Implement initial configuration of Microsoft Entra ID Completed on 11/8/2023 · ________ · · Badge Investigate threats by using audit features in Microsoft 365 Defender and Microsoft Purview Standard Completed on 11/8/2023 · ________ · · Badge Manage insider risk in Microsoft Purview Completed on 11/8/2023 · ________ · · Badge Respond to data loss prevention alerts using Microsoft 365 Completed on 11/8/2023 · ________ · · Badge Utilize Vulnerability Management in Microsoft Defender for Endpoint Completed on 11/8/2023 · ________ · · Badge Configure for alerts and detections in Microsoft Defender for Endpoint Completed on 11/8/2023 · ________ · · Badge Configure and manage automation using Microsoft Defender for Endpoint Completed on 11/8/2023 · ________ · · Badge Perform evidence and entities investigations using Microsoft Defender for Endpoint Completed on 11/8/2023 · ________ · · Badge Perform actions on a device using Microsoft Defender for Endpoint Completed on 11/8/2023 · ________ · · Badge Perform device investigations in Microsoft Defender for Endpoint Completed on 11/8/2023 · ________ · · Badge Implement Windows security enhancements with Microsoft Defender for Endpoint Completed on 11/8/2023 · ________ · · Badge Deploy the Microsoft Defender for Endpoint environment Completed on 11/8/2023 · ________ · · Badge Protect against threats with Microsoft Defender for Endpoint Completed on 11/8/2023 · ________ · · Badge Challenge project - Develop foreach and if-elseif-else structures to process array data in C# Completed on 11/8/2023 · ________ · · Badge Guided project - Develop foreach and if-elseif-else structures to process array data in C# Completed on 11/8/2023 · ________ · · Badge Create readable code with conventions, whitespace, and comments in C# Completed on 11/8/2023 · ________ · · Badge Store and iterate through sequences of data using Arrays and the foreach statement in C# Completed on 11/8/2023 · ________ · · Badge Add decision logic to your code using `if`, `else`, and `else if` statements in C# Completed on 11/8/2023 · ________ · · Badge Call methods from the .NET Class Library using C# Completed on 11/8/2023 · ________ · · Badge Install and configure Visual Studio Code Completed on 11/8/2023 · ________ · · Badge Perform basic string formatting in C# Completed on 11/8/2023 · ________ · · Badge Store and retrieve data using literal and variable values in C# Completed on 11/8/2023 · ________ · · Badge Write your first C# code Completed on 11/8/2023 · ________ · · Badge Guided project - Calculate final GPA Completed on 11/8/2023 · ________ · · Badge Guided project - Calculate and print student grades Completed on 11/8/2023 · ________ · · Badge Perform basic operations on numbers in C# Completed on 11/8/2023 · ________ · · Badge Explore Windows Editions Completed on 11/8/2023 · ________ · · Badge Explore the Enterprise Desktop Completed on 11/8/2023 · ________ · · Badge Examine data security and compliance in Microsoft 365 Copilot Completed on 11/8/2023 · ________ · · Badge Implement Microsoft 365 Copilot Completed on 11/8/2023 · ________ · · Badge Examine the Microsoft 365 Copilot design Completed on 11/8/2023 · ________ · · Badge Manage records in Microsoft Purview Completed on 11/8/2023 · ________ · · Badge Manage data retention in Microsoft 365 workloads Completed on 11/8/2023 · ________ · · Badge Manage the data lifecycle in Microsoft Purview Completed on 11/8/2023 · ________ · · Badge Configure DLP policies for Microsoft Defender for Cloud Apps and Power Platform Completed on 11/8/2023 · ________ · · Badge Prevent data loss in Microsoft Purview Completed on 11/8/2023 · ________ · · Badge Manage data loss prevention policies and reports in Microsoft 365 Completed on 11/8/2023 · ________ · · Badge Apply and manage sensitivity labels Completed on 11/8/2023 · ________ · · Badge Protect information in Microsoft Purview Completed on 11/8/2023 · ________ · · Badge Deploy Microsoft Purview Message Encryption Completed on 11/8/2023 · ________ · · Badge Understand Microsoft 365 encryption Completed on 11/8/2023 · ________ · · Badge Create and manage sensitive information types Completed on 11/8/2023 · ________ · · Badge Classify data for protection and governance Completed on 11/8/2023 · ________ · · Badge Introduction to information protection and data lifecycle management in Microsoft Purview Completed on 11/8/2023 · ________ · · Badge Design an application architecture Completed on 11/8/2023 · ________ · · Badge Design an Azure compute solution Completed on 11/8/2023 · ________ · · Badge Design migrations Completed on 11/8/2023 · ________ · · Badge Design network solutions Completed on 11/8/2023 · ________ · · Badge Design a solution to log and monitor Azure resources Completed on 11/8/2023 · ________ · · Badge Design authentication and authorization solutions Completed on 11/8/2023 · ________ · · Badge Design governance Completed on 11/8/2023 · ________ · · Badge Save money with Azure Reserved Instances Completed on 11/8/2023 · ________ · · Badge Introduction to analyzing costs and creating budgets with Microsoft Cost Management Completed on 11/8/2023 · ________ · · Badge Microsoft Azure Well-Architected Framework - Cost optimization Completed on 11/8/2023 · ________ · · Badge Introduction to the Microsoft Azure Well-Architected Framework Completed on 11/8/2023 · ________ · · Badge Microsoft Cloud Adoption Framework for Azure Completed on 11/8/2023 · ________ · · Badge Describe Azure identity, access, and security Completed on 11/8/2023 · ________ · · Badge Describe Azure storage services Completed on 11/8/2023 · ________ · · Badge Describe Azure compute and networking services Completed on 11/8/2023 · ________ · · Badge Describe the core architectural components of Azure Completed on 11/8/2023 · ________ · · Badge Describe cloud service types Completed on 11/8/2023 · ________ · · Badge Describe the benefits of using cloud services Completed on 11/8/2023 · ________ · · Badge Describe cloud computing Completed on 11/8/2023 · ________ · · Badge Publish an API to Azure Static Web Apps Completed on 11/8/2023 · ________ · · Badge Publish an Angular, React, Svelte, or Vue JavaScript app with Azure Static Web Apps Completed on 11/8/2023 · ________ · · Badge Create and publish a static web app with Gatsby and Azure Static Web Apps Completed on 11/8/2023 · ________ · · Badge Publish a Blazor WebAssembly app and .NET API with Azure Static Web Apps Completed on 11/8/2023 · ________ · · Badge Authenticate users with Azure Static Web Apps Completed on 11/8/2023 · ________ · · Badge Sign in users with Microsoft Entra ID in a Java web app Completed on 11/8/2023 · ________ · · Badge Accelerate a Spring Boot application with Azure Cache for Redis Completed on 11/8/2023 · ________ · · Badge Enable asynchronous messaging in Java apps by using JMS and Azure Service Bus Completed on 11/8/2023 · ________ · · Badge Build a Java app with cloud-scale NoSQL Cosmos DB Completed on 11/8/2023 · ________ · · Badge Deploy a Java EE (Jakarta EE) application to Azure Completed on 11/8/2023 · ________ · · Badge Deploy Spring microservices to Azure Completed on 11/8/2023 · ________ · · Badge Store application data with Azure Blob Storage Completed on 11/8/2023 · ________ · · Badge Secure your Azure Storage account Completed on 11/8/2023 · ________ · · Badge Connect an app to Azure Storage Completed on 11/8/2023 · ________ · · Badge Create an Azure Storage account Completed on 11/8/2023 · ________ · · Badge Choose a data storage approach in Azure Completed on 11/8/2023 · ________ · · Badge Introduction to Docker containers Completed on 11/8/2023 · ________ · · Badge Secure your identities by using Microsoft Entra ID Completed on 11/8/2023 · ________ · · Badge Automate Azure tasks using scripts with PowerShell Completed on 11/8/2023 · ________ · · Badge Control Azure services with the CLI Completed on 11/8/2023 · ________ · · Badge Fundamentals of network security Completed on 11/8/2023 · ________ · · Badge Fundamentals of computer networking Completed on 11/8/2023 · ________ · · Badge Introduction to Azure virtual machines Completed on 11/8/2023 · ________ · · Badge Create a Windows virtual machine in Azure Completed on 11/8/2023 · ________ · · Badge Provisioning a Linux virtual machine in Microsoft Azure Completed on 11/8/2023 · ________ · · Badge Plan your Linux environment in Azure Completed on 11/8/2023 · ________ · · Badge Introduction to Linux on Azure Completed on 11/8/2023 · ________ · · Badge Build and run a web application with the MEAN stack on an Azure Linux virtual machine Completed on 11/8/2023 · ________ · · Badge Optimizing IT operations and management with Azure Automanage Completed on 11/8/2023 · ________ · · Badge Manage hybrid workloads with Azure Arc Completed on 11/8/2023 · ________ · · Badge Administer and manage Windows Server IaaS Virtual Machine remotely Completed on 11/8/2023 · ________ · · Badge Perform Windows Server secure administration Completed on 11/8/2023 · ________ · · Badge Perform post-installation configuration of Windows Server Completed on 11/8/2023 · ________ · · Badge Describe Windows Server administration tools Completed on 11/8/2023 · ________ · · Badge Implement and manage Active Directory Certificate Services Completed on 11/8/2023 · ________ · · Badge Manage advanced features of AD DS Completed on 11/8/2023 · ________ · · Badge Implement Group Policy Objects Completed on 11/8/2023 · ________ · · Badge Manage AD DS domain controllers and FSMO roles Completed on 11/8/2023 · ________ · · Badge Introduction to AD DS Completed on 11/8/2023 · ________ · · Badge Deploy and manage Azure IaaS Active Directory domain controllers in Azure Completed on 11/8/2023 · ________ · · Badge Implement hybrid identity with Windows Server Completed on 11/8/2023 · ________ · · Badge Implement hybrid network infrastructure Completed on 11/8/2023 · ________ · · Badge Implement remote access Completed on 11/8/2023 · ________ · · Badge Implement IP Address Management Completed on 11/8/2023 · ________ · · Badge Implement Windows Server DNS Completed on 11/8/2023 · ________ · · Badge Deploy and manage DHCP Completed on 11/8/2023 · ________ · · Badge Implement DNS for Windows Server IaaS VMs Completed on 11/8/2023 · ________ · · Badge Implement Windows Server IaaS VM IP addressing and routing Completed on 11/8/2023 · ________ · · Badge Implement Windows Server IaaS VM network security Completed on 11/8/2023 · ________ · · Badge Windows Server update management Completed on 11/8/2023 · ________ · · Badge Hardening Windows Server Completed on 11/8/2023 · ________ · · Badge Secure Windows Server user accounts Completed on 11/8/2023 · ________ · · Badge Secure Windows Server DNS Completed on 11/8/2023 · ________ · · Badge Implement change tracking and file integrity monitoring for Windows IaaS VMs Completed on 11/8/2023 · ________ · · Badge Configure BitLocker disk encryption for Windows IaaS Virtual Machines Completed on 11/8/2023 · ________ · · Badge Create and implement application allowlists with adaptive application control Completed on 11/8/2023 · ________ · · Badge Manage Azure updates Completed on 11/8/2023 · ________ · · Badge Audit the security of Windows Server IaaS Virtual Machines Completed on 11/8/2023 · ________ · · Badge Configure and monitor Microsoft Sentinel Completed on 11/8/2023 · ________ · · Badge Enable and manage Microsoft Defender for Cloud Completed on 11/8/2023 · ________ · · Badge Configure and manage Azure Monitor Completed on 11/8/2023 · ________ · · Badge Improve your cloud security posture with Microsoft Defender for Cloud Completed on 11/8/2023 · ________ · · Badge Secure your cloud apps and services with Microsoft Defender for Cloud Apps Completed on 11/8/2023 ·

____________________ · · Badge Safeguard your environment with Microsoft Defender for Identity Completed on 11/8/2023 · ____________________ · · Badge Remediate risks with Microsoft Defender for Office 365 Completed on 11/8/2023 · ____________________ · · Badge Protect your identities with Microsoft Entra ID Protection Completed on 11/8/2023 · ____________________ · · Badge Mitigate incidents using Microsoft 365 Defender Completed on 11/8/2023 · ____________________ · · Badge Introduction to Microsoft 365 threat protection Completed on 11/8/2023 · ____________________ · · Badge Configure Azure Load Balancer Completed on 11/7/2023 · ____________________ · · Badge Configure network routing and endpoints Completed on 11/7/2023 · ____________________ · · Badge Configure Azure Virtual Network peering Completed on 11/7/2023 · ____________________ · · Badge Configure Azure DNS Completed on 11/7/2023 · ____________________ · · Badge Configure network security groups Completed on 11/7/2023 · ____________________ · · Badge Configure virtual networks Completed on 11/7/2023 · ____________________ · · Badge Improve application scalability and resiliency by using Azure Load Balancer Completed on 11/7/2023 · ____________________ · · Badge Manage and control traffic flow in your Azure deployment with routes Completed on 11/7/2023 · ____________________ · · Badge Host your domain on Azure DNS Completed on 11/7/2023 · ____________________ · · Badge Distribute your services across Azure virtual networks and integrate them by using virtual network peering Completed on 11/7/2023 · ____________________ · · Badge Design an IP addressing schema for your Azure deployment Completed on 11/7/2023 · ____________________ · · Badge Configure Azure Application Gateway Completed on 11/7/2023 · ____________________ · · Badge Design an enterprise governance strategy Completed on 11/7/2023 · ____________________ · · Badge Configure Microsoft Entra Privileged Identity Management Completed on 11/7/2023 · ____________________ · · Badge Deploy Microsoft Entra ID Protection Completed on 11/7/2023 · ____________________ · · Badge Implement Hybrid identity Completed on 11/7/2023 · ____________________ · · Badge Secure Azure solutions with Microsoft Entra ID Completed on 11/7/2023 · ____________________ · · Badge Functional Consultant skills Completed on 11/7/2023 · ____________________ · · Badge Use knowledge articles to resolve Dynamics 365 Customer Service cases Completed on 11/7/2023 · ____________________ · · Badge Search and filter knowledge articles by using Dynamics 365 Customer Service Completed on 11/7/2023 · ____________________ · · Badge Create knowledge management solutions in Dynamics 365 Customer Service Completed on 11/7/2023 · ____________________ · · Badge Translate Dynamics 365 apps and documentation with Dynamics 365 Translation Service Completed on 11/7/2023 · ____________________ · · Badge Challenge project - Architecting solutions for a new product line for customers Completed on 11/7/2023 · ____________________ · · Badge Perform fit gap analysis Completed on 11/7/2023 · ____________________ · · Badge Work with requirements for Microsoft Power Platform and Dynamics 365 Completed on 11/7/2023 · ____________________ · · Badge Propose a solution as a Solution Architect for Microsoft Power Platform and Dynamics 365 Completed on 11/7/2023 · ____________________ · · Badge Discover customer needs as a Solution Architect for Dynamics 365 and Microsoft Power Platform Completed on 11/7/2023 · ____________________ · · Badge Becoming a solution architect for Dynamics 365 and Microsoft Power Platform Completed on 11/7/2023 · ____________________ · · Badge Integration design for Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Review the security model for your Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Create a data migration strategy for Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Gap solution design for Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Business intelligence and analytics design for Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Design data models for Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Plan a testing strategy for your Dynamics 365 solution Completed on 11/7/2023 · ____________________ · · Badge Create a solution blueprint for Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Get started with Success by Design for Dynamics 365 Completed on 11/7/2023 · ____________________ · · Badge Post go-live strategy for Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Cutover strategy for Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Implement a performance strategy for Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Dual-write implementation for Dynamics 365 solutions Completed on 11/7/2023 · ____________________ · · Badge Implement common integration features in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Personalize finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Work with workflows in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Set up batch jobs in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Plan and implement legal entities in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Plan and configure the global address book in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Feature management in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Prepare to go-live with finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Implement role-based security in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Plan and implement security in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Work with performance and monitoring tools in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Updates and upgrades for finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Design and build mobile apps for finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Describe building automation with Microsoft Power Automate Completed on 11/7/2023 · ____________________ · · Badge Identify foundational components of Microsoft Power Platform Completed on 11/7/2023 · ____________________ · · Badge Describe how to build applications with Microsoft Power Apps Completed on 11/7/2023 · ____________________ · · Badge Describe the business value of the Microsoft Power Platform Completed on 11/7/2023 · ____________________ · · Badge Work with analytics and reporting in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Data integrations with finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Identify data integration patterns and scenarios in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Consume business events in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Explore extensions and the extension framework in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Implement application lifecycle management in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Prepare data for migration to finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Work with data management in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Perform user acceptance testing in finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Design and plan an implementation of finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge Get started with Lifecycle Services for finance and operations apps Completed on 11/7/2023 · ____________________ · · Badge FastTrack Customer Success Program for finance and operations Completed on 11/7/2023 · ____________________ · · Badge Get started with a finance and operations implementation project Completed on 11/7/2023 · ____________________ · · Badge Use approval workflows in Dynamics 365 Business Central Completed on 11/7/2023 · ____________________ · · Badge Create workflows in Dynamics 365 Business Central Completed on 11/7/2023 · ____________________ · · Badge Migrate on-premises data to Dynamics 365 Business Central Completed on 11/7/2023 · ____________________ · · Badge Migrate data to Business Central Completed on 11/7/2023 · ____________________ · · Badge Create new companies in Business Central Completed on 11/7/2023 · ____________________ · · Badge Administer Dynamics 365 Business Central online Completed on 11/7/2023 · ____________________ · · Badge Integrate Business Central with Outlook Completed on 11/7/2023 · ____________________ · · Badge Set up email in Dynamics 365 Business Central Completed on 11/7/2023 · ____________________ · · Badge Manage users and implement security in Business Central Completed on 11/7/2023 · ____________________ · · Badge Administer Microsoft Power Platform subscriptions Completed on 11/7/2023 · ____________________ · · Badge Manage Microsoft Power Platform deployments Completed on 11/7/2023 · ____________________ · · Badge Use administration options for Dataverse Completed on 11/7/2023 · ____________________ · · Badge Get started with security roles in Dataverse Completed on 11/7/2023 · ____________________ · · Badge Authentication and user management in Power Pages Completed on 11/7/2023 · ____________________ · · Badge Integrate Power Pages with web-based technologies Completed on 11/7/2023 · ____________________ · · Badge Power Pages administration Completed on 11/7/2023 · ____________________ · · Badge Power Pages maintenance and troubleshooting Completed on 11/7/2023 · ____________________ · · Badge Run a Power Automate for desktop flow in unattended mode Completed on 11/7/2023 · ____________________ · · Badge Use the Teams connector in Power Automate Completed on 11/7/2023 · ____________________ · · Badge Use AI Builder to process invoice forms in Power Automate Completed on 11/7/2023 · ____________________ · · Badge Integrate desktop flows with Outlook connector in Power Automate for desktop Completed on 11/7/2023 · ____________________ · · Badge Connect a cloud flow to desktop flows in Power Automate for desktop Completed on 11/7/2023 · ____________________ · · Badge Define input and output parameters in Power Automate Completed on 11/7/2023 · ____________________ · · Badge Build your first Power Automate for desktop flow Completed on 11/7/2023 · ____________________ · · Badge Optimize your business process with process advisor Completed on 11/7/2023 · ____________________ · · Badge Use AI Builder in Power Automate Completed on 11/7/2023 · ____________________ · · Badge Use the Admin center to manage environments and data policies in Power Automate Completed on 11/7/2023 · ____________________ · · Badge Power Automate's deep integration across multiple data sources Completed on 11/7/2023 · ____________________ · · Badge Build flows to manage user information Completed on 11/7/2023 · ____________________ · · Badge Build approval flows with Power Automate Completed on 11/7/2023 · ____________________ · · Badge Get started with Power Automate Completed on 11/7/2023 · ____________________ · · Badge Get data with Power BI Desktop Completed on 11/7/2023 · ____________________ · · Badge Secure, publish, and share data in Power BI Completed on 11/7/2023 · ____________________ · · Badge Design interactive data experiences with Power BI Desktop Completed on 11/7/2023 · ____________________ · · Badge Transition from Excel to Power BI Completed on 11/7/2023 · ____________________ · · Badge Introduction to foundations in data modeling Completed on 11/7/2023 · ____________________ · · Badge Automate data cleaning with Power Query Completed on 11/7/2023 · ____________________ · · Badge Introduction to modern analytics using Excel and Power BI Completed on 11/7/2023 · ____________________ · · Badge Describe the capabilities of Microsoft Power BI Completed on 11/7/2023 · ____________________ · · Badge Explore fundamentals of data visualization Completed on 11/7/2023 · ____________________ · · Badge Explore fundamentals of real-time analytics Completed on 11/7/2023 · ____________________ · · Badge Explore fundamentals of large-scale analytics Completed on 11/7/2023 · ____________________ · · Badge Explore data roles and services Completed on 11/7/2023 · ____________________ · · Badge Explore core data concepts Completed on 11/7/2023 · ____________________ · · Badge Automate multi-container Kubernetes deployments with Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Automate Docker container deployments with Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Automate Azure Functions deployments with Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Manage release cadence in Azure Pipelines by using deployment patterns Completed on 11/7/2023 · ____________________ · · Badge Run nonfunctional tests in Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Run functional tests in Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Create a multistage pipeline by using Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Create a release pipeline in Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Host your own build agent in Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Manage build dependencies with Azure Artifacts Completed on 11/7/2023 · ____________________ · · Badge Run quality tests in your build pipeline by using Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Create a build pipeline with Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Explore Azure Pipelines Completed on 11/7/2023 · ____________________ · · Badge Learn continuous integration with GitHub Actions Completed on 11/7/2023 · ____________________ · · Badge Introduction to GitHub Actions Completed on 11/7/2023 · ____________________ · · Badge Work with Azure Repos and GitHub Completed on 11/7/2023 · ____________________ · · Badge Describe types of source control systems Completed on 11/7/2023 · ____________________ · · Badge Introduction to source control Completed on 11/7/2023 · ____________________ · · Badge Plan Agile with GitHub Projects and Azure Boards Completed on 11/7/2023 · ____________________ · · Badge Choose the DevOps tools Completed on 11/7/2023 · ____________________ · · Badge Describe team structures Completed on 11/7/2023 · ____________________ · · Badge Choose the right project Completed on 11/7/2023 · ____________________ · · Badge Introduction to DevOps Completed on 11/7/2023 · ____________________ · · Badge Independent learning with math tools in OneNote Completed on 11/6/2023 · ____________________ · · Badge OneNote Class Notebook: A teacher's all-in-one notebook for students Completed on 11/6/2023 · ____________________ · · Badge Converse, collaborate, and build community in Teams Completed on 11/6/2023 · ____________________ · · Badge Organize content, create assignments, and assess learners' understanding in Teams Completed on 11/6/2023 · ____________________ · · Badge Collaborate with colleagues through live Teams meetings and OneNote Completed on 11/6/2023 · ____________________ · · Badge Work collaboratively with Staff and PLC Teams Completed on 11/6/2023 · ____________________ · · Badge Assemble learners and staff with Microsoft Teams meetings Completed on 11/6/2023 · ____________________ · · Badge Explore the benefits of becoming a Microsoft Educator Trainer Completed on 11/6/2023 · ____________________ · · Badge Engage and amplify with Flip Completed on 11/6/2023 · ____________________ · · Badge OneNote Staff Notebook: Tools for staff collaboration Completed on 11/6/2023 · ____________________ · · Badge Digital storytelling with Microsoft Sway Completed on 11/6/2023 · ____________________ · · Badge Create authentic assessments with Microsoft Forms Completed on 11/6/2023 · ____________________ · · Badge Engage teachers and students with Windows 11 and Windows 11 SE: Course 201 Completed on 11/6/2023 · 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Transcript Legal name: Tshingombe Tshitadi Fiston 46307064 Edit display name in settings Username: 46307064 Edit user name in settings Contact email: tshingombefiston@gmail.com Edit contact email in settings Modules completed 924 Training hours completed 738 hr 43 min Modules completed N/A in the module assessment result column means either the module assessment doesn't exist or there's no pass record for it. All modules in this table are complete. Module title Description Completed on Duration Module Assessment Result Introduction to Azure Load Balancer This module explains what Azure Load Balancer does, how it works, and when you should choose to use Load Balancer as a solution to meet your organization's needs. Jan 10, 2025 18 min N/A Enhance your service availability and data locality by using Azure Traffic Manager Discover how Azure Traffic Manager provides DNS load balancing for your application to improve the performance and availability of your application. Jan 10, 2025 29 min N/A Improve your reliability with modern operations practices: An introduction Discover a map for navigating reliability challenges and sustainably achieving the appropriate level of reliability in your systems, services, and products. Jan 10, 2025 10 min N/A Expand your AI skills based on your role Get ready to use Copilot and build AI apps. Discover the transformational experiences you can implement by using Microsoft's AI apps and services. Select a role to explore focused skilling resources. Developer Business or technical leader Business user IT professional Data scientist Data professional Low-code developer Security professional Developer Accelerate app development by using GitHub Copilot Find out how to use GitHub Copilot to interpret and document code, author new code features more efficiently, and refactor, debug, and test code. Build AI apps with Azure Services and best practices Get the details on designing and building a cloud-native AI app, developing a back-end database, and integrating Azure AI services into applications. Build and extend copilots with Microsoft Copilot Studio Use Microsoft Copilot Studio to create conversational AI solutions, and learn how to build actions that extend Microsoft 365 Copilot. Extend Microsoft 365 Copilot (for developers) Use Copilot Studio actions, and learn about building plugins and connectors for Microsoft 365 Copilot. Discover how to choose the right option for your use case. Thank you for your interest in Microsoft! Inbox Microsoft Recruiting Unsubscribe Thu, Feb 27, 9:00 PM (15 hours ago) to me Hi Fiston Tshingombe teodor, Thank you for your interest in a career at Microsoft. Unfortunately, we will not be moving forward with your candidacy for the position of Design Verification Engineer II, 1776092 at this time. However, we'd like to encourage you to continue to explore other career opportunities on Microsoft Careers as we continually update openings on a daily basis. We look forward to considering you for other positions at Microsoft! Thank you, Microsoft Recruiting Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. This mail is sent from an unmonitored mailbox. Please do not reply. ____________________ This message was sent to tshingombefiston@gmail.com. If you don't want to receive these emails from this company in the future, please go to: https://ms.icims.com/icims2/?r=11B617365170&contactId=129540225 Thank you for your interest in Microsoft! Inbox Microsoft Recruiting Unsubscribe Thu, Feb 27, 9:00 PM (15 hours ago) to me Hi Fiston Tshingombe teodor, Thank you for your interest in a career at Microsoft. Unfortunately, we will not be moving forward with your candidacy for the position of Design Verification Engineer II, 1776092 at this time. However, we'd like to encourage you to continue to explore other career opportunities on Microsoft Careers as we continually update openings on a daily basis. We look forward to considering you for other positions at Microsoft! Thank you, Microsoft Recruiting Microsoft respects your privacy. To learn more, please read our Microsoft Data Privacy Notice. This mail is sent from an unmonitored mailbox. Please do not reply. ____________________ This message was sent to tshingombefiston@gmail.com. If you don't want to receive these emails from this company in the future, please go to: https://ms.icims.com/icims2/?r=11B617365170&contactId=129540225 Access Control and Identity Management, 3rd Ed. by Mike Chapple. Publisher: Jones and Bartlett Learning. (Sep, 2020). ____________________ Building an Information Security Awareness Program, 1st Ed. by Bill Gardner and Valerie Thomas. Publisher: Syngress. 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Identifying Your Cyber Path and Industry This course invites you to explore a wide range of opportunities in cybersecurity and plan a skill development path toward a successful career. Identifying and Building Your Network This course invites you to review the critical role networking plays in professional development by unlocking new opportunities, facilitating knowledge sharing and supporting long-term career success. Resume/CV/Portfolio Building and Management This course invites you to review the critical components of documents such as resumes, CVs and portfolios that showcase your unique strengths and value to potential employers. 1 2 3 > >| Go to the main content Privacy and Cookies This website stores cookies on your computer which help us make the website work better for you. 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Register for exam Effective Date: September 2024 SSCP Certification Exam Outline View and download the latest PDF version of the SSCP Certification Exam Outline in the following languages: SSCP - English | SSCP - Japanese | SSCP - Spanish About SSCP The Systems Security Certified Practitioner (SSCP) is the ideal certification for those with proven technical skills and practical, hands-on security knowledge in operational IT roles. It provides confirmation of a practitioner's ability to implement, monitor and administer IT infrastructure in accordance with information security policies and procedures that ensure data confidentiality, integrity and availability. The broad spectrum of topics included in the SSCP Common Body of Knowledge (CBK) ensure its relevancy across all disciplines in the field of information security. Successful candidates are competent in the following domains: Security Concepts and Practices Access Controls Risk Identification, Monitoring, and Analysis Incident Response and Recovery Cryptography Network and Communications Security Systems and Application Security Experience Requirements Candidates must have a minimum of one year cumulative work experience in one or more of the domains of the SSCP CBK. A one year prerequisite pathway will be granted for candidates who received a degree (bachelors or masters) in a cybersecurity program. A candidate that doesn't have the required experience to become an SSCP may become an Associate of ISC2 by successfully passing the SSCP examination. The Associate of ISC2 will then have two years to earn the one year required experience. You can learn more about SSCP experience requirements and how to account for part-time work and internships at www.isc2.org/Certifications/SSCP/SSCP-Experience-Requirements. Accreditation SSCP is in compliance with the stringent requirements of ANSI/ISO/IEC Standard 17024. Job Task Analysis (JTA) ISC2 has an obligation to its membership to maintain the relevancy of the SSCP. Conducted at regular intervals, the Job Task Analysis (JTA) is a methodical and critical process of determining the tasks that are performed by security professionals who are engaged in the profession defined by the SSCP. The results of the JTA are used to update the examination. This process ensures that candidates are tested on the topic areas relevant to the roles and responsibilities of today's practicing information security professionals. SSCP Examination Information Length of exam 3 hours Number of items 125 Item format Multiple choice Passing grade 700 out of 1000 points Language availability English, Japanese and Spanish Testing center Pearson VUE Testing Center SSCP Examination Weights Domains Average Weight 1. Security Concepts and Practices 16% 2. Access Controls 15% 3. Risk Identification, Monitoring and Analysis 15% 4. Incident Response and Recovery 14% 5. Cryptography 9% 6. Network and Communications Security 16% 7. Systems and Application Security 15% Total 100% Domains 1.1 - Comply with codes of ethics ISC2 Code of Ethics Organizational code of ethics 1.2 - Understand security concepts Confidentiality Integrity Availability Accountability Non-repudiation Least privilege Segregation of duties (SoD) 1.3 - Identify and implement security controls Technical controls (e.g., firewalls, intrusion detection systems (IDS), access control list (ACL) Physical controls (e.g., mantraps, cameras, locks) Administrative controls (e.g., security policies, standards, procedures, baselines) Assessing compliance requirements Periodic audit and review 1.4 - Document and maintain functional security controls Deterrent controls Preventative controls Detective controls Corrective controls Compensating controls 1.5 - Support and implement asset management lifecycle (i.e., hardware, software, and data) Process, planning, design and initiation Development /Acquisition (e.g., DevSecOps, testing) Inventory and licensing (e.g., open source, closed-source) Implementation/Assessment Operation/Maintenance/End of Life (EOL) Archival and retention requirements Disposal and destruction 1.6 - Support and/or implement change management lifecycle Change management (e.g., roles, responsibilities, processes, communications, audit) Security impact analysis Configuration management (CM) 1.7 - Support and/or implement security awareness and training (e.g., social engineering/phishing/tabletop exercises/awareness communications) 1.8 - Collaborate with physical security operations (e.g., data center/facility assessment, badging and visitor management, personal device restrictions) 2.1 - Implement and maintain authentication methods Single/Multi-factor authentication (MFA) Single sign-on (SSO) (e.g., Active Directory Federation Services (ADFS), OpenID Connect) Device authentication (e.g., certificate, Media Access Control (MAC) address, Trusted Platform Module (TPM)) Federated access (e.g., Open Authorization 2 (OAuth2), Security Assertion Markup Language (SAML)) 2.2 - Understand and support internetwork trust architectures Trust relationships (e.g., 1-way, 2-way, transitive, zero) Internet, intranet, extranet, and demilitarized zone (DMZ) Third-party connections (e.g., application programming interface (API), app extensions, middleware) 2.3 - Support and/or implement the identity management lifecycle Authorization Proofing Provisioning/De-provisioning Monitoring, Reporting, and Maintenance (e.g., role changes, new security standards) Entitlement (e.g., inherited rights, resources) Identity and access management (IAM) systems 2.4 - Understand and administer access controls Mandatory Discretionary Role-based (e.g., subject-based, object-based, Privileged Access Management (PAM)) Rule-based Attribute-based 3.1 - Understand risk management Risk visibility and reporting (e.g., risk register, sharing threat intelligence, indicators of Compromise (IOC), Common Vulnerability Scoring System (CVSS), socialization, MITRE/ATT&CK model) Risk management concepts (e.g., impact assessments, threat modeling, scope) Risk management frameworks Risk tolerance (e.g., appetite, risk quantification) Risk treatment (e.g., accept, transfer, mitigate, avoid) 3.2 - Understand legal and regulatory concerns (e.g., jurisdiction, limitations, privacy) 3.3 - Perform security assessments and vulnerability management activities Risk management frameworks implementation Security testing Risk review (e.g., internal, supplier, architecture) Vulnerability management lifecycle (e.g., scanning, reporting, analysis, remediation) 3.4 - Operate and monitor security platforms (e.g., continuous monitoring) Source systems (e.g., applications, security appliances, network devices, hosts) Events of interest (e.g., errors, omissions, anomalies, unauthorized changes, compliance violations, policy failures) Log management (e.g., policy, integrity, preservation, architectures, configuration, aggregation, tuning) Security information and event management (SIEM) (e.g., real-time monitoring, analysis, tracking, audit) 3.5 - Analyze monitoring results Security baselines and anomalies (e.g., correlation, noise reduction) Visualizations, metrics, and trends (e.g., notifications, dashboards, timelines) Event data analysis Document and communicate findings (e.g., escalation) 4.1 - Understand and support incident response lifecycle (e.g., National Institute of Standards and Technology (NIST), International Organization for Standardization (ISO)) Preparation (e.g., defining roles, training programs) Detection, analysis, and escalation (e.g., incident communication, public relations) Containment Eradication Recovery (e.g., incident documentation) Post incident activities (e.g., lessons learned, new countermeasures, continuous improvement) 4.2 - Understand and support forensic investigations Legal (e.g., civil, criminal, administrative) and ethical principles Evidence handling (e.g., first responder, triage, chain of custody, preservation of scene) Reporting of analysis Organization Security Policy Compliance 4.3 - Understand and support business continuity plan (BCP) and disaster recovery plan (DRP) Emergency response plans and procedures (e.g., information system contingency, pandemic, natural disaster, crisis management) Interim or alternate processing strategies Restoration planning (e.g., Restore Time Objective (RTO), Restore Point Objectives (RPO), Maximum Tolerable Downtime (MTD)) Backup and redundancy implementation Testing and drills (e.g., playbook, tabletop, disaster recovery exercises, scheduling) 5.1 - Understand reasons and requirements for cryptography Confidentiality Integrity and authenticity Data sensitivity (e.g., personally identifiable information (PII), intellectual property (IP), protected health information (PHI)) Regulatory and industry best practice (e.g., Payment Card Industry Data Security Standards (PCI-DSS), International Organization for Standardization (ISO)) Cryptography entropy (e.g., quantum cryptography, quantum key distribution) 5.2 - Apply cryptography concepts Hashing Salting Symmetric/Asymmetric encryption/Elliptic curve cryptography (ECC) Non-repudiation (e.g., digital signatures/certificates, Hash-based Message Authentication Code (HMAC), audit trails) Strength of encryption algorithms and keys (e.g., Advanced Encryption Standards (AES), Rivest-Shamir-Adleman (RSA) Cryptographic attacks and cryptanalysis 5.3 - Understand and implement secure protocols Services and protocols Common use cases (e.g., credit card processing, file transfer, web client, virtual private network (VPN), transmission of PII data) Limitations and vulnerabilities 5.4 - Understand public key infrastructure (PKI) Fundamental key management concepts (e.g., storage, rotation, composition, generation, destruction, exchange, revocation, escrow) Web of Trust (WOT) (e.g., Pretty Good Privacy (PGP), GNU Privacy Guard (GPG), blockchain) 6.1 - Understand and apply fundamental concepts of networking Open Systems Interconnection (OSI) and Transmission Control Protocol/Internet Protocol (TCP/IP) models Network topologies Network relationships (e.g., peer-to-peer (P2P), client server) Transmission media types (e.g., wired, wireless) Software-defined networking (SDN) (e.g., Software-Defined Wide Area Network (SD-WAN), network virtualization, automation) Commonly used ports and protocols 6.2 - Understand network attacks (e.g., distributed denial of service (DDoS), man-in-the-middle (MITM), Domain Name System (DNS) cache poisoning) Countermeasures (e.g., content delivery networks (CDN), firewalls, network access controls, intrusion detection and prevention systems (IDPS)) 6.3 - Manage network access controls Network access controls, standards and protocols (e.g., Institute of Electrical and Electronics Engineers (IEEE) 802.1X, Remote Authentication Dial-In User Service (RADIUS), Terminal Access Controller Access-Control System Plus (TACACS+)) Remote access operation and configuration (e.g., thin client, virtual private network (VPN), virtual desktop infrastructure) 6.4 - Manage network security Logical and physical placement of network devices (e.g., inline, passive, virtual) Segmentation (e.g., physical/logical, data/control plane, virtual local area network (VLAN), access control list (ACL), firewall zones, micro-segmentation) Secure device management 6.5 - Operate and configure network-based security appliances and services Firewalls and proxies (e.g., filtering methods, web application firewall (WAF), cloud access security broker (CASB)) Network intrusion detection/prevention systems Routers and switches Traffic-shaping devices (e.g., wide area network (WAN) optimization, load balancing) Network Access Control (NAC) Data Loss Prevention (DLP) Unified Threat Management (UTM) 6.6 - Secure wireless communications Technologies (e.g., cellular network, Wi-Fi, Bluetooth, Near-Field Communication (NFC)) Authentication and encryption protocols (e.g., Wi-Fi Protected Access (WPA), Extensible Authentication Protocol (EAP), Wi-Fi Protected Access 2 (WPA2), Wi-Fi Protected Access 3 (WPA3)) 6.7 Secure and monitor Internet of Things (IoT) (e.g., configuration, network isolation, firmware updates, End of Life (EOL) management) 7.1 - Identify and analyze malicious code and activity Malware (e.g., rootkits, spyware, scareware, ransomware, trojans, virus, worms, trapdoors, backdoors, fileless, app/code/operatin3 system (OS)/mobile code vulnerabilities) Malware countermeasures (e.g., scanners, anti-malware, containment and remediation, software security) Types of malicious activity (e.g., insider threat, data theft, distributed denial of service (DDoS), botnet, zero-day exploits, web-based attacks, advanced persistent threat (APT)) Malicious activity countermeasures (e.g., user awareness/training, system hardening, patching, isolation, data loss prevention (DLP)) Social engineering methods (e.g., SPAM email, phishing/smishing/vishing, impersonation, scarcity, whaling) Behavior analytics (e.g., machine learning, Artificial Intelligence (AI), data analytics) 7.2 - Implement and operate endpoint device security Host-based intrusion prevention system (HIPS) Host-based intrusion detection system (HIDS) Host-based firewalls Application white listing Endpoint encryption (e.g., full disk encryption) Trusted Platform Module (TPM) (e.g., hardware security module management) Secure browsing (e.g., digital certificates) Endpoint detection and response (EDR) 7.3 - Administer and manage mobile devices Provisioning techniques (e.g., corporate owned, personally enabled (COPE), Bring Your Own Device (BYOD), Mobile Device Management (MDM)) Containerization Encryption Mobile application management 7.4 - Understand and configure cloud security Deployment models (e.g., public, private, hybrid, community) Service models (e.g., Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS)) Virtualization (e.g., hypervisor, Virtual Private Cloud (VPC)) Legal and regulatory concerns (e.g., privacy, surveillance, data ownership, jurisdiction, eDiscovery, shadow information technology (IT)) Data storage, processing, and transmission (e.g., archiving, backup, recovery, resilience) Third-party/Outsourcing requirements (e.g., service-level agreement (SLA), data portability/ privacy/destruction/auditing) Shared responsibility model 7.5 - Operate and maintain secure virtual environments Hypervisor (i.e., Type 1 (e.g., bare metal), Type 2 (e.g., software)) Virtual appliances Containers Continuity and resilience Storage management (e.g., data domain) Threats, attacks, and countermeasures (e.g., brute-force attack, virtual machine escape, threat hunting) Additional Examination Information Supplementary References Candidates are encouraged to supplement their education and experience by reviewing relevant resources that pertain to the CBK and identifying areas of study that may need additional attention. View the full list of supplementary references at www.isc2.org/certifications/References. Examination Policies and Procedures ISC2 recommends that SSCP candidates review exam policies and procedures prior to registering for the examination. Read the comprehensive breakdown of this important information at www.isc2.org/Register-for-Exam. A safe and secure cyber world The Center for Cyber Safety & EducationISC2 CareersCommunityBlog Frequently Asked QuestionsContact UsPolicies and Procedures ISC2 Authorized China AgencyISC2 Japan © Copyright 1996-2025. ISC2, Inc. All Rights Reserved. All contents of this site constitute the property of ISC2, Inc. and may not be copied, reproduced or distributed without prior written permission. ISC2, CISSP, SSCP, CCSP, CGRC, CSSLP, HCISPP, ISSAP, ISSEP, ISSMP, CC, and CBK are registered marks of ISC2, Inc. 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Candidates that do not agree to the terms and conditions will not be permitted to sit for any ISC2 examination. Non-Disclosure Agreement (NDA) Failure to read or accept the ISC2 NDA agreement within the allotted five minutes will result in exam termination and forfeiture of exam appointment. Forfeiture of exam appointment also includes forfeiture of all exam fees. To take the examination at a later date you will be required to re-register for the exam and pay all applicable registration fees. Important Information on ISC2 Exams One of the benefits to candidates taking an examination via Computer-Based Testing is that most candidates receive their scores immediately upon completing their examination. In some cases, ISC2 must conduct periodic psychometric analyses prior to releasing exam results. For the small number of candidates affected by this process, it is expected that candidates will receive their results within 6 -8 weeks following the exam. 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Once an accommodation is approved, ISC2 will inform the Pearson VUE Accommodations team. Please allow up to three business days for Pearson VUE to receive this information. Then, contact Cart Collapsed, toggle side navigation to expand Edit my profile Tshingombe Tshingombe Tshitadi ISC2 ID: 1907033 Dashboard My Profile Sign out Almost there... back to previous step Confirm Order Details Description Details Price Exam CC: Certified in Cybersecurity (CC) Language: English Length: 120 minutes Appointment Friday, March 14, 2025 Start time: 8:00 AM Africa/Johannesburg - SAST Location Pearson Professional Centers-Johannesburg Pearson VUE 6th Floor Sandton City Office Tower Sandton City Shopping Centre 158 5th Street, SANDTON Johannesburg 2146 South Africa 199.00 Payment Details Exams for Name: Tshingombe Tshingombe Tshitadi ISC2 ID: 1907033 Order Total Subtotal: 199.00 Tax: 0.00 TOTAL DUE: USD 199.00 USD 199.00 Pearson VUE, so you can schedule your exam, contact information can be found at www.pearsonvue.com/isc2/contact. Accommodations are not a guarantee of improved performance or exam completion. Once an initial exam appointment is scheduled, there may be a US$50 fee to reschedule an exam with an approved accommodation. Agree to ISC2 policies back to previous step CCSP: Certified Cloud Security Professional (CCSP) CGRC: Certified in Governance Risk and Compliance CISSP: Certified Information Systems Security Professional CSSLP: Certified Secure Software Lifecycle Professional ISSAP: Information Systems Security Architecture Professional ISSMP: Information Systems Security Management Professional SSCP: Systems Security Certified Practitioner Certification Exam Outline Effective Date: November 15, 20222 ISSMP Certification Exam Outline About CISSP-ISSMP The Information Systems Security Management Professional (ISSMP) is a CISSP who specializes in establishing, presenting and governing information security programs and demonstrates management and leadership skills. CISSP-ISSMPs direct the alignment of security programs with the organization's mission, goals and strategies in order to meet enterprise financial and operational requirements in support of its desired risk position. The broad spectrum of topics included in the CISSP-ISSMP Common Body of Knowledge (CBK®) ensure its relevancy across all disciplines in the field of information security management. Successful candidates are competent in the following six domains: • Leadership and Business Management • Systems Lifecycle Management • Risk Management • Threat Intelligence and Incident Management • Contingency Management • Law, Ethics and Security Compliance Management Experience Requirements Candidates must be a CISSP in good standing and have two years cumulative paid work experience in one or more of the six domains of the CISSP-ISSMP CBK. You can learn more about CISSP-ISSMP experience requirements and how to account for part-time work and internships at www.isc2.org/Certifications/CISSP-Concentrations#steps-to-certification. Accreditation CISSP-ISSMP is in compliance with the stringent requirements of ANSI/ISO/IEC Standard 17024. Job Task Analysis (JTA) (ISC)² has an obligation to its membership to maintain the relevancy of the CISSP-ISSMP. Conducted at regular intervals, the Job Task Analysis (JTA) is a methodical and critical process of determining the tasks that are performed by security professionals who are engaged in the profession defined by the CISSP-ISSMP. The results of the JTA are used to update the examination. This process ensures that candidates are tested on the topic areas relevant to the roles and responsibilities of today's practicing information security professionals.3 ISSMP Certification Exam Outline CISSP-ISSMP Examination Information CISSP-ISSMP Examination Weights Length of exam Number of items Item format Passing grade Exam availability Testing center 3 hours 125 Multiple choice 700 out of 1000 points English Pearson VUE Testing Center Domains Weight 1. Leadership and Business Management 20% 2. Systems Lifecycle Management 18% 3. Risk Management 19% 4. Threat Intelligence and Incident Management 17% 5. Contingency Management 15% 6. Law, Ethics and Security Compliance Management 11% Total: 100%4 ISSMP Certification Exam Outline Domain 1: Leadership and Business Management 1.1 Establish security's role in organizational culture, vision and mission » Define information security program vision and mission » Align security with organizational goals, objectives and values » Define security's relationship to the overall business processes » Define the relationship between organizational culture and security 1.2 Align security program with organizational governance » Identify and navigate organizational governance structure » Validate roles of key stakeholders » Validate sources and boundaries of authorization » Advocate and obtain organizational support for security initiatives 1.3 Define and implement information security strategies » Identify security requirements from business initiatives » Evaluate capacity and capability to implement security strategies » Manage implementation of security strategies » Review and maintain security strategies » Prescribe security architecture and engineering theories, concepts and methods 1.4 Define and maintain security policy framework Determine applicable external standards » Determine applicable external standards » Determine data classification and protection requirements » Establish internal policies » Advocate and obtain organizational support for policies » Develop procedures, standards, guidelines and baselines » Ensure periodic review of security policy framework5 ISSMP Certification Exam Outline » Define roles and responsibilities » Determine and manage team accountability » Build cross-functional relationships » Resolve conflicts between security and other stakeholders » Identify communication bottlenecks and barriers » Integrate security controls into human resources processes » Evaluate service management agreements (e.g., risk, financial) » Govern managed services (e.g., infrastructure, cloud services) » Manage impact of organizational change (e.g., mergers and acquisitions, outsourcing) » Ensure that appropriate regulatory compliance statements and requirements are included in contractual agreements » Monitor and enforce compliance with contractual agreements 1.5 Manage security requirements in contracts and agreements 1.6 Manage security awareness and training programs » Promote security programs to key stakeholders » Identify needs and implement training programs by target segment » Monitor and report on effectiveness of security awareness and training programs 1.7 Define, measure and report security metrics » Identify Key Performance Indicators (KPI) » Associate Key Performance Indicators (KPI) to the risk posture of the organization » Use metrics to drive security program development and operations 1.8 Prepare, obtain and administer security budget » Prepare and secure annual budget » Adjust budget based on evolving risks and threat landscape » Manage and report financial responsibilities 1.9 Manage security programs 1.10 Apply product development and project management principles » Incorporate security into project lifecycle » Identify and apply appropriate project management methodology » Analyze project time, scope and cost relationship6 ISSMP Certification Exam Outline 2.1 Manage integration of security into Systems Development Life Cycle (SDLC) » Integrate information security gates (decision points) and requirements into lifecycle » Implement security controls into system lifecycle » Oversee security configuration management (CM) processes 2.2 Integrate new business initiatives and emerging technologies into the security architecture » Integrate security into new business initiatives and emerging technologies » Address impact of new business initiatives on security posture 2.3 Define and oversee comprehensive vulnerability management programs (e.g., vulnerability scanning, penetration testing, threat analysis) » Identify, classify and prioritize assets, systems and services based on criticality to business » Prioritize threats and vulnerabilities » Manage security testing » Manage mitigation and/or remediation of vulnerabilities based on risk 2.4 Manage security aspects of change control » Integrate security requirements with change control process » Identify and coordinate with the stakeholders » Manage documentation and tracking » Ensure policy compliance (e.g., continuous monitoring) Domain 2: Systems Lifecycle Management 7 ISSMP Certification Exam Outline Domain 3: Risk Management 3.1 Develop and manage a risk management program » Identify risk management program objectives » Communicate and agree on risk management objectives with risk owners and other stakeholders » Determine scope of organizational risk program » Identify organizational security risk tolerance/appetite » Obtain and verify organizational asset inventory » Analyze organizational risks » Determine countermeasures, compensating and mitigating controls » Perform cost-benefit analysis (CBA) of risk treatment options 3.2 Conduct risk assessments » Identify risk factors 3.3 Manage security risks within the supply chain (e.g., supplier, vendor, third-party risk) » Identify supply chain security risk requirements » Integrate supply chain security risks into organizational risk management » Validate security risk control within the supply chain » Monitor and review the supply chain security risks8 ISSMP Certification Exam Outline 4.1 Establish and maintain threat intelligence program » Aggregate threat data from multiple threat intelligence sources » Conduct baseline analysis of network traffic, data and user behavior » Detect and analyze anomalous behavior patterns for potential concerns » Conduct threat modeling » Identify and categorize an attack » Correlate related security event and threat data » Create actionable alerting to appropriate resources 4.2 Establish and maintain incident handling and investigation program » Develop program documentation » Establish incident response case management process » Establish incident response team » Apply incident management methodologies » Establish and maintain incident handling process » Establish and maintain investigation process » Quantify and report financial and operational impact of incidents and investigations to stakeholders » Conduct root cause analysis (RCA) Domain 4: Threat Intelligence and Incident Management 9 ISSMP Certification Exam Outline 5.1 Facilitate development of contingency plans » Identify and analyze factors related to the Continuity of Operations Plan (COOP) » Identify and analyze factors related to the business continuity plan (BCP) (e.g., time, resources, verification) » Identify and analyze factors related to the disaster recovery plan (DRP) (e.g., time, resources, verification) » Coordinate contingency management plans with key stakeholders » Define internal and external crisis communications plans » Define and communicate contingency roles and responsibilities » Identify and analyze contingency impact on business processes and priorities » Manage third-party contingency dependencies » Prepare security management succession plan 5.2 Develop recovery strategies » Identify and analyze alternatives » Recommend and coordinate recovery strategies » Assign recovery roles and responsibilities 5.3 Maintain contingency plan, Continuity of Operations Plan (COOP), business continuity plan (BCP) and disaster recovery plan (DRP) » Plan testing, evaluation and modification » Determine survivability and resiliency capabilities » Manage plan update process 5.4 Manage disaster response and recovery process » Declare disaster » Implement plan » Restore normal operations » Gather lessons learned » Update plan based on lessons learned Domain 5: Contingency Management 10 ISSMP Certification Exam Outline 10 6.1 Identify the impact of laws and regulations that relate to information security 6.2 Adhere to the (ISC) 2 Code of Ethics as related to management issues 6.3 Validate compliance in accordance with applicable laws, regulations and industry best practices 6.4 Coordinate with auditors and regulators in support of the internal and external audit processes 6.5 Document and manage compliance exceptions » Identify and document compensating controls and workarounds » Report and obtain authorized approval of risk waiver Domain 6: Law, Ethics and Security Compliance Management » Identify applicable privacy laws » Identify legal jurisdictions the organization and users operate within (e.g., trans-border data flow) » Identify export laws » Identify intellectual property (IP) laws » Identify applicable industry regulations » Identify and advise on non-compliance risks » Inform and advise senior management » Evaluate and select compliance framework(s) » Implement the compliance framework(s) » Define and monitor compliance metrics » Plan » Schedule » Coordinate audit activities » Evaluate and validate findings » Formulate response » Validate implemented mitigation and remediation actions11 ISSMP Certification Exam Outline Additional Examination Information Supplementary References Candidates are encouraged to supplement their education and experience by reviewing relevant resources that pertain to the CBK and identifying areas of study that may need additional attention. View the full list of supplementary references at www.isc2.org/certifications/References. Examination Policies and Procedures (ISC)2 recommends that CISSP-ISSMP candidates review exam policies and procedures prior to registering for the examination. Read the comprehensive breakdown of this important information at www.isc2.org/Exams/Before-Your-Exam. Legal Info For any questions related to (ISC) 2 's legal policies, please contact the (ISC)2 Legal Department at legal@isc2.org. Any Questions? (ISC)2 Americas Tel: +1.866.331.ISC2 (4722) Email: info@isc2.org (ISC)2 Asia-Pacific Tel: +(852) 28506951 Email: isc2asia@isc2.org (ISC)2 EMEA Tel: +44 (0)203 300 1625 Email: info-emea@isc2.org 11 v222Certification Exam Outline Effective Date: November 13, 20202 ISSEP Certification Exam Outline About CISSP-ISSEP The Information Systems Security Engineering Professional (ISSEP) is a CISSP who specializes in the practical application of systems engineering principles and processes to develop secure systems. An ISSEP analyzes organizational needs, defines security requirements, designs security architectures, develops secure designs, implements system security, and supports system security assessment and authorization for government and industry. The broad spectrum of topics included in the ISSEP Common Body of Knowledge (CBK®) ensure its relevancy across all disciplines in the field of security engineering. Successful candidates are competent in the following five domains: • Systems Security Engineering Foundations • Risk Management • Security Planning and Design • Systems Implementation, Verification and Validation • Secure Operations, Change Management and Disposal Experience Requirements Candidates must be a CISSP in good standing and have two years cumulative paid work experience in one or more of the five domains of the CISSP-ISSEP CBK. You can learn more about CISSP-ISSEP experience requirements and how to account for part-time work and internships at www.isc2.org/Certifications/CISSP-ISSEP/experience-requirements. Accreditation CISSP-ISSEP is in compliance with the stringent requirements of ANSI/ISO/IEC Standard 17024. Job Task Analysis (JTA) (ISC)² has an obligation to its membership to maintain the relevancy of the ISSEP. 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Secure Operations, Change Management and Disposal 17% Total: 100%4 ISSEP Certification Exam Outline Domain 1: Systems Security Engineering Foundations 1.1 Apply systems security engineering fundamentals 1.2 Execute systems security engineering processes 1.3 Integrate with applicable system development methodology 1.4 Perform technical management 1.5 Participate in the acquisition process 1.6 Design Trusted Systems and Networks (TSN) » Understand systems security engineering trust concepts and hierarchies » Identify the relationships between systems and security engineering processes » Apply structural security design principles » Integrate security tasks and activities » Verify security requirements throughout the process » Integrate software assurance methods » Perform project planning processes » Perform project assessment and control processes » Perform decision management processes » Perform risk management processes » Perform configuration management processes » Perform information management processes » Perform measurement processes » Perform Quality Assurance (QA) processes » Identify opportunities for security process automation » Identify organizational security authority » Identify system security policy elements » Integrate design concepts (e.g., open, proprietary, modular) » Prepare security requirements for acquisitions » Participate in selection process » Participate in Supply Chain Risk Management (SCRM) » Participate in the development and review of contractual documentation5 ISSEP Certification Exam Outline Domain 2: Risk Management 2.1 Apply security risk management principles 2.2 Address risk to system 2.3 Manage risk to operations » Establish risk context » Identify system security risks » Perform risk analysis » Perform risk evaluation » Recommend risk treatment options » Document risk findings and decisions » Determine stakeholder risk tolerance » Identify remediation needs and other system changes » Determine risk treatment options » Assess proposed risk treatment options » Recommend risk treatment options » Align security risk management with Enterprise Risk Management (ERM) » Integrate risk management throughout the lifecycle6 ISSEP Certification Exam Outline 3.1 Analyze organizational and operational environment 3.2 Apply system security principles 3.3 Develop system requirements 3.4 Create system security architecture and design Domain 3: Security Planning and Design » Capture stakeholder requirements » Identify relevant constraints and assumptions » Assess and document threats » Determine system protection needs » Develop Security Test Plans (STP) » Incorporate resiliency methods to address threats » Apply defense-in-depth concepts » Identify fail-safe defaults » Reduce Single Points of Failure (SPOF) » Incorporate least privilege concept » Understand economy of mechanism » Understand Separation of Duties (SoD) concept » Develop system security context » Identify functions within the system and security Concept of Operations (CONOPS) » Document system security requirements baseline » Analyze system security requirements » Develop functional analysis and allocation » Maintain traceability between specified design and system requirements » Develop system security design components » Perform trade-off studies » Assess protection effectiveness7 ISSEP Certification Exam Outline Domain 4: Systems Implementation, Verification and Validation 4.1 Implement, integrate and deploy security solutions 4.2 Verify and validate security solutions » Perform system security implementation and integration » Perform system security deployment activities » Perform system security verification » Perform security validation to demonstrate security controls meet stakeholder security requirements8 ISSEP Certification Exam Outline Domain 5: Secure Operations, Change Management and Disposal 5.1 Develop secure operations strategy 5.2 Participate in secure operations 5.3 Participate in change management 5.4 Participate in the disposal process » Specify requirements for personnel conducting operations » Contribute to the continuous communication with stakeholders for security relevant aspects of the system » Develop continuous monitoring solutions and processes » Support the Incident Response (IR) process » Develop secure maintenance strategy » Participate in change reviews » Determine change impact » Perform verification and validation of changes » Update risk assessment documentation » Identify disposal security requirements » Develop secure disposal strategy » Develop decommissioning and disposal procedures » Audit results of the decommissioning and disposal process9 ISSEP Certification Exam Outline Additional Examination Information Supplementary References Candidates are encouraged to supplement their education and experience by reviewing relevant resources that pertain to the CBK and identifying areas of study that may need additional attention. View the full list of supplementary references at www.isc2.org/certifications/References. Examination Policies and Procedures (ISC)² recommends that ISSEP candidates review exam policies and procedures prior to registering for the examination. Read the comprehensive breakdown of this important information at www.isc2.org/Register-for-Exam. Legal Info For any questions related to (ISC)²'s legal policies, please contact the (ISC)2 Legal Department at legal@isc2.org. Any Questions? (ISC)² Americas Tel: +1-866-331-ISC2(4722) Email: membersupport@isc2.org (ISC)² Asia Pacific Tel: +852-2850-6951 Email: membersupportapac@isc2.org (ISC)² EMEA Tel: +44-203-960-7800 Email: membersupportemea@isc2.org 9 Attachments Rate this Details Lenovo and Intel are Driving AI Innovation at the Edge Flynn Maloy, Chief Marketing Officer of Lenovo ISG Jan 23 2025| 0 mins Lenovo and Intel's long-standing partnership is transforming industries by bringing cutting-edge AI solutions to the edge and beyond. From PCs to data centers, our collaboration has consistently pushed technological boundaries. The strength of Lenovo's ThinkEdge portfolio is enabling AI-driven applications in manufacturing sites, retail stores, schools, and more. Join @Flynn Maloy, Chief Marketing Officer of Lenovo ISG, as he details how Lenovo and Intel® are leading the way in AI innovation: - Comprehensive solutions for diverse industries: From computer vision in manufacturing to advanced AI in education and retail, Lenovo and Intel's joint solutions empower a variety of applications. - Next-gen AI with CPUs: Not every AI workload requires massive GPUs. Intel's CPUs are driving the next wave of edge AI, particularly in inferencing and delivering efficient and accessible AI solutions. - Scalable and powerful edge portfolio: Lenovo's edge clients and servers, powered by Intel, are designed to meet the demands of modern businesses, offering flexibility and performance across workloads. - A partnership that drives innovation: With a shared vision for the future of AI, Lenovo and Intel continue to push the boundaries of what's possible for our customers. Together, Lenovo and Intel are leading the charge in making AI more accessible, scalable, and impactful for businesses worldwide. State of Cloud 2025: Navigating EMEA's Cloud Revolution John Bradshaw, Director of Cloud Computing Technology and Strategy, EMEA, Akamai & Bryan Glick, Editor in Chief, Computer Weekly Feb 27 2025| 18 mins Boris Cipot, Senior Security Engineer Sep 05 2024| 30 mins Python is a fast, platform-agnostic, and easy-to-learn programming language that is suited for beginners and experienced developers alike. Ever since its first release in 1991, Python has had a constant presence in the computer world and has become a go-to language thanks to its easy-to-understand code and versatility. Today, Python can boast a wide array of libraries and frameworks, and they are the cornerstone of fast and easy Python programming—the so-called Pythonic way of development. But like all programming languages, Python is not immune to security threats. Secure coding best practices must be adopted to avoid risks from attackers. In this webinar, we'll explore Python security best practices that should employed when building secure application. One-Stop DevOps: Simplifying Toolchains with GitLab and Google Cloud Nate Avery, Outbound Product Manager - Google | Jackie Porter, Director of Product - Gitlab | Torsten Volk, Principal Analyst - ESG Dec 04 2024| 28 mins Seamless Edge Deployment and Management with Lenovo and Intel Blake Kerrigan, Senior Director, ThinkEdge Business Group Jan 23 2025| 1 mins Sort by Career Opportunity Senior Applied Scientist – Copilot Team Posted: March 3, 2025 Location: Beijing, China Research Area(s): Artificial intelligence We are inviting you to join the Copilot Team, where we are redefining the future of AI-powered experiences. 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As a team, we are very customer focused and driven by curiosity, creativity, teamwork, agility, accountability and desire to learn everyday.… Career Opportunity

Applied Scientist II – Power Apps Posted: March 1, 2025 Location: Redmond, WA, US; Remote (within US) Research Area(s): Algorithms, Artificial intelligence, Data platforms and analytics, Programming languages and software engineering The Power Apps team at Microsoft is looking to hire an Applied Scientist II. As a team, we are very customer focused and driven by curiosity, creativity, team work, agility, accountability and desire to learn everyday. If… Career Opportunity Principal Applied Scientist – Advanced Autonomy and Applied Robotics Posted: March 1, 2025 Location: Redmond, WA, US Research Area(s): Artificial intelligence, Hardware and devices, Human-computer interaction, Technology for emerging markets Within Microsoft's Strategic Missions and Technologies (SMT) division, the Advanced Autonomy and Applied Robotics team is seeking a Principal Applied Scientist.The role involves building the future platform for human-robot-agent teaming. This individual will leverage cutting-edge AI and robotics technologies… Career Opportunity Senior Applied Scientist – Advanced Autonomy and Applied Robotics Posted: March 1, 2025 Location: Redmond, WA, US Research Area(s): Artificial intelligence, Hardware and devices, Human-computer interaction, Technology for emerging markets Within Microsoft's Strategic Missions and Technologies (SMT) division, the Advanced Autonomy and Applied Robotics team is seeking a Senior Applied Scientist. The role involves building the future platform for human-robot-agent teaming. This individual will leverage… Career Opportunity Principal Researcher – Generative AI – Microsoft Research AI Frontiers Posted: March 1, 2025 Location: New York, NY, US; Redmond, WA, US Research Area(s): Artificial intelligence We are seeking a Principal Researcher to join our team and lead efforts on the advancement of Generative AI and Large Language Models (LLMs) technologies. As a Principal Researcher, you will play a crucial role in leading,… Career Opportunity Senior Applied Scientist Posted: March 1, 2025 Location: Cairo, Egypt Research Area(s): Artificial intelligence In shaping the future of monetization for personalized AI assistants and pioneering innovation in the advertiser agentic space, as a Senior Applied Scientist, you will collaborate with engineers, data scientists, and product managers to develop… Career Opportunity Principal Data Scientist – Real-Time Intelligence team Posted: February 28, 2025 Location: Redmond, WA, US Research Area(s): Artificial intelligence, Data platforms and analytics, Systems and networking Microsoft Fabric's Real-Time Intelligence team is leading the transformation of real-time analytics in the world of data. We are hiring a Principal Data Scientist to tackle challenges in both open-source and proprietary technologies related to engineering Inbox tshingombe fiston Mon, Mar 3, 3:19 PM (18 hours ago) to me namics 365 Community / My Profile CU03031227-0 Stats 0 Comments 0 Posts 1 Likes 0 Questions My activity Achievements Personal information Achievements Notifications Notification settings Quick responses Personal information Email tshingombefiston@gmail.com Confirmation Registration details Name tshingombe tshitadi Status Registered Registration ID 102231646 Quick Links Go to the Microsoft Research Forum Website Registration support Cancel registration Please note: event emails will be sent to the email address you provided during registration. If you are not receiving event communications, please check your 'junk', 'spam', or 'clutter' folders to confirm your email settings have not redirected the emails. 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(AI features only available to subscription owner and cannot be shared; AI usage limits apply; minimum age limits may apply to subscription activation and use of AI features. Learn more.) • • Microsoft 365 is compatible with PC, Mac, Android and iOS. See system requirements for compatible versions of your devices, and for other feature requirements. • • No. Microsoft 365's applications are tailored for each platform and each operating system. The applications available for Mac users and the specific features included may be different from those available for PC users. With Microsoft 365, you can be flexible. With your account, you are not limited to exclusively Mac or exclusively PC, so you can transition across devices. • • Yes. Documents that you have created belong fully to you. You can choose to store them online on OneDrive or locally on your PC or Mac. • • Internet access is required to install and activate all the latest releases of apps and services included in all Microsoft 365 subscription plans. Note that if you are an existing subscriber, you do not need to reinstall or purchase another subscription. For Microsoft 365 plans, internet access is also needed to manage your subscription account, for example to install Office apps on other PCs or to change billing options. Internet access is also required to access documents stored on OneDrive, unless you install the OneDrive desktop app. You should also connect to the internet regularly to keep your version of Microsoft 365 up to date and to benefit from automatic upgrades. If you do not connect to the internet at least every 31 days, your apps will go into reduced functionality mode, which means that you can view or print your documents but cannot edit the documents or create new ones. To reactivate your apps, simply reconnect to the internet. You do not need to be connected to the internet to use the Office apps, such as Word, Excel and PowerPoint, because the apps are fully installed on your computer. • • Your Microsoft account is the combination of an email address and password that you use to sign in to services like OneDrive, Xbox LIVE and Outlook.com. If you use any of these services, you already have a Microsoft account that you can use, or you can create a new account. Learn more about Microsoft accounts. As part of signing up for a trial or purchasing Microsoft 365, you will be prompted to sign in with a Microsoft account. You must be signed in with this account to install and manage your Microsoft 365 subscription, or to use some subscription benefits, including cloud storage. • • You can share Microsoft 365 Family with five other people, for a total of six users. Microsoft 365 Personal can be used by one person. • • If you have an active Microsoft 365 Family subscription, you can share it with up to five other people. Each person you share your subscription with can install Microsoft 365 on all their devices and sign in to five devices at the same time. To add someone to your subscription, sign in to your Microsoft account and follow the on-screen instructions to add a user. Each person you add will receive an email with the steps they need to follow. Once they have accepted and completed the steps, their information, including the installs they are using, will appear on their My Account page. You can stop sharing your subscription with someone or remove a device they are using by logging into your Microsoft account. • • Visit learn more about free apps. • • Microsoft Defender is a cross-device security app that helps individuals and families protect their data and devices by continuously scanning the web for threats to your identity and personal data (US only). Defender also helps you stay safer online with malware protection, real-time security notifications and security tips. Download the Microsoft Defender app. • • Microsoft Defender is a new cross-device app that helps people and families stay safer online. Microsoft Defender adds new features and a simplified user interface. Microsoft Defender also brings valuable device protection to iOS, Android, Windows and Mac, with malware protection, web protection, real-time security notifications and security tips. Microsoft Defender is available in the Apple, Google and Microsoft app stores and requires a Microsoft 365 Personal or Family subscription to use. Windows Security, formerly known as Windows Defender Security Centre, is built-in security on Windows PCs to protect your device and data. Windows Security is pre-installed and automatically enabled. Windows Security includes Microsoft Defender Antivirus software that protects your Windows device and data against viruses, ransomware, trojans and other malware unless non-Microsoft antivirus software is active. • • A free in-browser video editing platform designed to make video creation accessible for everyone. • • AI features included in Microsoft 365 Family plans are only available to the subscription owner and cannot be shared with others. • • To use Copilot in Word, Excel, PowerPoint, OneNote and Outlook, make sure you have the latest version of Microsoft 365 installed. If you're signed in, have the latest updates installed, and still don't see Copilot, please restart your Microsoft 365 apps. Learn more about why I am not seeing Copilot in my apps. • • Microsoft 365 supports Arabic, Chinese Simplified, Chinese Traditional, Czech, Danish, Dutch, English, Finnish, French, German, Hebrew, Hungarian, Italian, Japanese, Korean, Norwegian, Polish, Portuguese, Russian, Spanish, Swedish, Thai and Turkish. Some Designer features, like inline editing capabilities, are available only in English. We plan to add more languages soon. You can also learn more about Copilot supported languages here: Copilot for Microsoft 365 supported languages – Microsoft Support. • • Visit our Copilot help & learning site to start using Copilot today. • • Microsoft Designer is a graphic design and image editing app powered by AI. Create eye-catching images with your words, craft next-level designs that pop and even edit photos like an expert. Designer is integrated across your favourite Microsoft apps like Word and PowerPoint to help you create when and where you need it. • • Beyond the Microsoft Designer web and mobile app, certain Designer features are integrated across some of your favourite Microsoft apps like Word and PowerPoint, helping spark creativity where and when you need it. For Windows users, Designer is also integrated into Microsoft Photos. • • Usage limits apply to AI-powered features, including Copilot and Designer. Your Microsoft 365 Personal or Family subscription unlocks AI credits to experience and engage with Copilot across Microsoft 365 apps and beyond. Learn more about credits. • Microsoft 365 Business Basic, Business Standard and Business Premium are tailored for businesses, offering professional email with a custom domain, admin controls for managing access and devices and scalability to add additional users as your business grows. They include advanced security features like Exchange Online Protection to guard against phishing and malware, with Business Premium adding Microsoft Defender for Business for ransomware protection and advanced threat management. Plus, you can access professional collaboration tools like Microsoft Teams with meeting recordings, transcription and team workspaces, while business apps such as Microsoft Bookings can simplify meeting and appointment scheduling. Additionally, Microsoft 365 Copilot, an AI-powered assistant for work, is available as an add-on to boost productivity and creativit Course Microsoft Azure AI Fundamentals Course AI-900T00-A: Microsoft Azure AI Fundamentals At a glance Level Beginner Product Azure Role AI Engineer Languages English Arabic Chinese (Simplified) Chinese (Traditional) French German Indonesian Italian Japanese Korean Portuguese (Brazil) Russian Spanish Course Duration 1 day Related certifications Microsoft Certified: Azure AI Fundamentals Overview This course introduces fundamentals concepts related to artificial intelligence (AI), and the services in Microsoft Azure that can be used to create AI solutions. The course is not designed to teach students to become professional data scientists or software developers, but rather to build awareness of common AI workloads and the ability to identify Azure services to support them. The course is designed as a blended learning experience that combines instructor-led training with online materials on the Microsoft Learn platform (https://azure.com/learn). The hands-on exercises in the course are based on Learn modules, and students are encouraged to use the content on Learn as reference materials to reinforce what they learn in the class and to explore topics in more depth. Audience Profile The Azure AI Fundamentals course is designed for anyone interested in learning about the types of solution artificial intelligence (AI) makes possible, and the services on Microsoft Azure that you can use to create them. You don't need to have any experience of using Microsoft Azure before taking this course, but a basic level of familiarity with computer technology and the Internet is assumed. Some of the concepts covered in the course require a basic understanding of mathematics, such as the ability to interpret charts. The course includes hands-on activities that involve working with data and running code, so a knowledge of fundamental programming principles will be helpful. Course Syllabus You can prepare in instructor-led training or self-paced study Learning Path Microsoft Azure AI Fundamentals: AI Overview 3 Modules Beginner AI Engineer Azure AI Bot Service 70% • • Learning Path Microsoft Azure AI Fundamentals: Computer Vision 3 Modules Beginner AI Engineer Azure 97% • • Learning Path Microsoft Azure AI Fundamentals: Natural Language Processing 5 Modules Beginner AI Engineer Azure Portal 95% • • Learning Path Microsoft Azure AI Fundamentals: Document Intelligence and Knowledge Mining 2 Modules Beginner AI Engineer Azure Completed • • Learning Path Microsoft Azure AI Fundamentals: Generative AI 1 of 4 modules completed Beginner AI Engineer Azure OpenAI Service 20% Search for a training provider Course Microsoft Azure AI Fundamentals Course AI-900T00-A: Microsoft Azure AI Fundamentals At a glance Level Beginner Product Azure Role AI Engineer Languages English Arabic Chinese (Simplified) Chinese (Traditional) French German Indonesian Italian Japanese Korean Portuguese (Brazil) Russian Spanish Course Duration 1 day Related certifications Microsoft Certified: Azure AI Fundamentals Overview This course introduces fundamentals concepts related to artificial intelligence (AI), and the services in Microsoft Azure that can be used to create AI solutions. 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Course Syllabus You can prepare in instructor-led training or self-paced study Learning Path Microsoft Azure AI Fundamentals: AI Overview 3 Modules Beginner AI Engineer Azure AI Bot Service 70% • • Learning Path Microsoft Azure AI Fundamentals: Computer Vision 3 Modules Beginner AI Engineer Azure 97% • • Learning Path Microsoft Azure AI Fundamentals: Natural Language Processing 5 Modules Beginner AI Engineer Azure Portal 95% • • Learning Path Microsoft Azure AI Fundamentals: Document Intelligence and Knowledge Mining 2 Modules Beginner AI Engineer Azure Completed • • Learning Path Microsoft Azure AI Fundamentals: Generative AI 1 of 4 modules completed Beginner AI Engineer Azure OpenAI Service 20% Course Microsoft Azure AI Fundamentals Course AI-900T00-A: Microsoft Azure AI Fundamentals At a glance Level Beginner Product Azure Role AI Engineer Languages English Arabic Chinese (Simplified) Chinese (Traditional) French German Indonesian Italian Japanese Korean Portuguese (Brazil) Russian Spanish Course Duration 1 day Related certifications Microsoft Certified: Azure AI Fundamentals Overview This course introduces fundamentals concepts related to artificial intelligence (AI), and the services in Microsoft Azure that can be used to create AI solutions. 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It offers an overview of the principles, governance system, and procedures followed at Microsoft, but we encourage you to develop your own AI strategy. Learning objectives In this module, you will: Prepare for the implications of responsible AI Describe principles of responsible AI Establish a system for AI governance Take actions for AI governance Engage across teams and organizations to implement responsible AI principles Take inspiration from ho Fundamentals of Generative AI 9 min remaining Module 11 Units Beginner AI Engineer Developer Solution Architect Student Azure OpenAI Service Azure In this module, you explore the way in which language models enable AI applications and services to generate original content based on natural language input. You also learn how generative AI enables the creation of agents that can assist humans in creative tasks. Learning objectives By the end of this module, you are able to: Understand generative AI's place in the development of artificial intelligence. Understand language models and their role in intelligent applications. Describe examples of Microsoft Copilot, agents, and good prompts. Knowledge check Completed 200 XP Module assessment 3 minutes 1. What are Large Language Models? Models that detect additional meaning in paragraphs of text. Lists of words and code that computers use to generate text. Models that use deep learning to process and understand natural language on a massive scale. 2. Which Microsoft Copilot should a customer support agent use to research and resolve a support issue? Microsoft Copilot for Microsoft Edge Microsoft Copilot in Dynamics 365 Customer Service Copilot for Security 3. Which tool should a professional developer use to build a custom copilot and deploy it as a service endpoint in Azure? Copilot for Azure Microsoft Copilot Studio Microsoft Azure AI Foundry ____ All units complete: Having an issue? We can help! 3900 XP Craft effective prompts for Microsoft 365 Copilot 2 hr 10 min Learning Path 0 of 4 modules completed At a glance Level Beginner Skill Create effective prompts for Microsoft Copilot for Microsoft 365 Product Microsoft Copilot Microsoft 365 Microsoft 365 Apps Word PowerPoint Excel Outlook Microsoft Teams OneNote Role Business User Subject Business applications Productivity Artificial intelligence Discover ways to craft effective and contextual prompts for Microsoft 365 Copilot that create, simplify, transform, and compile content across Microsoft 365 applications. Learn the importance of providing a clear goal, context, source, and expectation in your prompt for the best results. This course covers real world scenarios and examples using Copilot in Microsoft 365 apps like Word, Excel, PowerPoint, Teams, Outlook, OneNote, and Chat. Note This content was partially created with the help of AI. An author reviewed and revised the content as needed. Read more. Prerequisites Learners should have completed the following content prior to this course: Fundamentals of Generative AI Get started with Microsoft 365 Copilot Developer Accelerate app development by using GitHub Copilot Find out how to use GitHub Copilot to interpret and document code, author new code features more efficiently, and refactor, debug, and test code. Build AI apps with Azure Services and best practices Get the details on designing and building a cloud-native AI app, developing a back-end database, and integrating Azure AI services into applications. Build and extend copilots with Microsoft Copilot Studio Use Microsoft Copilot Studio to create conversational AI solutions, and learn how to build actions that extend Microsoft 365 Copilot. Extend Microsoft 365 Copilot (for developers) Use Copilot Studio actions, and learn about building plugins and connectors for Microsoft 365 Copilot. Discover how to choose the right option for your u Business or technical leader Transform your business with Microsoft AI In this learning path, business leaders will find the knowledge and resources to adopt AI in their organizations. Explore planning, strategizing, and scaling AI projects in a responsible way. Implement data integration and model grounding with Azure AI Foundry and Microsoft Fabric Discover how to create advanced AI solutions, ground models in their data, connect and integrate data from various sources, and use OneLake in Microsoft Fabric. Accelerate gen AI model selection, evaluation, and multimodal integration with Azure AI Foundry Find out how to benchmark models, apply multimodal models to help enhance customer satisfaction, and complete evaluations to help ensure performance and safety. Unlocking business potential with AI solutions Learn how to initiate your organization's AI strategy, assess infrastructure readiness, and understand the business impact of AI Business user Design a dream destination using Microsoft Copilot Bring your personal creativity and passion to dream up a novel destination and create the content to help tell its story. Interact with Microsoft Copilot to learn about the capabilities of generative AI. Build your Microsoft 365 Copilot skills (for end users) Find out how to create effective prompts in Microsoft 365 Copilot to help boost your productivity. Explore real-world prompts for specific use case scenarios. Work smarter with AI Get more done and unleash your creativity with Microsoft Copilot. In this learning path, you'll explore how to use Microsoft Copilot to help you research, find information, and generate Data scientist Make your data AI ready with Microsoft Fabric Discover how to implement large-scale data engineering, lakehouse, and warehouse solutions using Microsoft Fabric. Build the skills to use Fabric to effectively manage and analyze data. Run data analytics solutions with Azure Databricks Work with Apache Spark and Azure Databricks to run large data engineering workloads in the cloud, and use Azure Databricks for comprehensive data analytics solutions. IT professional Get AI-Ready with Microsoft 365 Admin This content helps admins ensure that Microsoft 365 tenants are set up and configured for AI so that future AI features can be integrated as seamlessly as possible. Discover Microsoft 365 Copilot (for administrators) Focus on security and compliance features to configure in your Microsoft 365 tenant to help protect your organizational data before you implement Microsoft 365 Copilot. Low-code developer Create Power Platform solutions with AI and Copilot Learn to use Copilot to set up Dataverse, create Power Apps, and build Automated Processes. Explore what Microsoft Copilot Studio can do to help you build and extend custom copilots. Accelerate AI development with Low Code Learn how to develop on Dataverse, Power Apps, and Power Automate. This curated content will also cover creation of custom copilots with Microsoft Copilot Studio. Extend Microsoft 365 Copilot (for developers) Use Copilot Studio actions, and learn about building plugins and connectors for Microsoft 365 Copilot. Discover how to choose the right option for your use case. Build and extend copilots with Microsoft Copilot Studio Use Microsoft Copilot Studio to create conversational AI solutions, and learn how to build actions that extend Microsoft 365 Copilot. ecurity professional Help secure your data in the age of AI Work with Microsoft Purview, Microsoft Sentinel, and Microsoft Copilot for Security, and learn how to effectively manage, protect, and govern sensitive information in AI-driven environments. Plan Help secure your data in the age of AI 3 milestones This Plan is designed to offer you interactive experience working with Microsoft technologies, including Microsoft Purview, Microsoft Sentinel, and Microsoft Copilot for Security, so you can effectively manage, protect, and govern sensitive information in AI-driven environments. Discover how to create a secure and compliant data estate that can easily adapt to AI.• Access Control and Identity Management, 3rd Ed. by Mike Chapple. Publisher: Jones and Bartlett Learning. (Sep, 2020). ____ • Building an Informati Published on 3/4/2025 Created by 46307064 Accelerate app development by using GitHub Copilot 3 milestones This Plan is designed to help you enhance your coding efficiency and accuracy. Find out how to use GitHub Copilot to interpret and document code, so you can quickly ramp up on unfamiliar or complex codebases. Learn to author new code features more efficiently by using GitHub Copilot autocompletion and chat features. Additionally, get the details on refactoring, debugging, and testing code with GitHub Copilot. Published on 3/4/2025 Created by 46307064 Tell us about your PDF experience. Install C and C++ support in Visual Studio Article • 12/09/2021 If you haven't downloaded and installed Visual Studio and the Microsoft C/C++ tools yet, here's how to get started. Visual Studio 2022 Installation Welcome to Visual Studio 2022! In this version, it's easy to choose and install just the features you need. And because of its reduced minimum footprint, it installs quickly and with less system impact. 7 Note This topic applies to installation of Visual Studio on Windows. Visual Studio Code is a lightweight, cross-platform development environment that runs on Windows, Mac, and Linux systems. The Microsoft C/C++ for Visual Studio Code extension supports IntelliSense, debugging, code formatting, auto-completion. Visual Studio for Mac doesn't support Microsoft C++, but does support .NET languages and cross-platform development. For installation instructions, see Install Visual Studio for Mac. Want to know more about what else is new in this version? See the Visual Studio release notes. Ready to install? We'll walk you through it, step-by-step. Step 1 - Make sure your computer is ready for Visual Studio Before you begin installing Visual Studio: 1. Check the system requirements. These requirements help you know whether your computer supports Visual Studio 2022. 2. Apply the latest Windows updates. These updates ensure that your computer has both the latest security updates and the required system components for Visual Studio.3. Reboot. The reboot ensures that any pending installs or updates don't hinder the Visual Studio install. 4. Free up space. Remove unneeded files and applications from your %SystemDrive% by, for example, running the Disk Cleanup app. For questions about running previous versions of Visual Studio side by side with Visual Studio 2022, see the Visual Studio 2022 Platform Targeting and Compatibility page. Step 2 - Download Visual Studio Next, download the Visual Studio bootstrapper file. To do so, choose the following button to go to the Visual Studio download page. Select the edition of Visual Studio that you want and choose the Free trial or Free download button. Download Visual Studio Step 3 - Install the Visual Studio installer Run the bootstrapper file you downloaded to install the Visual Studio Installer. This new lightweight installer includes everything you need to both install and customize Visual Studio. 1. From your Downloads folder, double-click the bootstrapper that matches or is similar to one of the following files: vs_community.exe for Visual Studio Community vs_professional.exe for Visual Studio Professional vs_enterprise.exe for Visual Studio Enterprise If you receive a User Account Control notice, choose Yes to allow the bootstrapper to run. 2. We'll ask you to acknowledge the Microsoft License Terms and the Microsoft Privacy Statement . Choose Continue. Step 4 - Choose workloads After the installer is installed, you can use it to customize your installation by selecting the workloads, or feature sets, that you want. Here's how. 1. Find the workload you want in the Installing Visual Studio screen.For core C and C++ support, choose the "Desktop development with C++" workload. It comes with the default core editor, which includes basic code editing support for over 20 languages, the ability to open and edit code from any folder without requiring a project, and integrated source code control. Additional workloads support other kinds of development. For example, choose the "Universal Windows Platform development" workload to create apps that use the Windows Runtime for the Microsoft Store. Choose "Game development with C++" to create games that use DirectX, Unreal, and Cocos2d. Choose "Linux development with C++" to target Linux platforms, including IoT development. The Installation details pane lists the included and optional components installed by each workload. You can select or deselect optional components in this list. For example, to support development by using the Visual Studio 2017 or 2015 compiler toolsets, choose the MSVC v141 or MSVC v140 optional components. You can add support for MFC, the experimental Modules language extension, IncrediBuild, and more. 2. After you choose the workload(s) and optional components you want, choose Install. Next, status screens appear that show the progress of your Visual Studio installation. ☐ Tip At any time after installation, you can install workloads or components that you didn't install initially. If you have Visual Studio open, go to Tools > Get Tools andFeatures... which opens the Visual Studio Installer. Or, open Visual Studio Installer from the Start menu. From there, you can choose the workloads or components that you wish to install. Then, choose Modify. Step 5 - Choose individual components (Optional) If you don't want to use the Workloads feature to customize your Visual Studio installation, or you want to add more components than a workload installs, you can do so by installing or adding individual components from the Individual components tab. Choose what you want, and then follow the prompts. Step 6 - Install language packs (Optional) By default, the installer program tries to match the language of the operating system when it runs for the first time. To install Visual Studio in a language of your choosing, choose the Language packs tab from the Visual Studio Installer, and then follow the prompts. Change the installer language from the command line Another way that you can change the default language is by running the installer from the command line. For example, you can force the installer to run in English by using the following command: vs_installer.exe --locale en-US . The installer will remember this setting when it's run the next time. The installer supports the following language tokens: zh-cn, zh-tw, cs-cz, en-us, es-es, fr-fr, de-de, it-it, ja-jp, ko-kr, pl-pl, pt-br, ru-ru, and tr-tr.Step 7 - Change the installation location (Optional) You can reduce the installation footprint of Visual Studio on your system drive. You can choose to move the download cache, shared components, SDKs, and tools to different drives, and keep Visual Studio on the drive that runs it the fastest.) Important You can select a different drive only when you first install Visual Studio. If you've already installed it and want to change drives, you must uninstall Visual Studio and then reinstall it. Step 8 - Start developing 1. After Visual Studio installation is complete, choose the Launch button to get started developing with Visual Studio. 2. On the start window, choose Create a new project. 3. In the search box, enter the type of app you want to create to see a list of available templates. The list of templates depends on the workload(s) that you chose during installation. To see different templates, choose different workloads. You can also filter your search for a specific programming language by using the Language drop-down list. You can filter by using the Platform list and the Project type list, too. 4. Visual Studio opens your new project, and you're ready to code! When Visual Studio is running, you're ready to continue to the next step. Next Steps Create a C++ projectWhat is Visual Studio? Article • 06/19/2024 Visual Studio is a powerful developer tool that you can use to complete the entire development cycle in one place. It's a comprehensive integrated development environment (IDE) that you can use to write, edit, debug, and build code. Then deploy your app. Visual Studio includes compilers, code completion tools, source control, extensions, and many other features to enhance every stage of the software development process. With the variety of features and languages support in Visual Studio, you can grow from writing your first "Hello World" program to developing and deploying apps. For example, build, debug, and test .NET and C++ apps, edit ASP.NET pages in the web designer view, develop cross-platform mobile and desktop apps with .NET, or build responsive Web UIs in C#. To install Visual Studio, select the following button, and choose the edition of Visual Studio to download. Download Visual Studio Why use Visual Studio? Visual Studio provides developers a feature rich development environment to develop high-quality code efficiently and collaboratively. Workload-based installer - install only what you need Powerful coding tools and features - everything you need to build your apps in one placeMultiple language support - code in C++, C#, JavaScript, TypeScript, Python, and more Cross-platform development - build apps for any platform Version control integration - collaborate on code with team mates AI-assisted development - write code more efficiently with AI assistance Discover Visual Studio Visual Studio supports different parts of the software development cycle. Develop your code Visual Studio IDE provides many features that make it easier for you to write and manage your code with confidence. For example, code quickly and accurately with AI assisted development tools. These tools include GitHub Copilot and IntelliCode. Make quick improvements to your code using light bulbs that suggest actions, or expand/collapse blocks of code using outlining. 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You can run multi-processor builds for C++ and C# projects. Visual Studio also provides several options that you can configure when you build applications. You can create a custom build configuration in addition to the built-in configurations, hide certain warning messages, or increase build output information. Learn more about how to compile and build in Visual Studio: Create build configurations for your project Build an application Debug your code Integrated debugging in Visual Studio enables you to debug, profile, and diagnose with ease. You step through your code and look at the values stored in variables, set watches on variables to see when values changes, examine the execution path of your code. Visual Studio offers other ways to debug your code while it runs. Learn more about debugging effectively in Visual Studio: Debug your app Debugging techniques and tools Measure app performance Debug with Copilot Tips and tricks Test your code You can write high-quality code with comprehensive testing tools in Visual Studio. Unit tests give developers and testers a quick way to find logic errors in code. You can analyze how much code you're testing and see instant results in a test suite. Know the impact of every change you make with advanced features that test code while you type. Learn more about the testing tools available in Visual Studio: Use testing tools in Visual Studio Create and run unit tests Analyze code coverage Version controlWith the integrated Git features in Visual Studio, you can clone, create, or open your own repositories. The Git tool window has everything you need to commit and push changes, manage branches, and resolve merge conflicts. If you have a GitHub account, you can manage those repos directly within Visual Studio. Learn more about version control in Visual Studio: Version control with Git Visual Studio and GitHub Collaborate with others Visual Studio Live Share enables real-time collaborative development. With Live Share you can share your project with your peers, no matter the language or platform. Get to the bottom of an issue fast by allowing your team to connect, navigate, set break points, and type in your editor session. Learn more about how to collaborate with Live Share: Collaborate with Live Share Common use cases Deploy your app By deploying an application, service, or component, you distribute it for installation on other computers, devices, or servers, or in the cloud. You can choose the appropriate method in Visual Studio for the type of deployment that you need. Share your apps and code by publishing to the web or Azure, or by deploying to a network share or a local folder. Learn more about how to deploy your app using Visual Studio: Deploy your app from Visual Studio Deploy your app to a folder, a web server, Azure, or another destination Choose your Visual Studio edition There are three editions of Visual Studio: Community - free, fully featured IDE for students, open-source developers, and individual developers. Professional - a subscription based option for individual developers or small teams.Feedback Was this page helpful? Provide product feedback | Ask the community Enterprise - a subscription based option for small to large business and enterprise organizations. Compare features across Visual Studio editions and acquire the Visual Studio edition that best fits your needs. Select the following button to install Visual Studio, and choose the edition of Visual Studio. Dive into coding with one of the following language-specific tutorials: Create a simple C# console app Get started with Python Create a simple VB console app Create a C++ console app Create a Node.js and Express app To develop any type of app, or learn a language, you work in the feature rich Visual Studio Integrated Development Environment (IDE). Explore Visual Studio further with one of these introductory articles: Tour the IDE to get familiar with the IDE features and to learn how to use it for basic tasks. Cover the basics in this Learn module: Introduction to Visual Studio Install Visual Studio Download Visual Studio Get started Related content Yes NoCreate a C++ console app project Article • 07/06/2023 The usual starting point for a C++ programmer is a "Hello, world!" application that runs on the command line. That's what you create in Visual Studio in this step. Prerequisites Have Visual Studio with the Desktop development with C++ workload installed and running on your computer. If it's not installed yet, see Install C++ support in Visual Studio. Create your app project Visual Studio uses projects to organize the code for an app, and solutions to organize your projects. A project contains all the options, configurations, and rules used to build your apps. It manages the relationship between all the project's files and any external files. To create your app, first, create a new project and solution. 1. In Visual Studio, open the File menu and choose New > Project to open the Create a new Project dialog. Select the Console App template that has C++, Windows, and Console tags, and then choose Next.2. In the Configure your new project dialog, enter HelloWorld in the Project name edit box. Choose Create to create the project. Visual Studio creates a new project. It's ready for you to add and edit your source code. By default, the Console App template provides source code for a "Hello World" app, like this: When the code looks like this in the editor, you're ready to go on to the next step and build your app.I ran into a problem. Next steps Build and run a C++ project Troubleshooting guide Come here for solutions to common issues when you create your first C++ project. Create your app project: issues The New Project dialog should show a Console App template that has C++, Windows, and Console tags. If you don't see it, there are two possible causes. It might be filtered out of the list, or it might not be installed. First, check the filter dropdowns at the top of the list of templates. Set them to C++, Windows, and Console. The C++ Console App template should appear; otherwise, the Desktop development with C++ workload isn't installed. To install Desktop development with C++, you can run the installer right from the New Project dialog. Choose the Install more tools and features link at the bottom of the template list to start the installer. If the User Account Control dialog requests permissions, choose Yes. In the installer, make sure the Desktop development with C++ workload is checked. Then choose Modify to update your Visual Studio installation. If another project with the same name already exists, choose another name for your project. Or, delete the existing project and try again. To delete an existing project, delete the solution folder (the folder that contains the helloworld.sln file) in File Explorer. Go back.Build and run a C++ console app project Article • 07/01/2024 In Create a C++ console app project you created a C++ console app project and entered your code. Now you can build and run it within Visual Studio. Then, run it as a stand-alone app from the command line. Prerequisites Have Visual Studio with the Desktop development with C++ workload installed and running on your computer. If it's not installed, follow the steps in Install C++ support in Visual Studio. Create a "Hello, World!" project. By default, it contains code to print Hello World! . If you haven't done this step yet, follow the steps in Create a C++ console app project. If Visual Studio looks like this, you're ready to build and run your app: Build and run your code in Visual Studio1. To build your project, from the main menu choose Build > Build Solution. The Output window shows the results of the build process. 2. To run the code, on the menu bar, choose Debug, Start without debugging. A console window opens and then runs your app. When you start a console app in Visual Studio, it runs your code, then prints "Press any key to continue . . ." to give you a chance to see the output.Congratulations! You created your first "Hello, world!" console app in Visual Studio! Press a key to dismiss the console window and return to Visual Studio. I ran into a problem. Run your code in a command window Normally, you run console apps at the command prompt, not in Visual Studio. Once Visual Studio builds your app, you can run it from a command window. Here's how to find and run your new app in a command prompt window. 1. In Solution Explorer, select the HelloWorld solution (not the HelloWorld project) and right-click to open the context menu. Choose Open Folder in File Explorer to open a File Explorer window in the HelloWorld solution folder. 2. In the File Explorer window, open the x64 folder and then the Debug folder. This folder contains your app, HelloWorld.exe , and debugging files. Hold down the Shift key and right-click on HelloWorld.exe to open the context menu. Choose Copy as path to copy the path to your app to the clipboard. If you see HelloWorld.exe.recipe , it's because you did the Open Folder in File Explorer step on the HelloWorld project instead of the HelloWorld solution. Navigate up a level in File Explorer to get to the solution folder. This folder also contains a x64\Debug\ folder, where HelloWorld.exe is. 3. To open a command prompt window, press Windows+R to open the Run dialog. Enter cmd.exe in the Open textbox, then choose OK to run a command prompt window. 4. In the command prompt window, right-click to paste the path to your app into the command prompt. Press Enter to run your app.Congratulations, you built and ran a console app in Visual Studio! I ran into a problem. Next Steps Once you build and run this simple app, you're ready for more complex projects. For more information, see Using the Visual Studio IDE for C++ Desktop Development. It has more detailed walkthroughs that explore the capabilities of Microsoft C++ in Visual Studio. Troubleshooting guide Come here for solutions to common issues when you create your first C++ project. Build and run your code in Visual Studio: issues If red squiggles appear under anything in the source code editor, the build may have errors or warnings. Check that your code matches the example in spelling, punctuation, and case. Go back. Run your code in a command window: issuesFeedback Was this page helpful? Provide product feedback | Get help at Microsoft Q&A If the path shown in File Explorer ends in \HelloWorld\HelloWorld , you opened the HelloWorld project instead of the HelloWorld solution. You won't see your app in the x64\Debug folder. Navigate up a level in File Explorer to get to the solution folder, the first HelloWorld in the path. This folder also contains a x64\Debug folder, where your app is. You can also navigate to the solution x64\Debug folder at the command line to run your app. Your app won't run from other directories without specifying the path to the app. However, you can copy your app to another directory and run it from there. It's also possible to copy it to a directory specified by your PATH environment variable, then run it from anywhere. If you don't see Copy as path in the shortcut menu, dismiss the menu, and then hold down the Shift key while you open it again. This command is just for convenience. You can also copy the path to the folder from the File Explorer search bar, and paste it into the Run dialog, and then enter the name of your executable at the end. It's just a little more typing, but it has the same result. Go back. Yes NoWelcome back to C++ - Modern C++ Article • 11/07/2022 Since its creation, C++ has become one of the most widely used programming languages in the world. Well-written C++ programs are fast and efficient. The language is more flexible than other languages: It can work at the highest levels of abstraction, and down at the level of the silicon. C++ supplies highly optimized standard libraries. It enables access to low-level hardware features, to maximize speed and minimize memory requirements. C++ can create almost any kind of program: Games, device drivers, HPC, cloud, desktop, embedded, and mobile apps, and much more. Even libraries and compilers for other programming languages get written in C++. One of the original requirements for C++ was backward compatibility with the C language. As a result, C++ has always permitted C-style programming, with raw pointers, arrays, null-terminated character strings, and other features. They may enable great performance, but can also spawn bugs and complexity. The evolution of C++ has emphasized features that greatly reduce the need to use C-style idioms. The old C programming facilities are still there when you need them. However, in modern C++ code you should need them less and less. Modern C++ code is simpler, safer, more elegant, and still as fast as ever. The following sections provide an overview of the main features of modern C++. Unless noted otherwise, the features listed here are available in C++11 and later. In the Microsoft C++ compiler, you can set the /std compiler option to specify which version of the standard to use for your project. Resources and smart pointers One of the major classes of bugs in C-style programming is the memory leak. Leaks are often caused by a failure to call delete for memory that was allocated with new . Modern C++ emphasizes the principle of resource acquisition is initialization (RAII). The idea is simple. Resources (heap memory, file handles, sockets, and so on) should be owned by an object. That object creates, or receives, the newly allocated resource in its constructor, and deletes it in its destructor. The principle of RAII guarantees that all resources get properly returned to the operating system when the owning object goes out of scope. To support easy adoption of RAII principles, the C++ Standard Library provides three smart pointer types: std::unique_ptr, std::shared_ptr, and std::weak_ptr. A smart pointer handles the allocation and deletion of the memory it owns. The following exampleshows a class with an array member that is allocated on the heap in the call to make_unique() . The calls to new and delete are encapsulated by the unique_ptr class. When a widget object goes out of scope, the unique_ptr destructor will be invoked and it will release the memory that was allocated for the array. C++ Whenever possible, use a smart pointer to manage heap memory. If you must use the new and delete operators explicitly, follow the principle of RAII. For more information, see Object lifetime and resource management (RAII). C-style strings are another major source of bugs. By using std::string and std::wstring, you can eliminate virtually all the errors associated with C-style strings. You also gain the benefit of member functions for searching, appending, prepending, and so on. Both are highly optimized for speed. When passing a string to a function that requires only read only access, in C++17 you can use std::string_view for even greater performance benefit. The standard library containers all follow the principle of RAII. They provide iterators for safe traversal of elements. And, they're highly optimized for performance and have been thoroughly tested for correctness. By using these containers, you eliminate the potential #include class widget { private: std::unique_ptr data; public: widget(const int size) { data = std::make_unique(size); } void do_something() {} }; void functionUsingWidget() { widget w(1000000); // lifetime automatically tied to enclosing scope // constructs w, including the w.data gadget member // ... w.do_something(); // ... } // automatic destruction and deallocation for w and w.data std::string and std::string_view std::vector and other Standard Library containersfor bugs or inefficiencies that might be introduced in custom data structures. Instead of raw arrays, use vector as a sequential container in C++. C++ vector apples; apples.push_back("Granny Smith"); Use map (not unordered_map) as the default associative container. Use set, multimap, and multiset for degenerate and multi cases. C++ map apple_color; // ... apple_color["Granny Smith"] = "Green"; When performance optimization is needed, consider using: Unordered associative containers such as unordered_map. These have lower per element overhead and constant-time lookup, but they can be harder to use correctly and efficiently. Sorted vector . For more information, see Algorithms. Don't use C-style arrays. For older APIs that need direct access to the data, use accessor methods such as f(vec.data(), vec.size()); instead. For more information about containers, see C++ Standard Library Containers. Standard Library algorithms Before you assume that you need to write a custom algorithm for your program, first review the C++ Standard Library algorithms. The Standard Library contains an ever growing assortment of algorithms for many common operations such as searching, sorting, filtering, and randomizing. The math library is extensive. In C++17 and later, parallel versions of many algorithms are provided. Here are some important examples: for_each , the default traversal algorithm (along with range-based for loops). transform , for not-in-place modification of container elements find_if , the default search algorithm. sort , lower_bound , and the other default sorting and searching algorithms.To write a comparator, use strict < and use named lambdas when you can. C++ C++11 introduced the auto keyword for use in variable, function, and template declarations. auto tells the compiler to deduce the type of the object so that you don't have to type it explicitly. auto is especially useful when the deduced type is a nested template: C++ C-style iteration over arrays and containers is prone to indexing errors and is also tedious to type. To eliminate these errors, and make your code more readable, use range-based for loops with both Standard Library containers and raw arrays. For more information, see Range-based for statement. C++ auto comp = [](const widget& w1, const widget& w2) { return w1.weight() < w2.weight(); } sort(v.begin(), v.end(), comp); auto i = lower_bound(v.begin(), v.end(), widget{0}, comp); auto instead of explicit type names map<int,list>::iterator i = m.begin(); // C-style auto i = m.begin(); // modern C++ Range-based for loops #include #include int main() { std::vector v {1,2,3}; // C-style for(int i = 0; i < v.size(); ++i) { std::cout << v[i]; }Macros in C and C++ are tokens that are processed by the preprocessor before compilation. Each instance of a macro token is replaced with its defined value or expression before the file is compiled. Macros are commonly used in C-style programming to define compile-time constant values. However, macros are error-prone and difficult to debug. In modern C++, you should prefer constexpr variables for compile-time constants: C++ In modern C++, you can use brace initialization for any type. This form of initialization is especially convenient when initializing arrays, vectors, or other containers. In the following example, v2 is initialized with three instances of S . v3 is initialized with three instances of S that are themselves initialized using braces. The compiler infers the type of each element based on the declared type of v3 . C++ // Modern C++: for(auto& num : v) { std::cout << num; } } constexpr expressions instead of macros #define SIZE 10 // C-style constexpr int size = 10; // modern C++ Uniform initialization #include struct S { std::string name; float num; S(std::string s, float f) : name(s), num(f) {} }; int main() { // C-style initialization std::vector v; S s1("Norah", 2.7);For more information, see Brace initialization. Modern C++ provides move semantics, which make it possible to eliminate unnecessary memory copies. In earlier versions of the language, copies were unavoidable in certain situations. A move operation transfers ownership of a resource from one object to the next without making a copy. Some classes own resources such as heap memory, file handles, and so on. When you implement a resource-owning class, you can define a move constructor and move assignment operator for it. The compiler chooses these special members during overload resolution in situations where a copy isn't needed. The Standard Library container types invoke the move constructor on objects if one is defined. For more information, see Move Constructors and Move Assignment Operators (C++). In C-style programming, a function can be passed to another function by using a function pointer. Function pointers are inconvenient to maintain and understand. The function they refer to may be defined elsewhere in the source code, far away from the point at which it's invoked. Also, they're not type-safe. Modern C++ provides function objects, classes that override the operator() operator, which enables them to be called like a function. The most convenient way to create function objects is with inline lambda expressions. The following example shows how to use a lambda expression to pass a function object, that the find_if function will invoke on each element in the vector: C++ S s2("Frank", 3.5); S s3("Jeri", 85.9); v.push_back(s1); v.push_back(s2); v.push_back(s3); // Modern C++: std::vector v2 {s1, s2, s3}; // or... std::vector v3{ {"Norah", 2.7}, {"Frank", 3.5}, {"Jeri", 85.9} }; } Move semantics Lambda expressionsThe lambda expression [=](int i) { return i > x && i < y; } can be read as "function that takes a single argument of type int and returns a boolean that indicates whether the argument is greater than x and less than y ." Notice that the variables x and y from the surrounding context can be used in the lambda. The [=] specifies that those variables are captured by value; in other words, the lambda expression has its own copies of those values. Modern C++ emphasizes exceptions, not error codes, as the best way to report and handle error conditions. For more information, see Modern C++ best practices for exceptions and error handling. Use the C++ Standard Library std::atomic struct and related types for inter-thread communication mechanisms. Unions are commonly used in C-style programming to conserve memory by enabling members of different types to occupy the same memory location. However, unions aren't type-safe and are prone to programming errors. C++17 introduces the std::variant class as a more robust and safe alternative to unions. The std::visit function can be used to access the members of a variant type in a type-safe manner. C++ Language Reference Lambda Expressions C++ Standard Library Microsoft C/C++ language conformance std::vector v {1,2,3,4,5}; int x = 2; int y = 4; auto result = find_if(begin(v), end(v), [=](int i) { return i > x && i Options > Debugging > General and ensure that Require source files to exactly match the original version is checked. Create your app project Visual Studio uses projects to organize the code for an app, and solutions to organize one or more projects. A project contains all the options, configurations, and rules used to build an app. It also manages the relationship between all the project's files and any external files. To create your app, first, create a new project and solution. 1. Start Visual Studio--the Visual Studio Start dialog box appears. Select Create a new project to get started.2. In the Create a new project dialog, set the language dropdown to C++, set the platform dropdown to Windows, select Console App from the list of project types, then select Next.) Important Make sure you select the C++ version of the Console App template. It has the C++, Windows, and Console tags, and the icon has "++" in the corner.3. In the Configure your new project dialog box, select the Project name text box, name your new project CalculatorTutorial, then select Create. An empty C++ Windows console application 'Hello World' app is created. Console applications use a Windows console window to display output and accept user input. In Visual Studio, an editor window opens and shows the generated code: C++ // CalculatorTutorial.cpp : This file contains the 'main' function. Program execution begins and ends there. // #include int main() { std::cout < Start Without Debugging menu // Debug program: F5 or Debug > Start Debugging menu // Tips for Getting Started: // 1. Use the Solution Explorer window to add/manage files // 2. Use the Team Explorer window to connect to source control // 3. Use the Output window to see build output and other messages // 4. Use the Error List window to view errors // 5. Go to Project > Add New Item to create new code files, or Project > Add Existing Item to add existing code files to the project// 6. In the future, to open this project again, go to File > Open > Project and select the .sln file Verify that your new app builds and runs The template for a new Windows console application creates a simple C++ "Hello World" app. At this point, you can see how Visual Studio builds and runs the apps you create right from the IDE. 1. To build your project, select Build Solution from the Build menu. The Output window shows the results of the build process. 2. To run the code, on the menu bar, select Debug > Start without debugging (Ctrl+F5).A console window opens and your app runs within it. When you start a console app in Visual Studio, it runs your code, then prints "Press any key to close this window . . ." to give you a chance to see the output. Congratulations! You created your first "Hello, world!" console app in Visual Studio! 3. Press a key to dismiss the console window and return to Visual Studio. You now have the tools to build and run your app after every change, to verify that the code still works as you expect. Later, we show you how to debug it if it doesn't. Now let's modify the code in this template to be a calculator app. 1. Replace the contents of the CalculatorTutorial.cpp file with the following code so that it matches this example: C++ Edit the code // CalculatorTutorial.cpp : This file contains the 'main' function. Program execution begins and ends there. // #include using namespace std; int main() { cout << "Calculator Console Application" << endl << endl; cout << "Please enter the operation to perform. Format: a+b | a-b |Understanding the code: The #include statement brings in code in other files. Sometimes, you may see a filename surrounded by angle brackets like . The angle brackets instruct the compiler to look for the iostream header file first in the standard system directories, and if not found, to look in directories specific to the project. Other times, you may see a filename surrounded by quotes like "someHeader.h" . The quotes instruct the compiler to skip looking in the standard system directories and instead only look in directories specific to the project. The using namespace std; tells the compiler to expect code from the C++ Standard Library to be used in this file. Without this line, each keyword from the library would have to be preceded with std:: to denote its scope. For instance, without that line, each reference to cout would be written as std::cout . The using statement is added to make it more convenient to access code in another namespace. The cout keyword is used to print to standard output in C++. The << operator tells the compiler to send whatever is to the right of it to the standard output. The endl keyword is like the Enter key; it ends the line and moves the cursor to the next line. It's a better practice to put a \n inside the string (contained by "") to do the same thing because endl always flushes the buffer which can hurt the performance of the program. But since this is a very small app, endl is used instead. All C++ statements must end with semicolons and all C++ applications must contain a main() function. This function is what the program runs at a*b | a/b" < Start Without Debugging menu // Debug program: F5 or Debug > Start Debugging menu // Tips for Getting Started: // 1. Use the Solution Explorer window to add/manage files // 2. Use the Team Explorer window to connect to source control // 3. Use the Output window to see build output and other messages // 4. Use the Error List window to view errors // 5. Go to Project > Add New Item to create new code files, or Project > Add Existing Item to add existing code files to the project // 6. In the future, to open this project again, go to File > Open > Project and select the .sln filethe start. All code must be accessible from main() in order to be used. 2. To save the file, press Ctrl+S, or select the floppy disk icon in the toolbar under the menu bar. 3. To run the application, press Ctrl+F5 or go to the Debug menu and select Start Without Debugging. You should see a console window appear that looks like this. 4. Close the console window when you're done. Add code to do some math A class is like a blueprint for an object that does something. In this case, we define a calculator class to contain the math logic. Add a Calculator class 1. Go to the Project menu and select Add Class. In the Class Name edit box, enter Calculator. Select OK. Two new files get added to your project. To save all your changed files at once, press Ctrl+Shift+S. It's a keyboard shortcut for File > Save All. There's also a toolbar button for Save All, an icon of two floppy disks, found beside the Savebutton. In general, it's good practice to do Save All frequently, so you don't miss saving any changes. The Add Class wizard creates .h and .cpp files that have the same name as the class. You can see a full list of your project files in the Solution Explorer window, visible on the side of the IDE. If the window isn't visible, open it from the menu bar via View > Solution Explorer. You can open a file by double-clicking it in the Solution Explorer window. Double click Calculator.h to open it. 2. Replace the contents of Calculator.h with the following code so that the file now looks like this: C++ Understanding the code This code declares a new function called Calculate , which handles math operations for addition, subtraction, multiplication, and division. #pragma once class Calculator { public: double Calculate(double x, char oper, double y); };C++ code is organized into header (.h) files and source (.cpp) files. Some other file extensions are supported by various compilers, but these are the main ones to know about. Functions and variables are normally declared, that is, given a name and a type, in header files, and implemented, or given a definition, in source files. To access code defined in another file, you can use #include "filename.h" , where filename.h is the name of the file that declares the variables or functions you want to use. It's good practice to organize your code into different files based on what it does, so it's easy to find the code you need later. In our case, we define the Calculator class separately from the file containing the main() function, but we plan to reference the Calculator class in main() . 3. A green squiggle appears under Calculate because although the Calculate function is declared, it isn't defined. Hover over Calculate , click the down arrow on the screwdriver icon, and select Create definition of 'Calculate' in Calculator.cpp . This code is added to Calculator.cpp :Currently, it just returns 0.0. Let's change that. 4. Switch to the Calculator.cpp file in the editor window. Replace the contents of Calculator::Calculate(double x, char oper, double y) with: C++ Understanding the code The function Calculate takes a number, an operator, and a second number. Then it performs the requested operation on the two numbers. The switch statement checks which operator was provided, and executes the case corresponding to that operation. The default: case is a fallback double Calculator::Calculate(double x, char oper, double y) { switch(oper) { case '+': return x + y; case '-': return x - y; case '*': return x * y; case '/': return x / y; default: return 0.0; } }in case the user types an operator that isn't handled by any of the preceding case statements. It's best to handle invalid user input in a more elegant way, but this is beyond the scope of this tutorial. The double keyword denotes a type of number that supports decimals. This type of number is called a floating-point number, and double means a floating point number that has extra precision. This way, the calculator can handle both decimal math and integer math. The Calculate function is required to always return a double-precision floating point number due to the double at the start of the code (this denotes the function's return type), which is why we return 0.0 in the default case. The .h file declares the function prototype, which tells the compiler upfront what parameters it requires, and what return type to expect from it. The .cpp file has all the implementation details of the function. If you build and run the code again at this point, it immediately exits after asking which operation to perform. So, modify the main function to do multiple calculations. 1. Update the main function in CalculatorTutorial.cpp as follows: C++ Call the Calculator class member functions // CalculatorTutorial.cpp : This file contains the 'main' function. Program execution begins and ends there. // #include #include "Calculator.h" using namespace std; int main() { double x = 0.0; double y = 0.0; double result = 0.0; char oper = '+'; cout << "Calculator Console Application" << endl << endl; cout << "Please enter the operation to perform. Format: a+b | a-b | a*b | a/b" <> x >> oper >> y; result = c.Calculate(x, oper, y); cout << "Result " << "of " << x << oper << y << " is: " << result < Windows > Autos. To see all of the variables from that function, switch to the Locals window. Because this is a small function, the Autos and Locals window show the same variables. But you can modify the values of these variables in the Locals window while debugging to see what effect they would have on the program. In this case, we leave them alone. Open the Locals window by selecting Locals at the bottom of the Autos window, or by selecting from the main menu Debug > Windows > Locals.You can also hover over variables in the code to see their current values at the point where execution is currently paused. Make sure the editor window is in focus by clicking on it first. Continue debugging 1. The yellow arrow on the left shows the current point of execution. The current line calls Calculate , so press F11 to Step Into the function. Now you're executing code in the body of the Calculate function. Be careful with Step Into because it steps into any functions on the line you're on, including standard library functions. It's fine to step into the standard library, but you may be more interested in focusing on your code instead of library code. 2. Now that the point of execution is at the start of the Calculate function, press F10 to move to the next line in the program's execution. F10 is also known as Step Over. You can use Step Over to move from line to line, without delving into the details of what is occurring in each part of the line. In general, you should use Step Over instead of Step Into unless you want to dive more deeply into code that is being called from elsewhere (as you did to reach the body of Calculate). 3. Continue using F10 to Step Over each line until you get back to the main() function in the other file, and stop on the cout line.The program is doing what's expected: it takes the first number, and divides it by the second. On the cout line, hover over the result variable or take a look at result in the Autos window. Its value is inf , which doesn't look right. Let's fix it. The cout line outputs whatever value is stored in result , so when you step one more line forward using F10, the console window displays: This result is because division by zero is undefined, so the program doesn't have a numerical answer for the requested operation. Fix the "divide by zero" error Let's handle division by zero more gracefully so that it's easier for the user to understand the problem. 1. Make the following changes in CalculatorTutorial.cpp . You can leave the program running as you edit, thanks to a debugger feature called Edit andContinue. Add an if statement following cin >> x >> oper >> y; to check for division by zero and output a message to the user if it happens. Otherwise, the result is printed. C++ 2. Press F5 once. Program execution continues until it has to pause to ask for user input. Enter 10 / 0 again. Now, a more helpful message is printed. The user is asked for more input, and the program continues executing normally. // CalculatorTutorial.cpp : This file contains the 'main' function. Program execution begins and ends there. // #include #include "Calculator.h" using namespace std; int main() { double x = 0.0; double y = 0.0; double result = 0.0; char oper = '+'; cout << "Calculator Console Application" << endl << endl; cout << "Please enter the operation to perform. Format: a+b | a-b | a*b | a/b" <> x >> oper >> y; if (oper == '/' && y == 0) { cout << "Math error: Attempted to divide by zero!" << endl; continue; } else { result = c.Calculate(x, oper, y); } cout << "Result " << "of " << x << oper << y << " is: " << result <Options->General needs to be enabled..." To fix this, from the main menu select Tools > Options > Debugging > General and ensure that Require source files to exactly match the original version is checked. Understanding the Run and Debug shortcuts F5, or Debug > Start Debugging, starts a debugging session, if one isn't already active, and runs the program until a breakpoint is hit or the program needs user input. If no user input is needed and no breakpoint is available to hit, the program terminates and the console window closes itself when the program finishes running. If your program outputs to the console, use Ctrl+F5 or set a breakpoint before you press F5 to keep the window open. Ctrl+F5, or Debug > Start Without Debugging, runs the application without going into debug mode. This is slightly faster than debugging, and the console window stays open after the program finishes executing. F10, known as Step Over, lets you iterate through code, line-by-line, and visualize how the code is run and what variable values are at each step of execution.F11, known as Step Into, works similarly to Step Over, except it steps into any functions called on the line of execution. For example, if the line being executed calls a function, pressing F11 moves the pointer into the body of the function, so you can follow the function's code being run before coming back to the line you started at. Pressing F10 steps over the function call and just moves to the next line; the function call still happens, but the program doesn't pause to show you what it's doing. Close the app If it's still running, close the console window to stop the calculator app. Add Git source control Now that you've created an app, you might want to add it to a Git repository. We've got you covered. Visual Studio makes that process easy with Git tools you can use directly from the IDE. Tip Git is the most widely used modern version control system, so whether you're a professional developer or you're learning how to code, Git can be very useful. If you're new to Git, the https://git-scm.com/ website is a good place to start. There, you can find cheat sheets, a popular online book, and Git Basics videos. To associate your code with Git, you start by creating a new Git repository where your code is located. Here's how: 1. In the status bar at the bottom-right corner of Visual Studio, select Add to Source Control, and then select Git. 2. In the Create a Git repository dialog box, sign in to GitHub.The repository name auto-populates based on your folder location. By default, your new repository is private, which means you're the only one who can access it. Tip Whether your repository is public or private, it's best to have a remote backup of your code stored securely on GitHub. Even if you aren't working with a team, a remote repository makes your code available to you from any computer. 3. Select Create and Push. After you create your repository, status details appear in the status bar. The first icon with the arrows shows how many outgoing/incoming commits are in your current branch. You can use this icon to pull any incoming commits or push any outgoing commits. You can also choose to view these commits first. To do so, select the icon, and then select View Outgoing/Incoming.Feedback Was this page helpful? Provide product feedback | Get help at Microsoft Q&A The second icon with the pencil shows the number of uncommitted changes to your code. You can select this icon to view those changes in the Git Changes window. To learn more about how to use Git with your app, see the Visual Studio version control documentation. Congratulations! You completed the code for the calculator app, built and debugged it, and added it to a repo, all in Visual Studio. Learn more about Visual Studio for C++ The finished app Next steps Yes NoGet started with C++/WinRT Article • 02/13/2023) Important For info about setting up Visual Studio for C++/WinRT development—including installing and using the C++/WinRT Visual Studio Extension (VSIX) and the NuGet package (which together provide project template and build support)—see Visual Studio support for C++/WinRT. To get you up to speed with using C++/WinRT, this topic walks through a simple code example based on a new Windows Console Application (C++/WinRT) project. This topic also shows how to add C++/WinRT support to a Windows Desktop application project. 7 Note While we recommend that you develop with the latest versions of Visual Studio and the Windows SDK, if you're using Visual Studio 2017 (version 15.8.0 or later), and targeting the Windows SDK version 10.0.17134.0 (Windows 10, version 1803), then a newly created C++/WinRT project may fail to compile with the error "error C3861: 'from_abi': identifier not found", and with other errors originating in base.h. The solution is to either target a later (more conformant) version of the Windows SDK, or set project property C/C++ > Language > Conformance mode: No (also, if /permissive- appears in project property C/C++ > Language > Command Line under Additional Options, then delete it). A C++/WinRT quick-start Create a new Windows Console Application (C++/WinRT) project. Edit pch.h and main.cpp to look like this. C++/WinRT // pch.h #pragma once #include C++/WinRT Let's take the short code example above piece by piece, and explain what's going on in each part. C++/WinRT With the default project settings, the included headers come from the Windows SDK, inside the folder %WindowsSdkDir%Include\cppwinrt\winrt . Visual Studio includes that path in its IncludePath macro. But there's no strict dependency on the #include #include // main.cpp #include "pch.h" using namespace winrt; using namespace Windows::Foundation; using namespace Windows::Web::Syndication; int main() { winrt::init_apartment(); Uri rssFeedUri{ L"https://blogs.windows.com/feed" }; SyndicationClient syndicationClient; syndicationClient.SetRequestHeader(L"User-Agent", L"Mozilla/5.0 (compatible; MSIE 10.0; Windows NT 6.2; WOW64; Trident/6.0)"); SyndicationFeed syndicationFeed = syndicationClient.RetrieveFeedAsync(rssFeedUri).get(); for (const SyndicationItem syndicationItem : syndicationFeed.Items()) { winrt::hstring titleAsHstring = syndicationItem.Title().Text(); // A workaround to remove the trademark symbol from the title string, because it causes issues in this case. std::wstring titleAsStdWstring{ titleAsHstring.c_str() }; titleAsStdWstring.erase(remove(titleAsStdWstring.begin(), titleAsStdWstring.end(), L'™'), titleAsStdWstring.end()); titleAsHstring = titleAsStdWstring; std::wcout << titleAsHstring.c_str() << std::endl; } } #include #include Windows SDK, because your project (via the cppwinrt.exe tool) generates those same headers into your project's $(GeneratedFilesDir) folder. They'll be loaded from that folder if they can't be found elsewhere, or if you change your project settings. The headers contain Windows APIs projected into C++/WinRT. In other words, for each Windows type, C++/WinRT defines a C++-friendly equivalent (called the projected type). A projected type has the same fully-qualified name as the Windows type, but it's placed in the C++ winrt namespace. Putting these includes in your precompiled header reduces incremental build times.) Important Whenever you want to use a type from a Windows namespaces, you must #include the corresponding C++/WinRT Windows namespace header file, as shown above. The corresponding header is the one with the same name as the type's namespace. For example, to use the C++/WinRT projection for the Windows::Foundation::Collections::PropertySet runtime class, include the winrt/Windows.Foundation.Collections.h header. It is common for a C++/WinRT projection header to automatically include related namespace header files. For example, winrt/Windows.Foundation.Collections.h includes winrt/Windows.Foundation.h . But you shouldn't rely on this behavior, since it's an implementation detail that changes over time. You must explicitly include any headers that you need. C++/WinRT using namespace winrt; using namespace Windows::Foundation; using namespace Windows::Web::Syndication; The using namespace directives are optional, but convenient. The pattern shown above for such directives (allowing unqualified name lookup for anything in the winrt namespace) is suitable for when you're beginning a new project and C++/WinRT is the only language projection you're using inside of that project. If, on the other hand, you're mixing C++/WinRT code with C++/CX and/or SDK application binary interface (ABI) code (you're either porting from, or interoperating with, one or both of those models), then see the topics Interop between C++/WinRT and C++/CX, Move to C++/WinRT from C++/CX, and Interop between C++/WinRT and the ABI. C++/WinRTwinrt::init_apartment(); The call to winrt::init_apartment initializes the thread in the Windows Runtime; by default, in a multithreaded apartment. The call also initializes COM. C++/WinRT Uri rssFeedUri{ L"https://blogs.windows.com/feed" }; SyndicationClient syndicationClient; Stack-allocate two objects: they represent the uri of the Windows blog, and a syndication client. We construct the uri with a simple wide string literal (see String handling in C++/WinRT for more ways you can work with strings). C++/WinRT SyndicationFeed syndicationFeed = syndicationClient.RetrieveFeedAsync(rssFeedUri).get(); SyndicationClient::RetrieveFeedAsync is an example of an asynchronous Windows Runtime function. The code example receives an asynchronous operation object from RetrieveFeedAsync, and it calls get on that object to block the calling thread and wait for the result (which is a syndication feed, in this case). For more about concurrency, and for non-blocking techniques, see Concurrency and asynchronous operations with C++/WinRT. C++/WinRT for (const SyndicationItem syndicationItem : syndicationFeed.Items()) { ... } SyndicationFeed.Items is a range, defined by the iterators returned from begin and end functions (or their constant, reverse, and constant-reverse variants). Because of this, you can enumerate Items with either a range-based for statement, or with the std::for_each template function. Whenever you iterate over a Windows Runtime collection like this, you'll need to #include . C++/WinRT winrt::hstring titleAsHstring = syndicationItem.Title().Text(); // Omitted: there's a little bit of extra work here to remove the trademark symbol from the title text.std::wcout << titleAsHstring.c_str() < Windows Desktop > Windows Desktop Application project. You can optionally install the C++/WinRT Visual Studio Extension (VSIX) and the NuGet package. For details, see Visual Studio support for C++/WinRT. Set project properties Go to project property General > Windows SDK Version, and select All Configurations and All Platforms. Ensure that Windows SDK Version is set to 10.0.17134.0 (Windows 10, version 1803) or greater. Confirm that you're not affected by Why won't my new project compile?. Because C++/WinRT uses features from the C++17 standard, set project property C/C++ > Language > C++ Language Standard to ISO C++17 Standard (/std:c++17).The precompiled header The default project template creates a precompiled header for you, named either framework.h , or stdafx.h . Rename that to pch.h . If you have a stdafx.cpp file, then rename that to pch.cpp . Set project property C/C++ > Precompiled Headers > Precompiled Header to Create (/Yc), and Precompiled Header File to pch.h. Find and replace all #include "framework.h" (or #include "stdafx.h") with #include "pch.h" . In pch.h , include winrt/base.h . C++/WinRT // pch.h ... #include Linking The C++/WinRT language projection depends on certain Windows Runtime free (non member) functions, and entry points, that require linking to the WindowsApp.lib umbrella library. This section describes three ways of satisfying the linker. The first option is to add to your Visual Studio project all of the C++/WinRT MSBuild properties and targets. To do this, install the Microsoft.Windows.CppWinRT NuGet package into your project. Open the project in Visual Studio, click Project > Manage NuGet Packages... > Browse, type or paste Microsoft.Windows.CppWinRT in the search box, select the item in search results, and then click Install to install the package for that project. You can also use project link settings to explicitly link WindowsApp.lib . Or, you can do it in source code (in pch.h , for example) like this. C++/WinRT #pragma comment(lib, "windowsapp") You can now compile and link, and add C++/WinRT code to your project (for example, code similar to that shown in the A C++/WinRT quick-start section, above). The three main scenarios for C++/WinRTAs you use and become familiar with C++/WinRT, and work through the rest of the documentation here, you'll likely notice that there are three main scenarios, as described in the following sections. Consuming Windows APIs and types In other words, using, or calling APIs. For example, making API calls to communicate using Bluetooth; to stream and present video; to integrate with the Windows shell; and so on. C++/WinRT fully and uncompromisingly supports this category of scenario. For more info, see Consume APIs with C++/WinRT. Authoring Windows APIs and types In other words, producing APIs and types. For example, producing the kinds of APIs described in the section above; or the graphics APIs; the storage and file system APIs; the networking APIs, and so on. For more info, see Author APIs with C++/WinRT. Authoring APIs with C++/WinRT is a little more involved than consuming them, because you must use IDL to define the shape of the API before you can implement it. There's a walkthrough of doing that in XAML controls; bind to a C++/WinRT property. XAML applications This scenario is about building applications and controls on the XAML UI framework. Working in a XAML application amounts to a combination of consuming and authoring. But since XAML is the dominant UI framework on Windows today, and its influence over the Windows Runtime is proportionate to that, it deserves its own category of scenario. Be aware that XAML works best with programming languages that offer reflection. In C++/WinRT, you sometimes have to do a little extra work in order to interoperate with the XAML framework. All of those cases are covered in the documentation. Good places to start are XAML controls; bind to a C++/WinRT property and XAML custom (templated) controls with C++/WinRT. Sample apps written in C++/WinRT See Where can I find C++/WinRT sample apps?. Important APIsFeedback Was this page helpful? Provide product feedback | Get help at Microsoft Q&A SyndicationClient::RetrieveFeedAsync method SyndicationFeed.Items property winrt::hstring struct winrt::hresult-error struct C++/CX Error handling with C++/WinRT Interop between C++/WinRT and C++/CX Interop between C++/WinRT and the ABI Move to C++/WinRT from C++/CX String handling in C++/WinRT Related topics Yes NoFeedback Was this page helpful? Get help at Microsoft Q&A Get Started with Win32 and C++ Article • 01/27/2022 The aim of this Get Started series is to teach you how to write a desktop program in C++ using Win32 and COM APIs. In the first module, you'll learn step-by-step how to create and show a window. Later modules will introduce the Component Object Model (COM), graphics and text, and user input. For this series, it is assumed that you have a good working knowledge of C++ programming. No previous experience with Windows programming is assumed. If you are new to C++, learning material is available in the C++ language documentation . Topic Description Intro to Win32 programming in C++ This section describes some of the basic terminology and coding conventions used in Windows programming. Module 1. Your First Windows Program In this module, you will create a simple Windows program that shows a blank window. Module 2. Using COM in Your Windows Program This module introduces the Component Object Model (COM), which underlies many of the modern Windows APIs. Module 3. Windows Graphics This module introduces the Windows graphics architecture, with a focus on Direct2D. Module 4. User Input This module describes mouse and keyboard input. Sample Code Contains links to download the sample code for this series. In this section Yes NoCreate a simple Universal Windows Platform (UWP) game with DirectX Article • 10/20/2022 In this set of tutorials, you'll learn how to use DirectX and C++/WinRT to create the basic Universal Windows Platform (UWP) sample game named Simple3DGameDX. The gameplay takes place in a simple first-person 3D shooting gallery. 7 Note The link from which you can download the Simple3DGameDX sample game itself is Direct3D sample game. The C++/WinRT source code is in the folder named cppwinrt . For info about other UWP sample apps, see Sample applications for Windows development. These tutorials cover all of the major parts of a game, including the processes for loading assets such as arts and meshes, creating a main game loop, implementing a simple rendering pipeline, and adding sound and controls. You'll also see UWP game development techniques and considerations. We'll focus on key UWP DirectX game development concepts, and call out Windows-Runtime-specific considerations around those concepts. Objective To learn about the basic concepts and components of a UWP DirectX game, and to become more comfortable designing UWP games with DirectX. What you need to know For this tutorial, you need to be familiar with these subjects. C++/WinRT. C++/WinRT is a standard modern C++17 language projection for Windows APIs, implemented as a header-file-based library, and designed to provide you with first-class access to the modern Windows APIs. Basic linear algebra and Newtonian physics concepts. Basic graphics programming terminology. Basic Windows programming concepts. Basic familiarity with the Direct2D and Direct3D 11 APIs.The Simple3DGameDX sample game implements a simple first-person 3D shooting gallery, where the player fires balls at moving targets. Hitting each target awards a set number of points, and the player can progress through 6 levels of increasing challenge. At the end of the levels, the points are tallied, and the player is awarded a final score. The sample demonstrates these game concepts. Interoperation between DirectX 11.1 and the Windows Runtime A first-person 3D perspective and camera Stereoscopic 3D effects Collision-detection between objects in 3D Handling player input for mouse, touch, and Xbox controller controls Audio mixing and playback A basic game state-machine Topic Description Set up the game project The first step in developing your game is to set up a project in Microsoft Visual Studio. After you've configured a project specifically for game development, you could later re-use it as a kind of template. Define the game's UWP app framework The first step in coding a Universal Windows Platform (UWP) game is building the framework that lets the app object interact with Windows. Game flow management Define the high-level state machine to enable player and system interaction. Learn how UI interacts with the overall game's state machine and how to create event handlers for UWP games. Direct3D UWP shooting gallery sampleTopic Description Define the main game object Now, we look at the details of the sample game's main object and how the rules it implements translate into interactions with the game world. Rendering framework I: Intro to rendering Learn how to develop the rendering pipeline to display graphics. Intro to rendering. Rendering framework II: Game rendering Learn how to assemble the rendering pipeline to display graphics. Game rendering, set up and prepare data. Add a user interface Learn how to add a 2D user interface overlay to a DirectX UWP game. Add controls Now, we take a look at how the sample game implements move-look controls in a 3-D game, and how to develop basic touch, mouse, and game controller controls. Add sound Develop a simple sound engine using XAudio2 APIs to playback game music and sound effects. Extend the sample game Learn how to implement a XAML overlay for a UWP DirectX game.Create a console calculator in C++ Article • 10/08/2024 The usual starting point for a C++ programmer is a "Hello, world!" application that runs on the command line. You start with that in this article, and then move on to something more challenging: a calculator app. Prerequisites Visual Studio with the Desktop development with C++ workload installed and running on your computer. To install it, see Install C++ support in Visual Studio. This tutorial demonstrates a feature called edit and continue which allows you to make changes to your code while the app is running. To enable edit and continue, from the main menu select Tools > Options > Debugging > General and ensure that Require source files to exactly match the original version is checked. Create your app project Visual Studio uses projects to organize the code for an app, and solutions to organize one or more projects. A project contains all the options, configurations, and rules used to build an app. It also manages the relationship between all the project's files and any external files. To create your app, first, create a new project and solution. 1. Start Visual Studio--the Visual Studio Start dialog box appears. Select Create a new project to get started.2. In the Create a new project dialog, set the language dropdown to C++, set the platform dropdown to Windows, select Console App from the list of project types, then select Next.) Important Make sure you select the C++ version of the Console App template. It has the C++, Windows, and Console tags, and the icon has "++" in the corner.3. In the Configure your new project dialog box, select the Project name text box, name your new project CalculatorTutorial, then select Create. An empty C++ Windows console application 'Hello World' app is created. Console applications use a Windows console window to display output and accept user input. In Visual Studio, an editor window opens and shows the generated code: C++ // CalculatorTutorial.cpp : This file contains the 'main' function. Program execution begins and ends there. // #include int main() { std::cout < Start Without Debugging menu // Debug program: F5 or Debug > Start Debugging menu // Tips for Getting Started: // 1. Use the Solution Explorer window to add/manage files // 2. Use the Team Explorer window to connect to source control // 3. Use the Output window to see build output and other messages // 4. Use the Error List window to view errors // 5. Go to Project > Add New Item to create new code files, or Project > Add Existing Item to add existing code files to the project// 6. In the future, to open this project again, go to File > Open > Project and select the .sln file Verify that your new app builds and runs The template for a new Windows console application creates a simple C++ "Hello World" app. At this point, you can see how Visual Studio builds and runs the apps you create right from the IDE. 1. To build your project, select Build Solution from the Build menu. The Output window shows the results of the build process. 2. To run the code, on the menu bar, select Debug > Start without debugging (Ctrl+F5).A console window opens and your app runs within it. When you start a console app in Visual Studio, it runs your code, then prints "Press any key to close this window . . ." to give you a chance to see the output. Congratulations! You created your first "Hello, world!" console app in Visual Studio! 3. Press a key to dismiss the console window and return to Visual Studio. You now have the tools to build and run your app after every change, to verify that the code still works as you expect. Later, we show you how to debug it if it doesn't. Now let's modify the code in this template to be a calculator app. 1. Replace the contents of the CalculatorTutorial.cpp file with the following code so that it matches this example: C++ Edit the code // CalculatorTutorial.cpp : This file contains the 'main' function. Program execution begins and ends there. // #include using namespace std; int main() { cout << "Calculator Console Application" << endl << endl; cout << "Please enter the operation to perform. Format: a+b | a-b |Understanding the code: The #include statement brings in code in other files. Sometimes, you may see a filename surrounded by angle brackets like . The angle brackets instruct the compiler to look for the iostream header file first in the standard system directories, and if not found, to look in directories specific to the project. Other times, you may see a filename surrounded by quotes like "someHeader.h" . The quotes instruct the compiler to skip looking in the standard system directories and instead only look in directories specific to the project. The using namespace std; tells the compiler to expect code from the C++ Standard Library to be used in this file. Without this line, each keyword from the library would have to be preceded with std:: to denote its scope. For instance, without that line, each reference to cout would be written as std::cout . The using statement is added to make it more convenient to access code in another namespace. The cout keyword is used to print to standard output in C++. The << operator tells the compiler to send whatever is to the right of it to the standard output. The endl keyword is like the Enter key; it ends the line and moves the cursor to the next line. It's a better practice to put a \n inside the string (contained by "") to do the same thing because endl always flushes the buffer which can hurt the performance of the program. But since this is a very small app, endl is used instead. All C++ statements must end with semicolons and all C++ applications must contain a main() function. This function is what the program runs at a*b | a/b" < Start Without Debugging menu // Debug program: F5 or Debug > Start Debugging menu // Tips for Getting Started: // 1. Use the Solution Explorer window to add/manage files // 2. Use the Team Explorer window to connect to source control // 3. Use the Output window to see build output and other messages // 4. Use the Error List window to view errors // 5. Go to Project > Add New Item to create new code files, or Project > Add Existing Item to add existing code files to the project // 6. In the future, to open this project again, go to File > Open > Project and select the .sln filethe start. All code must be accessible from main() in order to be used. 2. To save the file, press Ctrl+S, or select the floppy disk icon in the toolbar under the menu bar. 3. To run the application, press Ctrl+F5 or go to the Debug menu and select Start Without Debugging. You should see a console window appear that looks like this. 4. Close the console window when you're done. Add code to do some math A class is like a blueprint for an object that does something. In this case, we define a calculator class to contain the math logic. Add a Calculator class 1. Go to the Project menu and select Add Class. In the Class Name edit box, enter Calculator. Select OK. Two new files get added to your project. To save all your changed files at once, press Ctrl+Shift+S. It's a keyboard shortcut for File > Save All. There's also a toolbar button for Save All, an icon of two floppy disks, found beside the Savebutton. In general, it's good practice to do Save All frequently, so you don't miss saving any changes. The Add Class wizard creates .h and .cpp files that have the same name as the class. You can see a full list of your project files in the Solution Explorer window, visible on the side of the IDE. If the window isn't visible, open it from the menu bar via View > Solution Explorer. You can open a file by double-clicking it in the Solution Explorer window. Double click Calculator.h to open it. 2. Replace the contents of Calculator.h with the following code so that the file now looks like this: C++ Understanding the code This code declares a new function called Calculate , which handles math operations for addition, subtraction, multiplication, and division. #pragma once class Calculator { public: double Calculate(double x, char oper, double y); };C++ code is organized into header (.h) files and source (.cpp) files. Some other file extensions are supported by various compilers, but these are the main ones to know about. Functions and variables are normally declared, that is, given a name and a type, in header files, and implemented, or given a definition, in source files. To access code defined in another file, you can use #include "filename.h" , where filename.h is the name of the file that declares the variables or functions you want to use. It's good practice to organize your code into different files based on what it does, so it's easy to find the code you need later. In our case, we define the Calculator class separately from the file containing the main() function, but we plan to reference the Calculator class in main() . 3. A green squiggle appears under Calculate because although the Calculate function is declared, it isn't defined. Hover over Calculate , click the down arrow on the screwdriver icon, and select Create definition of 'Calculate' in Calculator.cpp . This code is added to Calculator.cpp :Currently, it just returns 0.0. Let's change that. 4. Switch to the Calculator.cpp file in the editor window. Replace the contents of Calculator::Calculate(double x, char oper, double y) with: C++ Understanding the code The function Calculate takes a number, an operator, and a second number. Then it performs the requested operation on the two numbers. The switch statement checks which operator was provided, and executes the case corresponding to that operation. The default: case is a fallback double Calculator::Calculate(double x, char oper, double y) { switch(oper) { case '+': return x + y; case '-': return x - y; case '*': return x * y; case '/': return x / y; default: return 0.0; } }in case the user types an operator that isn't handled by any of the preceding case statements. It's best to handle invalid user input in a more elegant way, but this is beyond the scope of this tutorial. The double keyword denotes a type of number that supports decimals. This type of number is called a floating-point number, and double means a floating point number that has extra precision. This way, the calculator can handle both decimal math and integer math. The Calculate function is required to always return a double-precision floating point number due to the double at the start of the code (this denotes the function's return type), which is why we return 0.0 in the default case. The .h file declares the function prototype, which tells the compiler upfront what parameters it requires, and what return type to expect from it. The .cpp file has all the implementation details of the function. If you build and run the code again at this point, it immediately exits after asking which operation to perform. So, modify the main function to do multiple calculations. 1. Update the main function in CalculatorTutorial.cpp as follows: C++ Call the Calculator class member functions // CalculatorTutorial.cpp : This file contains the 'main' function. Program execution begins and ends there. // #include #include "Calculator.h" using namespace std; int main() { double x = 0.0; double y = 0.0; double result = 0.0; char oper = '+'; cout << "Calculator Console Application" << endl << endl; cout << "Please enter the operation to perform. Format: a+b | a-b | a*b | a/b" <> x >> oper >> y; result = c.Calculate(x, oper, y); cout << "Result " << "of " << x << oper << y << " is: " << result < Windows > Autos. To see all of the variables from that function, switch to the Locals window. Because this is a small function, the Autos and Locals window show the same variables. But you can modify the values of these variables in the Locals window while debugging to see what effect they would have on the program. In this case, we leave them alone. Open the Locals window by selecting Locals at the bottom of the Autos window, or by selecting from the main menu Debug > Windows > Locals.You can also hover over variables in the code to see their current values at the point where execution is currently paused. Make sure the editor window is in focus by clicking on it first. Continue debugging 1. The yellow arrow on the left shows the current point of execution. The current line calls Calculate , so press F11 to Step Into the function. Now you're executing code in the body of the Calculate function. Be careful with Step Into because it steps into any functions on the line you're on, including standard library functions. It's fine to step into the standard library, but you may be more interested in focusing on your code instead of library code. 2. Now that the point of execution is at the start of the Calculate function, press F10 to move to the next line in the program's execution. F10 is also known as Step Over. You can use Step Over to move from line to line, without delving into the details of what is occurring in each part of the line. In general, you should use Step Over instead of Step Into unless you want to dive more deeply into code that is being called from elsewhere (as you did to reach the body of Calculate). 3. Continue using F10 to Step Over each line until you get back to the main() function in the other file, and stop on the cout line.The program is doing what's expected: it takes the first number, and divides it by the second. On the cout line, hover over the result variable or take a look at result in the Autos window. Its value is inf , which doesn't look right. Let's fix it. The cout line outputs whatever value is stored in result , so when you step one more line forward using F10, the console window displays: This result is because division by zero is undefined, so the program doesn't have a numerical answer for the requested operation. Fix the "divide by zero" error Let's handle division by zero more gracefully so that it's easier for the user to understand the problem. 1. Make the following changes in CalculatorTutorial.cpp . You can leave the program running as you edit, thanks to a debugger feature called Edit andContinue. Add an if statement following cin >> x >> oper >> y; to check for division by zero and output a message to the user if it happens. Otherwise, the result is printed. C++ 2. Press F5 once. Program execution continues until it has to pause to ask for user input. Enter 10 / 0 again. Now, a more helpful message is printed. The user is asked for more input, and the program continues executing normally. // CalculatorTutorial.cpp : This file contains the 'main' function. Program execution begins and ends there. // #include #include "Calculator.h" using namespace std; int main() { double x = 0.0; double y = 0.0; double result = 0.0; char oper = '+'; cout << "Calculator Console Application" << endl << endl; cout << "Please enter the operation to perform. Format: a+b | a-b | a*b | a/b" <> x >> oper >> y; if (oper == '/' && y == 0) { cout << "Math error: Attempted to divide by zero!" << endl; continue; } else { result = c.Calculate(x, oper, y); } cout << "Result " << "of " << x << oper << y << " is: " << result <Options->General needs to be enabled..." To fix this, from the main menu select Tools > Options > Debugging > General and ensure that Require source files to exactly match the original version is checked. Understanding the Run and Debug shortcuts F5, or Debug > Start Debugging, starts a debugging session, if one isn't already active, and runs the program until a breakpoint is hit or the program needs user input. If no user input is needed and no breakpoint is available to hit, the program terminates and the console window closes itself when the program finishes running. If your program outputs to the console, use Ctrl+F5 or set a breakpoint before you press F5 to keep the window open. Ctrl+F5, or Debug > Start Without Debugging, runs the application without going into debug mode. This is slightly faster than debugging, and the console window stays open after the program finishes executing. F10, known as Step Over, lets you iterate through code, line-by-line, and visualize how the code is run and what variable values are at each step of execution.F11, known as Step Into, works similarly to Step Over, except it steps into any functions called on the line of execution. For example, if the line being executed calls a function, pressing F11 moves the pointer into the body of the function, so you can follow the function's code being run before coming back to the line you started at. Pressing F10 steps over the function call and just moves to the next line; the function call still happens, but the program doesn't pause to show you what it's doing. Close the app If it's still running, close the console window to stop the calculator app. Add Git source control Now that you've created an app, you might want to add it to a Git repository. We've got you covered. Visual Studio makes that process easy with Git tools you can use directly from the IDE. Tip Git is the most widely used modern version control system, so whether you're a professional developer or you're learning how to code, Git can be very useful. If you're new to Git, the https://git-scm.com/ website is a good place to start. There, you can find cheat sheets, a popular online book, and Git Basics videos. To associate your code with Git, you start by creating a new Git repository where your code is located. Here's how: 1. In the status bar at the bottom-right corner of Visual Studio, select Add to Source Control, and then select Git. 2. In the Create a Git repository dialog box, sign in to GitHub.The repository name auto-populates based on your folder location. By default, your new repository is private, which means you're the only one who can access it. Tip Whether your repository is public or private, it's best to have a remote backup of your code stored securely on GitHub. Even if you aren't working with a team, a remote repository makes your code available to you from any computer. 3. Select Create and Push. After you create your repository, status details appear in the status bar. The first icon with the arrows shows how many outgoing/incoming commits are in your current branch. You can use this icon to pull any incoming commits or push any outgoing commits. You can also choose to view these commits first. To do so, select the icon, and then select View Outgoing/Incoming.Feedback Was this page helpful? Provide product feedback | Get help at Microsoft Q&A The second icon with the pencil shows the number of uncommitted changes to your code. You can select this icon to view those changes in the Git Changes window. To learn more about how to use Git with your app, see the Visual Studio version control documentation. Congratulations! You completed the code for the calculator app, built and debugged it, and added it to a repo, all in Visual Studio. Learn more about Visual Studio for C++ The finished app Next steps Yes NoGet started with C++/WinRT Article • 02/13/2023) Important For info about setting up Visual Studio for C++/WinRT development—including installing and using the C++/WinRT Visual Studio Extension (VSIX) and the NuGet package (which together provide project template and build support)—see Visual Studio support for C++/WinRT. To get you up to speed with using C++/WinRT, this topic walks through a simple code example based on a new Windows Console Application (C++/WinRT) project. This topic also shows how to add C++/WinRT support to a Windows Desktop application project. 7 Note While we recommend that you develop with the latest versions of Visual Studio and the Windows SDK, if you're using Visual Studio 2017 (version 15.8.0 or later), and targeting the Windows SDK version 10.0.17134.0 (Windows 10, version 1803), then a newly created C++/WinRT project may fail to compile with the error "error C3861: 'from_abi': identifier not found", and with other errors originating in base.h. The solution is to either target a later (more conformant) version of the Windows SDK, or set project property C/C++ > Language > Conformance mode: No (also, if /permissive- appears in project property C/C++ > Language > Command Line under Additional Options, then delete it). A C++/WinRT quick-start Create a new Windows Console Application (C++/WinRT) project. Edit pch.h and main.cpp to look like this. C++/WinRT // pch.h #pragma once #include C++/WinRT Let's take the short code example above piece by piece, and explain what's going on in each part. C++/WinRT With the default project settings, the included headers come from the Windows SDK, inside the folder %WindowsSdkDir%Include\cppwinrt\winrt . Visual Studio includes that path in its IncludePath macro. But there's no strict dependency on the #include #include // main.cpp #include "pch.h" using namespace winrt; using namespace Windows::Foundation; using namespace Windows::Web::Syndication; int main() { winrt::init_apartment(); Uri rssFeedUri{ L"https://blogs.windows.com/feed" }; SyndicationClient syndicationClient; syndicationClient.SetRequestHeader(L"User-Agent", L"Mozilla/5.0 (compatible; MSIE 10.0; Windows NT 6.2; WOW64; Trident/6.0)"); SyndicationFeed syndicationFeed = syndicationClient.RetrieveFeedAsync(rssFeedUri).get(); for (const SyndicationItem syndicationItem : syndicationFeed.Items()) { winrt::hstring titleAsHstring = syndicationItem.Title().Text(); // A workaround to remove the trademark symbol from the title string, because it causes issues in this case. std::wstring titleAsStdWstring{ titleAsHstring.c_str() }; titleAsStdWstring.erase(remove(titleAsStdWstring.begin(), titleAsStdWstring.end(), L'™'), titleAsStdWstring.end()); titleAsHstring = titleAsStdWstring; std::wcout << titleAsHstring.c_str() << std::endl; } } #include #include Windows SDK, because your project (via the cppwinrt.exe tool) generates those same headers into your project's $(GeneratedFilesDir) folder. They'll be loaded from that folder if they can't be found elsewhere, or if you change your project settings. The headers contain Windows APIs projected into C++/WinRT. In other words, for each Windows type, C++/WinRT defines a C++-friendly equivalent (called the projected type). A projected type has the same fully-qualified name as the Windows type, but it's placed in the C++ winrt namespace. Putting these includes in your precompiled header reduces incremental build times.) Important Whenever you want to use a type from a Windows namespaces, you must #include the corresponding C++/WinRT Windows namespace header file, as shown above. The corresponding header is the one with the same name as the type's namespace. For example, to use the C++/WinRT projection for the Windows::Foundation::Collections::PropertySet runtime class, include the winrt/Windows.Foundation.Collections.h header. It is common for a C++/WinRT projection header to automatically include related namespace header files. For example, winrt/Windows.Foundation.Collections.h includes winrt/Windows.Foundation.h . But you shouldn't rely on this behavior, since it's an implementation detail that changes over time. You must explicitly include any headers that you need. C++/WinRT using namespace winrt; using namespace Windows::Foundation; using namespace Windows::Web::Syndication; The using namespace directives are optional, but convenient. The pattern shown above for such directives (allowing unqualified name lookup for anything in the winrt namespace) is suitable for when you're beginning a new project and C++/WinRT is the only language projection you're using inside of that project. If, on the other hand, you're mixing C++/WinRT code with C++/CX and/or SDK application binary interface (ABI) code (you're either porting from, or interoperating with, one or both of those models), then see the topics Interop between C++/WinRT and C++/CX, Move to C++/WinRT from C++/CX, and Interop between C++/WinRT and the ABI. C++/WinRTwinrt::init_apartment(); The call to winrt::init_apartment initializes the thread in the Windows Runtime; by default, in a multithreaded apartment. The call also initializes COM. C++/WinRT Uri rssFeedUri{ L"https://blogs.windows.com/feed" }; SyndicationClient syndicationClient; Stack-allocate two objects: they represent the uri of the Windows blog, and a syndication client. We construct the uri with a simple wide string literal (see String handling in C++/WinRT for more ways you can work with strings). C++/WinRT SyndicationFeed syndicationFeed = syndicationClient.RetrieveFeedAsync(rssFeedUri).get(); SyndicationClient::RetrieveFeedAsync is an example of an asynchronous Windows Runtime function. The code example receives an asynchronous operation object from RetrieveFeedAsync, and it calls get on that object to block the calling thread and wait for the result (which is a syndication feed, in this case). For more about concurrency, and for non-blocking techniques, see Concurrency and asynchronous operations with C++/WinRT. C++/WinRT for (const SyndicationItem syndicationItem : syndicationFeed.Items()) { ... } SyndicationFeed.Items is a range, defined by the iterators returned from begin and end functions (or their constant, reverse, and constant-reverse variants). Because of this, you can enumerate Items with either a range-based for statement, or with the std::for_each template function. Whenever you iterate over a Windows Runtime collection like this, you'll need to #include . C++/WinRT winrt::hstring titleAsHstring = syndicationItem.Title().Text(); // Omitted: there's a little bit of extra work here to remove the trademark symbol from the title text.std::wcout << titleAsHstring.c_str() < Windows Desktop > Windows Desktop Application project. You can optionally install the C++/WinRT Visual Studio Extension (VSIX) and the NuGet package. For details, see Visual Studio support for C++/WinRT. Set project properties Go to project property General > Windows SDK Version, and select All Configurations and All Platforms. Ensure that Windows SDK Version is set to 10.0.17134.0 (Windows 10, version 1803) or greater. Confirm that you're not affected by Why won't my new project compile?. Because C++/WinRT uses features from the C++17 standard, set project property C/C++ > Language > C++ Language Standard to ISO C++17 Standard (/std:c++17).The precompiled header The default project template creates a precompiled header for you, named either framework.h , or stdafx.h . Rename that to pch.h . If you have a stdafx.cpp file, then rename that to pch.cpp . Set project property C/C++ > Precompiled Headers > Precompiled Header to Create (/Yc), and Precompiled Header File to pch.h. Find and replace all #include "framework.h" (or #include "stdafx.h") with #include "pch.h" . In pch.h , include winrt/base.h . C++/WinRT // pch.h ... #include Linking The C++/WinRT language projection depends on certain Windows Runtime free (non member) functions, and entry points, that require linking to the WindowsApp.lib umbrella library. This section describes three ways of satisfying the linker. The first option is to add to your Visual Studio project all of the C++/WinRT MSBuild properties and targets. To do this, install the Microsoft.Windows.CppWinRT NuGet package into your project. Open the project in Visual Studio, click Project > Manage NuGet Packages... > Browse, type or paste Microsoft.Windows.CppWinRT in the search box, select the item in search results, and then click Install to install the package for that project. You can also use project link settings to explicitly link WindowsApp.lib . Or, you can do it in source code (in pch.h , for example) like this. C++/WinRT #pragma comment(lib, "windowsapp") You can now compile and link, and add C++/WinRT code to your project (for example, code similar to that shown in the A C++/WinRT quick-start section, above). The three main scenarios for C++/WinRTAs you use and become familiar with C++/WinRT, and work through the rest of the documentation here, you'll likely notice that there are three main scenarios, as described in the following sections. Consuming Windows APIs and types In other words, using, or calling APIs. For example, making API calls to communicate using Bluetooth; to stream and present video; to integrate with the Windows shell; and so on. C++/WinRT fully and uncompromisingly supports this category of scenario. For more info, see Consume APIs with C++/WinRT. Authoring Windows APIs and types In other words, producing APIs and types. For example, producing the kinds of APIs described in the section above; or the graphics APIs; the storage and file system APIs; the networking APIs, and so on. For more info, see Author APIs with C++/WinRT. Authoring APIs with C++/WinRT is a little more involved than consuming them, because you must use IDL to define the shape of the API before you can implement it. There's a walkthrough of doing that in XAML controls; bind to a C++/WinRT property. XAML applications This scenario is about building applications and controls on the XAML UI framework. Working in a XAML application amounts to a combination of consuming and authoring. But since XAML is the dominant UI framework on Windows today, and its influence over the Windows Runtime is proportionate to that, it deserves its own category of scenario. Be aware that XAML works best with programming languages that offer reflection. In C++/WinRT, you sometimes have to do a little extra work in order to interoperate with the XAML framework. All of those cases are covered in the documentation. Good places to start are XAML controls; bind to a C++/WinRT property and XAML custom (templated) controls with C++/WinRT. Sample apps written in C++/WinRT See Where can I find C++/WinRT sample apps?. Important APIsFeedback Was this page helpful? Provide product feedback | Get help at Microsoft Q&A SyndicationClient::RetrieveFeedAsync method SyndicationFeed.Items property winrt::hstring struct winrt::hresult-error struct C++/CX Error handling with C++/WinRT Interop between C++/WinRT and C++/CX Interop between C++/WinRT and the ABI Move to C++/WinRT from C++/CX String handling in C++/WinRT Related topics Yes NoFeedback Was this page helpful? Get help at Microsoft Q&A Get Started with Win32 and C++ Article • 01/27/2022 The aim of this Get Started series is to teach you how to write a desktop program in C++ using Win32 and COM APIs. In the first module, you'll learn step-by-step how to create and show a window. Later modules will introduce the Component Object Model (COM), graphics and text, and user input. For this series, it is assumed that you have a good working knowledge of C++ programming. No previous experience with Windows programming is assumed. If you are new to C++, learning material is available in the C++ language documentation . Topic Description Intro to Win32 programming in C++ This section describes some of the basic terminology and coding conventions used in Windows programming. Module 1. Your First Windows Program In this module, you will create a simple Windows program that shows a blank window. Module 2. Using COM in Your Windows Program This module introduces the Component Object Model (COM), which underlies many of the modern Windows APIs. Module 3. Windows Graphics This module introduces the Windows graphics architecture, with a focus on Direct2D. Module 4. User Input This module describes mouse and keyboard input. Sample Code Contains links to download the sample code for this series. In this section Yes NoCreating an MFC Application Article • 02/14/2023 An MFC application is an executable application for Windows that is based on the Microsoft Foundation Class (MFC) Library. MFC executables generally fall into five types: standard Windows applications, dialog boxes, forms-based applications, Explorer-style applications, and Web browser-style applications. For more information, see: Using the Classes to Write Windows Applications Creating and Displaying Dialog Boxes Creating a Forms-Based MFC Application Creating a File Explorer-Style MFC Application Creating a Web Browser-Style MFC Application The MFC Application Wizard generates the appropriate classes and files for any of these types of applications, depending on the options you select in the wizard. The easiest way to create an MFC application is to use the MFC Application Wizard (MFC App project in Visual Studio 2019). To create an MFC console application (a command line program that uses MFC libraries but runs in the console window), use the Windows Desktop Wizard and choose the Console Application and MFC Headers options. To create an MFC forms or dialog-based application 1. From the main menu, choose File > New > Project. 2. Enter "MFC" into the search box and then choose MFC App from the result list. 3. Modify the defaults as needed, then press Create to open the MFC Application Wizard. 4. Modify the configuration values as needed, then press Finish. For more information, see Creating a forms-based MFC application.To create an MFC console application An MFC console application is a command-line program that uses MFC libraries but runs in the console window. 1. From the main menu, choose File > New > Project. 2. Enter "Desktop" into the search box and then choose Windows Desktop Wizard from the result list, then press Next. 3. Modify the project name and location as needed, then press Create to open the Windows Desktop Wizard. 4. Check the MFC Headers box and set other values as needed, then press OK.Once your project is created, you can view the files created in Solution Explorer. For more information about the files the wizard creates for your project, see the project generated file ReadMe.txt. For more information about the file types, see File Types Created for Visual Studio C++ projects. See also Adding Functionality with Code Wizards Property PagesWalkthrough: Create and use your own Dynamic Link Library (C++) Article • 12/10/2021 This step-by-step walkthrough shows how to use the Visual Studio IDE to create your own dynamic link library (DLL) written in Microsoft C++ (MSVC). Then it shows how to use the DLL from another C++ app. DLLs (also known as shared libraries in UNIX-based operating systems) are one of the most useful kinds of Windows components. You can use them as a way to share code and resources, and to shrink the size of your apps. DLLs can even make it easier to service and extend your apps. In this walkthrough, you'll create a DLL that implements some math functions. Then you'll create a console app that uses the functions from the DLL. You'll also get an introduction to some of the programming techniques and conventions used in Windows DLLs. This walkthrough covers these tasks: Create a DLL project in Visual Studio. Add exported functions and variables to the DLL. Create a console app project in Visual Studio. Use the functions and variables imported from the DLL in the console app. Run the completed app. Like a statically linked library, a DLL exports variables, functions, and resources by name. A client app imports the names to use those variables, functions, and resources. Unlike a statically linked library, Windows connects the imports in your app to the exports in a DLL at load time or at run time, instead of connecting them at link time. Windows requires extra information that isn't part of the standard C++ compilation model to make these connections. The MSVC compiler implements some Microsoft-specific extensions to C++ to provide this extra information. We explain these extensions as we go. This walkthrough creates two Visual Studio solutions; one that builds the DLL, and one that builds the client app. The DLL uses the C calling convention. It can be called from apps written in other programming languages, as long as the platform, calling conventions, and linking conventions match. The client app uses implicit linking, whereWindows links the app to the DLL at load-time. This linking lets the app call the DLL supplied functions just like the functions in a statically linked library. This walkthrough doesn't cover some common situations. The code doesn't show the use of C++ DLLs by other programming languages. It doesn't show how to create a resource-only DLL, or how to use explicit linking to load DLLs at run-time rather than at load-time. Rest assured, you can use MSVC and Visual Studio to do all these things. Even though the code of the DLL is written in C++, we've used C-style interfaces for the exported functions. There are two main reasons for this: First, many other languages support imports of C-style functions. The client app doesn't have to be written in C++. Second, it avoids some common pitfalls related to exported classes and member functions. It's easy to make hard-to-diagnose errors when exporting classes, since everything referred to within a class declaration has to have an instantiation that's also exported. This restriction applies to DLLs, but not static libraries. If your classes are plain old-data style, you shouldn't run into this issue. For links to more information about DLLs, see Create C/C++ DLLs in Visual Studio. For more information about implicit linking and explicit linking, see Determine which linking method to use. For information about creating C++ DLLs for use with programming languages that use C-language linkage conventions, see Exporting C++ functions for use in C-language executables. For information about how to create DLLs for use with .NET languages, see Calling DLL Functions from Visual Basic Applications. Prerequisites A computer that runs Microsoft Windows 7 or later versions. We recommend the latest version of Windows for the best development experience. A copy of Visual Studio. For information on how to download and install Visual Studio, see Install Visual Studio. When you run the installer, make sure that the Desktop development with C++ workload is checked. Don't worry if you didn't install this workload when you installed Visual Studio. You can run the installer again and install it now. An understanding of the basics of using the Visual Studio IDE. If you've used Windows desktop apps before, you can probably keep up. For an introduction, seeVisual Studio IDE feature tour. An understanding of enough of the fundamentals of the C++ language to follow along. Don't worry, we don't do anything too complicated. Create the DLL project In this set of tasks, you create a project for your DLL, add code, and build it. To begin, start the Visual Studio IDE, and sign in if you need to. The instructions vary slightly depending on which version of Visual Studio you're using. Make sure you have the correct version selected in the control in the upper left of this page. To create a DLL project in Visual Studio 2019 1. On the menu bar, choose File > New > Project to open the Create a New Project dialog box. 2. At the top of the dialog, set Language to C++, set Platform to Windows, and set Project type to Library. 3. From the filtered list of project types, select Dynamic-link Library (DLL), and then choose Next. 4. In the Configure your new project page, enter MathLibrary in the Project name box to specify a name for the project. Leave the default Location and Solution name values. Set Solution to Create new solution. Uncheck Place solution and project in the same directory if it's checked. 5. Choose the Create button to create the project.When the solution is created, you can see the generated project and source files in the Solution Explorer window in Visual Studio. Right now, this DLL doesn't do very much. Next, you'll create a header file to declare the functions your DLL exports, and then add the function definitions to the DLL to make it more useful. To add a header file to the DLL 1. To create a header file for your functions, on the menu bar, choose Project > Add New Item. 2. In the Add New Item dialog box, in the left pane, select Visual C++. In the center pane, select Header File (.h). Specify MathLibrary.h as the name for the header file.3. Choose the Add button to generate a blank header file, which is displayed in a new editor window. 4. Replace the contents of the header file with this code: C++ // MathLibrary.h - Contains declarations of math functions #pragma once #ifdef MATHLIBRARY_EXPORTS #define MATHLIBRARY_API __declspec(dllexport) #else #define MATHLIBRARY_API __declspec(dllimport) #endif // The Fibonacci recurrence relation describes a sequence F // where F(n) is { n = 0, a // { n = 1, bThis header file declares some functions to produce a generalized Fibonacci sequence, given two initial values. A call to fibonacci_init(1, 1) generates the familiar Fibonacci number sequence. Notice the preprocessor statements at the top of the file. The new project template for a DLL project adds _EXPORTS to the defined preprocessor macros. In this example, Visual Studio defines MATHLIBRARY_EXPORTS when your MathLibrary DLL project is built. When the MATHLIBRARY_EXPORTS macro is defined, the MATHLIBRARY_API macro sets the __declspec(dllexport) modifier on the function declarations. This modifier tells the compiler and linker to export a function or variable from the DLL for use by other applications. When MATHLIBRARY_EXPORTS is undefined, for example, when the header file is included by a client application, MATHLIBRARY_API applies the __declspec(dllimport) modifier to the declarations. This modifier optimizes the import of the function or variable in an application. For more information, see dllexport, dllimport. 1. In Solution Explorer, right-click on the Source Files node and choose Add > New Item. Create a new .cpp file called MathLibrary.cpp, in the same way that you added a new header file in the previous step. // { n > 1, F(n-2) + F(n-1) // for some initial integral values a and b. // If the sequence is initialized F(0) = 1, F(1) = 1, // then this relation produces the well-known Fibonacci // sequence: 1, 1, 2, 3, 5, 8, 13, 21, 34, ... // Initialize a Fibonacci relation sequence // such that F(0) = a, F(1) = b. // This function must be called before any other function. extern "C" MATHLIBRARY_API void fibonacci_init(const unsigned long long a, const unsigned long long b); // Produce the next value in the sequence. // Returns true on success and updates current value and index; // false on overflow, leaves current value and index unchanged. extern "C" MATHLIBRARY_API bool fibonacci_next(); // Get the current value in the sequence. extern "C" MATHLIBRARY_API unsigned long long fibonacci_current(); // Get the position of the current value in the sequence. extern "C" MATHLIBRARY_API unsigned fibonacci_index(); To add an implementation to the DLL2. In the editor window, select the tab for MathLibrary.cpp if it's already open. If not, in Solution Explorer, double-click MathLibrary.cpp in the Source Files folder of the MathLibrary project to open it. 3. In the editor, replace the contents of the MathLibrary.cpp file with the following code: C++ // MathLibrary.cpp : Defines the exported functions for the DLL. #include "pch.h" // use stdafx.h in Visual Studio 2017 and earlier #include #include "MathLibrary.h" // DLL internal state variables: static unsigned long long previous_; // Previous value, if any static unsigned long long current_; // Current sequence value static unsigned index_; // Current seq. position // Initialize a Fibonacci relation sequence // such that F(0) = a, F(1) = b. // This function must be called before any other function. void fibonacci_init(const unsigned long long a, const unsigned long long b) { index_ = 0; current_ = a; previous_ = b; // see special case when initialized } // Produce the next value in the sequence. // Returns true on success, false on overflow. bool fibonacci_next() { // check to see if we'd overflow result or position if ((ULLONG_MAX - previous_ 0) { // otherwise, calculate next sequence value previous_ += current_; } std::swap(current_, previous_); ++index_; return true; }To verify that everything works so far, compile the dynamic link library. To compile, choose Build > Build Solution on the menu bar. The DLL and related compiler output are placed in a folder called Debug directly below the solution folder. If you create a Release build, the output is placed in a folder called Release. The output should look something like this: Output Congratulations, you've created a DLL using Visual Studio! Next, you'll create a client app that uses the functions exported by the DLL. When you create a DLL, think about how client apps may use it. To call the functions or access the data exported by a DLL, client source code must have the declarations available at compile time. At link time, the linker requires information to resolve the function calls or data accesses. A DLL supplies this information in an import library, a file that contains information about how to find the functions and data, instead of the actual code. And at run time, the DLL must be available to the client, in a location that the operating system can find. // Get the current value in the sequence. unsigned long long fibonacci_current() { return current_; } // Get the current index position in the sequence. unsigned fibonacci_index() { return index_; } 1>------ Build started: Project: MathLibrary, Configuration: Debug Win32 ------ 1>pch.cpp 1>dllmain.cpp 1>MathLibrary.cpp 1>Generating Code... 1> Creating library C:\Users\username\Source\Repos\MathLibrary\Debug\MathLibrary.lib and object C:\Users\username\Source\Repos\MathLibrary\Debug\MathLibrary.exp 1>MathLibrary.vcxproj -> C:\Users\username\Source\Repos\MathLibrary\Debug\MathLibrary.dll ========== Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped ========== Create a client app that uses the DLLWhether it's your own or from a third-party, your client app project needs several pieces of information to use a DLL. It needs to find the headers that declare the DLL exports, the import libraries for the linker, and the DLL itself. One solution is to copy all of these files into your client project. For third-party DLLs that are unlikely to change while your client is in development, this method may be the best way to use them. However, when you also build the DLL, it's better to avoid duplication. If you make a local copy of DLL files that are under development, you may accidentally change a header file in one copy but not the other, or use an out-of-date library. To avoid out-of-sync code, we recommend you set the include path in your client project to include the DLL header files directly from your DLL project. Also, set the library path in your client project to include the DLL import libraries from the DLL project. And finally, copy the built DLL from the DLL project into your client build output directory. This step allows your client app to use the same DLL code you build. To create a client app in Visual Studio 1. On the menu bar, choose File > New > Project to open the Create a new project dialog box. 2. At the top of the dialog, set Language to C++, set Platform to Windows, and set Project type to Console. 3. From the filtered list of project types, choose Console App then choose Next. 4. In the Configure your new project page, enter MathClient in the Project name box to specify a name for the project. Leave the default Location and Solution name values. Set Solution to Create new solution. Uncheck Place solution and project in the same directory if it's checked. 5. Choose the Create button to create the client project.A minimal console application project is created for you. The name for the main source file is the same as the project name that you entered earlier. In this example, it's named MathClient.cpp. You can build it, but it doesn't use your DLL yet. Next, to call the MathLibrary functions in your source code, your project must include the MathLibrary.h file. You could copy this header file into your client app project, then add it to the project as an existing item. This method can be a good choice for third party libraries. However, if you're working on the code for your DLL and your client at the same time, the header files could get out of sync. To avoid this issue, set the Additional Include Directories path in your project to include the path to the original header. To add the DLL header to your include path 1. Right-click on the MathClient node in Solution Explorer to open the Property Pages dialog. 2. In the Configuration drop-down box, select All Configurations if it's not already selected. 3. In the left pane, select Configuration Properties > C/C++ > General. 4. In the property pane, select the drop-down control next to the Additional Include Directories edit box, and then choose Edit.5. Double-click in the top pane of the Additional Include Directories dialog box to enable an edit control. Or, choose the folder icon to create a new entry. 6. In the edit control, specify the path to the location of the MathLibrary.h header file. You can choose the ellipsis (...) control to browse to the correct folder. You can also enter a relative path from your client source files to the folder that contains the DLL header files. If you followed the directions to put your client project in a separate solution from the DLL, the relative path should look like this: ..\..\MathLibrary\MathLibrary If your DLL and client projects are in the same solution, the relative path might look like this: ..\MathLibrary When the DLL and client projects are in other folders, adjust the relative path to match. Or, use the ellipsis control to browse for the folder. 7. After you've entered the path to the header file in the Additional Include Directories dialog box, choose the OK button. In the Property Pages dialog box, choose the OK button to save your changes. You can now include the MathLibrary.h file and use the functions it declares in your client application. Replace the contents of MathClient.cpp by using this code: C++This code can be compiled, but not linked. If you build the client app now, the error list shows several LNK2019 errors. That's because your project is missing some information: You haven't specified that your project has a dependency on the MathLibrary.lib library yet. And, you haven't told the linker how to find the MathLibrary.lib file. To fix this issue, you could copy the library file directly into your client app project. The linker would find and use it automatically. However, if both the library and the client app are under development, that might lead to changes in one copy that aren't shown in the other. To avoid this issue, you can set the Additional Dependencies property to tell the build system that your project depends on MathLibrary.lib. And, you can set an Additional Library Directories path in your project to include the path to the original library when you link. 1. Right-click on the MathClient node in Solution Explorer and choose Properties to open the Property Pages dialog. 2. In the Configuration drop-down box, select All Configurations if it's not already selected. It ensures that any property changes apply to both Debug and Release builds. 3. In the left pane, select Configuration Properties > Linker > Input. In the property pane, select the drop-down control next to the Additional Dependencies edit box, and then choose Edit. // MathClient.cpp : Client app for MathLibrary DLL. // #include "pch.h" Uncomment for Visual Studio 2017 and earlier #include #include "MathLibrary.h" int main() { // Initialize a Fibonacci relation sequence. fibonacci_init(1, 1); // Write out the sequence values until overflow. do { std::cout << fibonacci_index() << ": " << fibonacci_current() << std::endl; } while (fibonacci_next()); // Report count of values written before overflow. std::cout << fibonacci_index() + 1 << " Fibonacci sequence values fit in an " << "unsigned 64-bit integer." < Linker > General. In the property pane, select the drop-down control next to the Additional Library Directories edit box, and then choose Edit.7. Double-click in the top pane of the Additional Library Directories dialog box to enable an edit control. In the edit control, specify the path to the location of the MathLibrary.lib file. By default, it's in a folder called Debug directly under the DLL solution folder. If you create a release build, the file is placed in a folder called Release. You can use the $(IntDir) macro so that the linker can find your DLL, no matter which kind of build you create. If you followed the directions to put your client project in a separate solution from the DLL project, the relative path should look like this: ..\..\MathLibrary\$(IntDir) If your DLL and client projects are in other locations, adjust the relative path to match.8. Once you've entered the path to the library file in the Additional Library Directories dialog box, choose the OK button to go back to the Property Pages dialog box. Choose OK to save the property changes. Your client app can now compile and link successfully, but it still doesn't have everything it needs to run. When the operating system loads your app, it looks for the MathLibrary DLL. If it can't find the DLL in certain system directories, the environment path, or the local app directory, the load fails. Depending on the operating system, you'll see an error message like this: One way to avoid this issue is to copy the DLL to the directory that contains your client executable as part of the build process. You can add a Post-Build Event to your project, to add a command that copies the DLL to your build output directory. The command specified here copies the DLL only if it's missing or has changed. It uses macros to copy to and from the Debug or Release locations, based on your build configuration. To copy the DLL in a post-build event 1. Right-click on the MathClient node in Solution Explorer and choose Properties to open the Property Pages dialog.2. In the Configuration drop-down box, select All Configurations if it isn't already selected. 3. In the left pane, select Configuration Properties > Build Events > Post-Build Event. 4. In the property pane, select the edit control in the Command Line field. If you followed the directions to put your client project in a separate solution from the DLL project, then enter this command: xcopy /y /d "..\..\MathLibrary\$(IntDir)MathLibrary.dll" "$(OutDir)" If your DLL and client projects are in other directories, change the relative path to the DLL to match. 5. Choose the OK button to save your changes to the project properties. Now your client app has everything it needs to build and run. Build the application by choosing Build > Build Solution on the menu bar. The Output window in Visual Studio should have something like the following example depending on your version of Visual Studio: Output 1>------ Build started: Project: MathClient, Configuration: Debug Win32 ------ 1>MathClient.cpp 1>MathClient.vcxproj ->C:\Users\username\Source\Repos\MathClient\Debug\MathClient.exe 1>1 File(s) copied ========== Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped ========== Congratulations, you've created an application that calls functions in your DLL. Now run your application to see what it does. On the menu bar, choose Debug > Start Without Debugging. Visual Studio opens a command window for the program to run in. The last part of the output should look like: Press any key to dismiss the command window. Now that you've created a DLL and a client application, you can experiment. Try setting breakpoints in the code of the client app, and run the app in the debugger. See what happens when you step into a library call. Add other functions to the library, or write another client app that uses your DLL. When you deploy your app, you must also deploy the DLLs it uses. The simplest way to make the DLLs that you build, or that you include from third parties, available is to put them in the same directory as your app. It's known as app-local deployment. For more information about deployment, see Deployment in Visual C++. See also Calling DLL Functions from Visual Basic ApplicationsWalkthrough: Create and use a static library Article • 10/29/2021 This step-by-step walkthrough shows how to create a static library (.lib file) for use with C++ apps. Using a static library is a great way to reuse code. Rather than reimplementing the same routines in every app that requires the functionality, you write them one time in a static library and then reference it from the apps. Code linked from a static library becomes part of your app—you don't have to install another file to use the code. This walkthrough covers these tasks: Create a static library project Add a class to the static library Create a C++ console app that references the static library Use the functionality from the static library in the app Run the app Prerequisites An understanding of the fundamentals of the C++ language. Create a static library project The instructions for how to create the project vary depending on your version of Visual Studio. To see the documentation for your preferred version of Visual Studio, use the Version selector control. It's found at the top of the table of contents on this page. To create a static library project in Visual Studio 1. On the menu bar, choose File > New > Project to open the Create a New Project dialog. 2. At the top of the dialog, set Language to C++, set Platform to Windows, and set Project type to Library.3. From the filtered list of project types, select Windows Desktop Wizard, then choose Next. 4. In the Configure your new project page, enter MathLibrary in the Project name box to specify a name for the project. Enter StaticMath in the Solution name box. Choose the Create button to open the Windows Desktop Project dialog. 5. In the Windows Desktop Project dialog, under Application type, select Static Library (.lib). 6. Under Additional options, uncheck the Precompiled header check box if it's checked. Check the Empty project box. 7. Choose OK to create the project. 1. To create a header file for a new class, right-click to open the shortcut menu for the MathLibrary project in Solution Explorer, and then choose Add > New Item. 2. In the Add New Item dialog box, select Visual C++ > Code. In the center pane, select Header File (.h). Specify a name for the header file—for example, MathLibrary.h—and then choose the Add button. A nearly blank header file is displayed. 3. Add a declaration for a class named Arithmetic to do common mathematical operations such as addition, subtraction, multiplication, and division. The code should resemble: C++ Add a class to the static library To add a class to the static library // MathLibrary.h #pragma once namespace MathLibrary { class Arithmetic { public: // Returns a + b static double Add(double a, double b); // Returns a - b static double Subtract(double a, double b);4. To create a source file for the new class, open the shortcut menu for the MathLibrary project in Solution Explorer, and then choose Add > New Item. 5. In the Add New Item dialog box, in the center pane, select C++ File (.cpp). Specify a name for the source file—for example, MathLibrary.cpp—and then choose the Add button. A blank source file is displayed. 6. Use this source file to implement the functionality for class Arithmetic . The code should resemble: C++ // Returns a * b static double Multiply(double a, double b); // Returns a / b static double Divide(double a, double b); }; } // MathLibrary.cpp // compile with: cl /c /EHsc MathLibrary.cpp // post-build command: lib MathLibrary.obj #include "MathLibrary.h" namespace MathLibrary { double Arithmetic::Add(double a, double b) { return a + b; } double Arithmetic::Subtract(double a, double b) { return a - b; } double Arithmetic::Multiply(double a, double b) { return a * b; } double Arithmetic::Divide(double a, double b) { return a / b; } }7. To build the static library, select Build > Build Solution on the menu bar. The build creates a static library, MathLibrary.lib, that can be used by other programs. 7 Note When you build on the Visual Studio command line, you must build the program in two steps. First, run cl /c /EHsc MathLibrary.cpp to compile the code and create an object file that's named MathLibrary.obj. (The cl command invokes the compiler, Cl.exe, and the /c option specifies compile without linking. For more information, see /c (Compile Without Linking).) Second, run lib MathLibrary.obj to link the code and create the static library MathLibrary.lib. (The lib command invokes the Library Manager, Lib.exe. For more information, see LIB Reference.) Create a C++ console app that references the static library To create a C++ console app that references the static library in Visual Studio 1. In Solution Explorer, right-click on the top node, Solution 'StaticMath', to open the shortcut menu. Choose Add > New Project to open the Add a New Project dialog. 2. At the top of the dialog, set the Project type filter to Console. 3. From the filtered list of project types, choose Console App then choose Next. In the next page, enter MathClient in the Name box to specify a name for the project. 4. Choose the Create button to create the client project. 5. After you create a console app, an empty program is created for you. The name for the source file is the same as the name that you chose earlier. In the example, it's named MathClient.cpp . Use the functionality from the static library in the appTo use the functionality from the static library in the app 1. Before you can use the math routines in the static library, you must reference it. Open the shortcut menu for the MathClient project in Solution Explorer, and then choose Add > Reference. 2. The Add Reference dialog box lists the libraries that you can reference. The Projects tab lists the projects in the current solution and any libraries they reference. Open the Projects tab, select the MathLibrary check box, and then choose the OK button. 3. To reference the MathLibrary.h header file, you must modify the included directories path. In Solution Explorer, right-click on MathClient to open the shortcut menu. Choose Properties to open the MathClient Property Pages dialog box. 4. In the MathClient Property Pages dialog box, set the Configuration drop-down to All Configurations. Set the Platform drop-down to All Platforms. 5. Select the Configuration Properties > C/C++ > General property page. In the Additional Include Directories property, specify the path of the MathLibrary directory, or browse for it. To browse for the directory path: a. Open the Additional Include Directories property value drop-down list, and then choose Edit. b. In the Additional Include Directories dialog box, double-click in the top of the text box. Then choose the ellipsis button (...) at the end of the line. c. In the Select Directory dialog box, navigate up a level, and then select the MathLibrary directory. Then choose the Select Folder button to save your selection. d. In the Additional Include Directories dialog box, choose the OK button. e. In the Property Pages dialog box, choose the OK button to save your changes to the project. 6. You can now use the Arithmetic class in this app by including the #include "MathLibrary.h" header in your code. Replace the contents of MathClient.cpp with this code: C++7. To build the executable, choose Build > Build Solution on the menu bar. 1. Make sure that MathClient is selected as the default project. To select it, right-click to open the shortcut menu for MathClient in Solution Explorer, and then choose Set as StartUp Project. 2. To run the project, on the menu bar, choose Debug > Start Without Debugging. The output should resemble: Output // MathClient.cpp // compile with: cl /EHsc MathClient.cpp /link MathLibrary.lib #include #include "MathLibrary.h" int main() { double a = 7.4; int b = 99; std::cout << "a + b = " << MathLibrary::Arithmetic::Add(a, b) << std::endl; std::cout << "a - b = " << MathLibrary::Arithmetic::Subtract(a, b) << std::endl; std::cout << "a * b = " << MathLibrary::Arithmetic::Multiply(a, b) << std::endl; std::cout << "a / b = " << MathLibrary::Arithmetic::Divide(a, b) < Source Control > Git Global Settings > Automatically load the solution when opening a Git repository. Open a project locally from a previously cloned GitHub repo 1. Open Visual Studio. 2. On the start window, select Open a project or solution. Visual Studio opens an instance of File Explorer, where you can browse to your solution or project, and then select it to open it. ☐ Tip If you opened the project or solution recently, select it from the Open recent section. Start coding! Use the IDE You can also use the Git menu or the Select Repository control in the Visual Studio IDE to interact with a repository's folders and files.Here's how. To clone a repo and open a project 1. In the Visual Studio IDE, select the Git menu, and then select Clone Repository. 2. Follow the prompts to connect to the Git repository that includes the files that you're looking for. To open local folders and files 1. In the Visual Studio IDE, select the Git menu, select Local Repositories, and then select Open Local Repository. 2. Follow the prompts to connect to the Git repository that has the files that you're looking for. Browse to an Azure DevOps repo Here's how to browse to and clone an Azure DevOps repo by using Visual Studio. 1. Open Visual Studio. 2. On the start window, select Clone a repository.☐ 3. In the Browse a repository section, select Azure DevOps. 4. Follow the prompts to clone an Azure DevOps repo that includes the files that you're looking for, and then open your project. Related content Feel free to dive into any of the following language-specific tutorials:Feedback Was this page helpful? Provide product feedback | Ask the community Visual Studio tutorials | C# Visual Studio tutorials | Visual Basic Visual Studio tutorials | C++ Visual Studio tutorials | Python Visual Studio tutorials | JavaScript, TypeScript, and Node.js For more information, see: About Git in Visual Studio Brpwse a repo Manage a repo ☐ Yes ☐ NoLearn to use the code editor Article • 01/24/2025 In this 10-minute introduction to the code editor in Visual Studio, we'll add code to a file to look at some of the ways that Visual Studio makes writing, navigating, and understanding code easier. If you haven't already installed Visual Studio, go to the Visual Studio downloads page to install it for free. This article assumes you're already familiar with a programming language. If you aren't, we suggest you look at one of the programming quickstarts first, such as create a web app with Python or C#, or create a console app with Visual Basic or C++. ☐ Tip To follow along with this article, make sure you have the C# settings selected for Visual Studio. For information about selecting settings for the integrated development environment (IDE), see Select environment settings. Create a new code file Start by creating a new file and adding some code to it. 1. Open Visual Studio. Select the Esc key, or select Continue without code on the start window, to open the development environment. 2. From the File menu on the menu bar, select New > File, or select the Ctrl+N keys. 3. In the New File dialog box, under the General category, select C# Class, and then select Open. A new file opens in the editor with the skeleton of a C# class.Use GitHub Copilot GitHub Copilot acts as an AI pair programmer to provide autocomplete-style code completions and context-aware multi-line code suggestions, as you code, in real-time, right in the editor. GitHub Copilot turns natural language prompts including comments and method names into coding suggestions. You can view and incorporate suggestions from GitHub Copilot directly within the editor. Try GitHub Copilot Let's use Copilot to generate code suggestions: 1. Place your cursor just below the final closing brace } in the file. 2. Type a natural language comment: // Add a method to add two numbers and Enter. 3. GitHub Copilot generates a code suggestion for you. The suggested implementation shows in gray text. 4. To accept the suggestion, select Tab.☐ Let's use Copilot Chat to submit a coding-related question as a prompt: 1. Select the GitHub Copilot badge in the upper-right corner of the IDE. 2. Select Open Chat Window from the dropdown. 3. Enter the following prompt in the chat window: Copilot prompt Generate sample code for a simple C# method to add two numbers. 4. Copilot Chat generates sample code in response to your prompt. GitHub Copilot is powered by AI, so surprises and mistakes are possible. For more information, see GitHub Copilot FAQs . Get started with GitHub Copilot in Visual Studio. Note that it requires Visual Studio 2022 version 17.8 or later. Use code snippetsVisual Studio provides useful code snippets that you can use to quickly and easily generate commonly used code blocks. Code snippets are available for different programming languages including C#, Visual Basic, and C++. Let's add the C# void Main snippet to our file. 1. Place your cursor just above the final closing brace } in the file, and type the characters svm . A pop-up dialog box appears with information about the svm code snippet. 2. Select the Tab key twice to insert the code snippet. You'll see the static void Main() method signature get added to the file. The Main() method is the entry point for C# applications. Available code snippets vary for different programming languages. You can look at the available code snippets for your language by choosing Edit > IntelliSense > Insert Snippet or by selecting the Ctrl+K, Ctrl+X keys, and then choosing the folder for your programming language. For C#, the snippet list looks like this:The list includes snippets for creating a class, a constructor, a for loop, an if or switch statement, and more. The Text Editor toolbar, which is the row of buttons under the menu bar in Visual Studio, helps make you more productive as you code. For example, you can toggle IntelliSense completion mode, increase or decrease a line indent, or comment out code that you don't want to compile. Let's comment out some code. 1. Paste the following code into the Main() method body. C# Comment out code // someWords is a string array. string[] someWords = { "the", "quick", "brown", "fox", "jumps" };2. We're not using the moreWords variable, but we might use it later so we don't want to delete it. Instead, we'll comment out those lines. Select the entire definition of moreWords down to the closing semicolon, and then choose the Comment out the selected lines button on the Text Editor toolbar. If you prefer to use the keyboard, select Ctrl+K, Ctrl+C. The C# comment characters // are added to the beginning of each selected line to comment out the code. When you want to uncomment lines, you can select them, and then choose the Uncomment the selected lines button on the Text Editor toolbar. If you prefer to use the keyboard, select Ctrl+K, Ctrl+U. We don't want to see the empty constructor that was generated for Class1 , so to unclutter our view of the code, let's collapse it. Choose the small gray box with the minus sign inside it in the margin of the first line of the constructor. Or, if you prefer to use the keyboard, place the cursor anywhere in the constructor code and select the Ctrl+M, Ctrl+M keys. string[] moreWords = { "over", "the", "lazy", "dog" }; // Alphabetically sort the words. IEnumerable query = from word in someWords orderby word select word; Collapse code blocksThe code block collapses to just the first line, followed by an ellipsis (...). To expand the code block again, select the same gray box that now has a plus sign in it, or select Ctrl+M, Ctrl+M again. This feature is called Outlining and is especially useful when you're collapsing long methods or entire classes. View symbol definitions The Visual Studio editor makes it easy to inspect the definition of a type, method, or variable. One way is to go to the definition, in whichever file has it, by choosing Go to Definition or by selecting the F12 key anywhere a symbol is referenced. An even quicker way that doesn't move your focus away from the code you're working on is to use Peek Definition. Let's peek at the definition of the string type. 1. Right-click on any occurrence of string and choose Peek Definition from the content menu. Or, select the Alt+F12 keys. A pop-up window appears with the definition of the String class. You can scroll within the pop-up window, or even peek at the definition of another type from the peeked code. 2. Close the peek definition window by choosing the small box with an "x" at the top right of the pop-up window. Use IntelliSense to complete words IntelliSense is an invaluable resource when you're coding. It can show you information about available members of a type, or parameter details for different overloads of amethod. You can also use IntelliSense to complete a word after you type enough characters to disambiguate it. Let's add a line of code to print out the ordered strings to the console window, which is the standard place for output from the program to go. 1. Below the query variable, start typing the following code: C# You'll see an IntelliSense pop-up appear with information about the query symbol. 2. To insert the rest of the word query by using IntelliSense word completion, select the Tab key. 3. Finish off the code block to look like the following code. You can practice further with code snippets by entering cw and then selecting Tab twice to generate the Console.WriteLine statement. C# Nobody gets code right the first time, and one of the things you might have to change is the name of a variable or method. Let's try out Visual Studio's refactor functionality to rename the someWords variable to unsortedWords . foreach (string str in qu foreach (string str in query) { Console.WriteLine(str); } Refactor a name1. Place your cursor over the definition of the someWords variable, and choose Rename from the right-click or context menu, or select the F2 key. A Rename dialog box appears at the top right of the editor. 2. Enter the desired name unsortedWords. You'll see that the reference to unsortedWords in the query assignment statement is also automatically renamed. Before you select the Enter key, select the Include comments checkbox in the Rename pop-up box. 3. Select the Enter key. Both occurrences of someWords in your code have been renamed, as well as the text someWords in your code comment. Next steps Learn about projects and solutionsFeedback Was this page helpful? Provide product feedback | Ask the community GitHub Copilot Completions in Visual Studio GitHub Copilot Chat in Visual Studio Code snippets Navigate code Outlining Go To Definition and Peek Definition Refactoring Use IntelliSense See also ☐ Yes ☐ NoCompile and build in Visual Studio Article • 02/03/2025 For a first introduction to building within the IDE, see Walkthrough: Building an application. You can use any of the following methods to build an application: the Visual Studio IDE, the MSBuild command-line tools, and Azure Pipelines: Build Method Benefits IDE - Create builds immediately and test them in a debugger. - Run multi-processor builds for C++ and C# projects. - Customize different aspects of the build system. CMake - Build C++ projects using the CMake tool - Use the same build system across Linux and Windows platforms. MSBuild command line - Build projects without installing Visual Studio. - Run multi-processor builds for all project types. - Customize most areas of the build system. Azure Pipelines - Automate your build process as part of a continuous integration/continuous delivery pipeline. - Apply automated tests with every build. - Employ virtually unlimited cloud-based resources for build processes. - Modify the build workflow and create build activities to perform deeply customized tasks. The documentation in this section goes into further details of the IDE-based build process. For more information on the other methods, see CMake, MSBuild and Azure Pipelines, respectively. When you create a project, Visual Studio created default build configurations for the project and the solution that contains the project. These configurations define how the solutions and projects are built and deployed. Project configurations in particular are unique for a target platform (such as Windows or Linux) and build type (such as debug or release). You can edit these configurations however you like, and can also create your own configurations as needed. / Expand table Building from the IDEFeedback Was this page helpful? Provide product feedback | Ask the community For a first introduction to building within the IDE, see Walkthrough: Building an application. Next, see Building and cleaning projects and solutions in Visual Studio to learn about the different customizations you can make to the process. Customizations include changing output directories, specifying custom build events, managing project dependencies, managing build log files, and suppressing compiler warnings. From there, you can explore a variety of other tasks: Understand build configurations Configure projects to target platforms Manage project and solution properties. Specify build events in C# and Visual Basic Set build options Build multiple projects in parallel Building (compiling) website projects CMake projects in Visual Studio Related content ☐ Yes ☐ NoQuickstart: Debug with C++ using the Visual Studio debugger Article • 01/12/2024 The Visual Studio debugger provides many powerful features to help you debug your apps. This topic provides a quick way to learn some of the basic features. 1. Open Visual Studio and create a project. Press Esc to close the start window. Type Ctrl + Q to open the search box, type c++, choose Templates, then choose Create new Console App project. In the dialog box that appears, choose Create. If you don't see the Windows Console Application project template, go to Tools > Get Tools and Features..., which opens the Visual Studio Installer. The Visual Studio Installer launches. Choose the Desktop development with C++ workload, then choose Modify. Visual Studio creates the project. 2. In MyDbgApp.cpp, replace the following code C++ with this code (do not remove #include "stdafx.h"): C++ Create a new project int main() { return 0; } #include #include using namespace std; void doWork() { list c1;A breakpoint is a marker that indicates where Visual Studio should suspend your running code so you can take a look at the values of variables, or the behavior of memory, or whether or not a branch of code is getting run. It is the most basic feature in debugging. 1. To set the breakpoint, click in the gutter to the left of the doWork function call (or select the line of code and press F9). 2. Now press F5 (or choose Debug > Start Debugging). The debugger pauses where you set the breakpoint. The statement where the debugger and app execution is paused is indicated by the yellow arrow. The line with the doWork function call has not yet executed. c1.push_back(10); c1.push_back(20); const list c2 = c1; const int &i = c2.front(); const int &j = c2.front(); cout << "The first element is " << i << endl; cout << "The second element is " << j < Step Over) a few times to advance the debugger and execute the edited code. F10 advances the debugger one statement at a time, but steps over functions instead of stepping into them (the code that you skip still executes). For more information on using edit-and-continue and on feature limitations, see Edit and Continue.Feedback Was this page helpful? In this tutorial, you've learned how to start the debugger, step through code, and inspect variables. You may want to get a high-level look at debugger features along with links to more information. Next steps First look at the debugger ☐ Yes ☐ NoWrite unit tests for C/C++ in Visual Studio Article • 12/16/2024 You can write and run your C++ unit tests by using the Test Explorer window. It works just like it does for other languages. For more information about using Test Explorer, see Run unit tests with Test Explorer. 7 Note Some features such as Live Unit Testing, Coded UI Tests and IntelliTest aren't supported for C++. Visual Studio includes these C++ test frameworks with no extra downloads required: Microsoft Unit Testing Framework for C++ Google Test Boost.Test CTest You can use the installed frameworks, or write your own test adapter for whatever framework you want to use within Visual Studio. A test adapter integrates unit tests with the Test Explorer window. Several non-Microsoft adapters are available on the Visual Studio Marketplace . For more information, see Install unit test frameworks. Visual Studio 2017 and later (Professional and Enterprise) C++ unit test projects support CodeLens. Visual Studio 2017 and later (all editions) Google Test Adapter is included as a default component of the Desktop development with C++ workload. It has a project template that you can add to a solution. Right-click on the solution node in Solution Explorer and choose Add > New Project on the shortcut menu to add the project template. It also has options you can configure by using Tools > Options. For more information, see How to: Use Google Test in Visual Studio. Boost.Test is included as a default component of the Desktop development with C++ workload. It's integrated with Test Explorer, but currently doesn'thave a project template. You must manually configure it. For more information, see How to: Use Boost.Test in Visual Studio. CTest support is included with the C++ CMake tools component, which is part of the Desktop development with C++ workload. For more information, see How to: Use CTest in Visual Studio. Earlier versions of Visual Studio You can download the Google Test adapter and Boost.Test Adapter extensions on the Visual Studio Marketplace. Find them at Test adapter for Boost.Test and Test adapter for Google Test . ☐ Tip You can also use Copilot /tests slash command to generate unit tests from code. For example, you can type /tests using Boost framework to generate Boost.Test tests. For more information, see Use slash commands in Copilot Chat. Basic test workflow The following sections show the basic steps to get you started with C++ unit testing. The basic configuration is similar for both the Microsoft and Google Test frameworks. Boost.Test requires that you manually create a test project. Create a test project in Visual Studio 2022 Define and run unit tests inside one or more test projects. A test project creates a separate app that calls the code in your executable and reports on its behavior. Create test projects in the same solution as the code you want to test. To add a new test project to an existing solution: 1. Right-click on the Solution node in Solution Explorer. 2. In the context menu, choose Add > New Project. 3. Set Language to C++ and type test in the search box. The following screenshot shows the test projects that are available when the Desktop Development with C++ and the UWP Development workload are installed:Create references to other projects in the solution To enable access to the functions in the project under test, add a reference to the project in your test project. In Solution Explorer, expand your test project. Right-click References and then select Add > Reference. In the Add Reference dialog box, choose the projects you want to test.Link to object or library files If the test code doesn't export the functions that you want to test, add the output .obj or .lib files to the dependencies of the test project. For more information, see To link the tests to the object or library files. Don't include object files that have a main function or another standard entry point such as wmain , WinMain , or DllMain . When you add new source files to your project, update the test project dependencies to include the corresponding object files. Add #include directives for header files In your unit test .cpp file, add an #include directive for any header files that declare the types and functions you want to test. Type #include " , and then IntelliSense activates to help you choose. Repeat for any more headers.☐ Tip To avoid having to type the full path in each include statement in the source file, add the required folders in Project > Properties > C/C++ > General > Additional Include Directories. Write test methods 7 Note This section shows syntax for the Microsoft Unit Testing Framework for C/C++. For more information, see Microsoft.VisualStudio.TestTools.CppUnitTestFramework API reference. For Google Test documentation, see Google Test primer . For Boost.Test, see Boost Test library: The unit test framework . The .cpp file in your test project has a stub class and method defined for you. They show an example of how to write test code. The signatures use the TEST_CLASS and TEST_METHOD macros, which make the methods discoverable from the Test Explorer window.TEST_CLASS and TEST_METHOD are part of the Microsoft Native Test Framework. Test Explorer discovers test methods in other supported frameworks in a similar way. A TEST_METHOD returns void. To produce a test result, use the static methods in the Assert class to test actual results against expected results. In the following example, assume MyClass has a constructor that takes a std::string . This example shows how you can test that the constructor initializes the class the way you expect: C++ In the previous example, the result of the Assert::AreEqual call determines whether the test passes or fails. The Assert class contains many other methods to compare expected results with actual results. You can add traits to test methods to specify test owners, priority, and other information. You can then use these values to sort and group tests in Test Explorer. For more information, see Run unit tests with Test Explorer. 1. On the Test menu, choose Test Explorer. The following illustration shows a test project before you run tests. TEST_METHOD(TestClassInit) { std::string name = "Bill"; MyClass mc(name); Assert::AreEqual(name, mc.GetName()); } Run the tests 7 Note CTest integration with Test Explorer is not yet available. Run CTest tests from the CMake main menu. 2. If any of your tests are missing from the window, build the test project by right clicking its node in Solution Explorer and choosing Build or Rebuild. 3. In Test Explorer, choose Run All, or select the specific tests you want to run. Right click on a test for other options, including running it in debug mode with breakpoints enabled. After all the tests run, the window shows the tests that passed and the ones that failed. For failed tests, the message displays details that help to diagnose the cause. Right-click on the failing test for a pop-up menu. Choose Debug to step through the function where the failure occurred.For more information on using Test Explorer, see Run unit tests with Test Explorer. For more information on unit testing, see Unit test basics. Use CodeLens Visual Studio 2017 and later (Professional and Enterprise editions) CodeLens lets you quickly see the status of a unit test without leaving the code editor. Initialize CodeLens for a C++ unit test project in any of the following ways: Edit and build your test project or solution. Rebuild your project or solution. Run tests from the Test Explorer window. After you initialize CodeLens, you can see the test status icons above each unit test. ☐ Choose the icon for more information, or to run or debug the unit test:Feedback Was this page helpful? Provide product feedback | Ask the community Unit test your code Related content ☐ Yes ☐ NoWalkthrough: Compiling a Native C++ Program on the Command Line Article • 02/08/2022 Visual Studio includes a command-line C and C++ compiler. You can use it to create everything from basic console apps to Universal Windows Platform apps, Desktop apps, device drivers, and .NET components. In this walkthrough, you create a basic, "Hello, World"-style C++ program by using a text editor, and then compile it on the command line. If you'd like to try the Visual Studio IDE instead of using the command line, see Walkthrough: Working with Projects and Solutions (C++) or Using the Visual Studio IDE for C++ Desktop Development. In this walkthrough, you can use your own C++ program instead of typing the one that's shown. Or, you can use a C++ code sample from another help article. Prerequisites To complete this walkthrough, you must have installed either Visual Studio and the optional Desktop development with C++ workload, or the command-line Build Tools for Visual Studio. Visual Studio is an integrated development environment (IDE). It supports a full-featured editor, resource managers, debuggers, and compilers for many languages and platforms. Versions available include the free Visual Studio Community edition, and all can support C and C++ development. For information on how to download and install Visual Studio, see Install C++ support in Visual Studio. The Build Tools for Visual Studio installs only the command-line compilers, tools, and libraries you need to build C and C++ programs. It's perfect for build labs or classroom exercises and installs relatively quickly. To install only the command-line tools, look for Build Tools for Visual Studio on the Visual Studio Downloads page. Before you can build a C or C++ program on the command line, verify that the tools are installed, and you can access them from the command line. Visual C++ has complex requirements for the command-line environment to find the tools, headers, and libraries it uses. You can't use Visual C++ in a plain command prompt window without doing some preparation. Fortunately, Visual C++ installs shortcuts for you to launch a developer command prompt that has the environment set up for command line builds. Unfortunately, the names of the developer command prompt shortcuts and wherethey're located are different in almost every version of Visual C++ and on different versions of Windows. Your first walkthrough task is finding the right one to use. 7 Note A developer command prompt shortcut automatically sets the correct paths for the compiler and tools, and for any required headers and libraries. You must set these environment values yourself if you use a regular Command Prompt window. For more information, see Use the MSVC toolset from the command line. We recommend you use a developer command prompt shortcut instead of building your own. Open a developer command prompt 1. If you have installed Visual Studio 2017 or later on Windows 10 or later, open the Start menu and choose All apps. Scroll down and open the Visual Studio folder (not the Visual Studio application). Choose Developer Command Prompt for VS to open the command prompt window. If you have installed Microsoft Visual C++ Build Tools 2015 on Windows 10 or later, open the Start menu and choose All apps. Scroll down and open the Visual C++ Build Tools folder. Choose Visual C++ 2015 x86 Native Tools Command Prompt to open the command prompt window. You can also use the Windows search function to search for "developer command prompt" and choose one that matches your installed version of Visual Studio. Use the shortcut to open the command prompt window. 2. Next, verify that the Visual C++ developer command prompt is set up correctly. In the command prompt window, enter cl and verify that the output looks something like this: Output C:\Program Files (x86)\Microsoft Visual Studio\2017\Enterprise>cl Microsoft (R) C/C++ Optimizing Compiler Version 19.10.25017 for x86 Copyright (C) Microsoft Corporation. All rights reserved. usage: cl [option...] filename... [/link linkoption...] There may be differences in the current directory or version numbers. These values depend on the version of Visual C++ and any updates installed. If the aboveoutput is similar to what you see, then you're ready to build C or C++ programs at the command line. 7 Note If you get an error such as "'cl' is not recognized as an internal or external command, operable program or batch file," error C1034, or error LNK1104 when you run the cl command, then either you are not using a developer command prompt, or something is wrong with your installation of Visual C++. You must fix this issue before you can continue. If you can't find the developer command prompt shortcut, or if you get an error message when you enter cl , then your Visual C++ installation may have a problem. Try reinstalling the Visual C++ component in Visual Studio, or reinstall the Microsoft Visual C++ Build Tools. Don't go on to the next section until the cl command works. For more information about installing and troubleshooting Visual C++, see Install Visual Studio. 7 Note Depending on the version of Windows on the computer and the system security configuration, you might have to right-click to open the shortcut menu for the developer command prompt shortcut and then choose Run as administrator to successfully build and run the program that you create by following this walkthrough. Create a Visual C++ source file and compile it on the command line 1. In the developer command prompt window, enter md c:\hello to create a directory, and then enter cd c:\hello to change to that directory. This directory is where both your source file and the compiled program get created. 2. Enter notepad hello.cpp in the command prompt window. Choose Yes when Notepad prompts you to create a new file. This step opens a blank Notepad window, ready for you to enter your code in a file named hello.cpp. 3. In Notepad, enter the following lines of code:C++ This code is a simple program that will write one line of text on the screen and then exit. To minimize errors, copy this code and paste it into Notepad. 4. Save your work! In Notepad, on the File menu, choose Save. Congratulations, you've created a C++ source file, hello.cpp, that is ready to compile. 5. Switch back to the developer command prompt window. Enter dir at the command prompt to list the contents of the c:\hello directory. You should see the source file hello.cpp in the directory listing, which looks something like: Output The dates and other details will differ on your computer. #include using namespace std; int main() { cout << "Hello, world, from Visual C++!" <dir Volume in drive C has no label. Volume Serial Number is CC62-6545 Directory of c:\hello 05/24/2016 05:36 PM . 05/24/2016 05:36 PM .. 05/24/2016 05:37 PM 115 hello.cpp 1 File(s) 115 bytes 2 Dir(s) 571,343,446,016 bytes free 7 Note If you don't see your source code file, hello.cpp , make sure the current working directory in your command prompt is the C:\hello directory you created. Also make sure that this is the directory where you saved your source file. And make sure that you saved the source code with a .cpp file name extension, not a .txt extension. Your source file gets saved in the current directory as a .cpp file automatically if you open Notepad at the commandprompt by using the notepad hello.cpp command. Notepad's behavior is different if you open it another way: By default, Notepad appends a .txt extension to new files when you save them. It also defaults to saving files in your Documents directory. To save your file with a .cpp extension in Notepad, choose File > Save As. In the Save As dialog, navigate to your C:\hello folder in the directory tree view control. Then use the Save as type dropdown control to select All Files (*.*). Enter hello.cpp in the File name edit control, and then choose Save to save the file. 6. At the developer command prompt, enter cl /EHsc hello.cpp to compile your program. The cl.exe compiler generates an .obj file that contains the compiled code, and then runs the linker to create an executable program named hello.exe. This name appears in the lines of output information that the compiler displays. The output of the compiler should look something like: Output c:\hello>cl /EHsc hello.cpp Microsoft (R) C/C++ Optimizing Compiler Version 19.10.25017 for x86 Copyright (C) Microsoft Corporation. All rights reserved. hello.cpp Microsoft (R) Incremental Linker Version 14.10.25017.0 Copyright (C) Microsoft Corporation. All rights reserved. /out:hello.exe hello.obj 7 Note If you get an error such as "'cl' is not recognized as an internal or external command, operable program or batch file," error C1034, or error LNK1104, your developer command prompt is not set up correctly. For information on how to fix this issue, go back to the Open a developer command prompt section. 7 Note If you get a different compiler or linker error or warning, review your source code to correct any errors, then save it and run the compiler again. Forinformation about specific errors, use the search box to look for the error number. 7. To run the hello.exe program, at the command prompt, enter hello . The program displays this text and exits: Output Hello, world, from Visual C++! Congratulations, you've compiled and run a C++ program by using the command line tools. Next steps This "Hello, World" example is about as simple as a C++ program can get. Real world programs usually have header files, more source files, and link to libraries. You can use the steps in this walkthrough to build your own C++ code instead of typing the sample code shown. These steps also let you build many C++ code sample programs that you find elsewhere. You can put your source code and build your apps in any writeable directory. By default, the Visual Studio IDE creates projects in your user folder, in a source\repos subfolder. Older versions may put projects in a Documents\Visual Studio \Projects folder. To compile a program that has additional source code files, enter them all on the command line, like: cl /EHsc file1.cpp file2.cpp file3.cpp The /EHsc command-line option instructs the compiler to enable standard

C++ exception handling behavior. Without it, thrown exceptions can result in undestroyed objects and resource leaks. For more information, see /EH (Exception Handling Model). When you supply additional source files, the compiler uses the first input file to create the program name. In this case, it outputs a program called file1.exe. To change the name to program1.exe, add an /out linker option: cl /EHsc file1.cpp file2.cpp file3.cpp /link /out:program1.exe And to catch more programming mistakes automatically, we recommend you compile by using either the /W3 or /W4 warning level option:cl /W4 /EHsc file1.cpp file2.cpp file3.cpp /link /out:program1.exe The compiler, cl.exe, has many more options. You can apply them to build, optimize, debug, and analyze your code. For a quick list, enter cl /? at the developer command prompt. You can also compile and link separately and apply linker options in more complex build scenarios. For more information on compiler and linker options and usage, see C/C++ Building Reference. You can use NMAKE and makefiles, MSBuild and project files, or CMake, to configure and build more complex projects on the command line. For more information on using these tools, see NMAKE Reference, MSBuild, and CMake projects in Visual Studio. The C and C++ languages are similar, but not the same. The MSVC compiler uses a simple rule to determine which language to use when it compiles your code. By default, the MSVC compiler treats files that end in .c as C source code, and files that end in .cpp as C++ source code. To force the compiler to treat all files as C++ independent of file name extension, use the /TP compiler option. The MSVC compiler includes a C Runtime Library (CRT) that conforms to the ISO C99 standard, with minor exceptions. Portable code generally compiles and runs as expected. Certain obsolete library functions, and several POSIX function names, are deprecated by the MSVC compiler. The functions are supported, but the preferred names have changed. For more information, see Security Features in the CRT and Compiler Warning (level 3) C4996. See also C++ Language Reference Projects and build systems MSVC Compiler OptionsWalkthrough: Compile a C program on the command line Article • 05/10/2022 The Visual Studio build tools include a C compiler that you can use to create everything from basic console programs to full Windows Desktop applications, mobile apps, and more. Microsoft C/C++ (MSVC) is a C and C++ compiler that, in its latest versions, conforms to some of the latest C language standards, including C11 and C17. This walkthrough shows how to create a basic, "Hello, World"-style C program by using a text editor, and then compile it on the command line. If you'd rather work in C++ on the command line, see Walkthrough: Compiling a Native C++ Program on the Command Line. If you'd like to try the Visual Studio IDE instead of using the command line, see Walkthrough: Working with Projects and Solutions (C++) or Using the Visual Studio IDE for C++ Desktop Development. Prerequisites To complete this walkthrough, you must have installed either Visual Studio or the Build Tools for Visual Studio and the optional Desktop development with C++ workload. Visual Studio is a powerful integrated development environment that supports a full featured editor, resource managers, debuggers, and compilers for many languages and platforms. For information on these features and how to download and install Visual Studio, including the free Visual Studio Community edition, see Install Visual Studio. The Build Tools for Visual Studio version of Visual Studio installs only the command-line toolset, the compilers, tools, and libraries you need to build C and C++ programs. It's perfect for build labs or classroom exercises and installs relatively quickly. To install only the command-line toolset, download Build Tools for Visual Studio from the Visual Studio downloads page and run the installer. In the Visual Studio installer, select the Desktop development with C++ workload (in older versions of Visual Studio, select the C++ build tools workload), and choose Install. When you've installed the tools, there's another tool you'll use to build a C or C++ program on the command line. MSVC has complex requirements for the command-line environment to find the tools, headers, and libraries it uses. You can't use MSVC in a plain command prompt window without some preparation. You need a developer command prompt window, which is a regular command prompt window that has all the required environment variables set. Fortunately, Visual Studio installs shortcuts for youto launch developer command prompts that have the environment set up for command line builds. Unfortunately, the names of the developer command prompt shortcuts and where they're located are different in almost every version of Visual Studio and on different versions of Windows. Your first walkthrough task is to find the right shortcut to use. 7 Note A developer command prompt shortcut automatically sets the correct paths for the compiler and tools, and for any required headers and libraries. Some of these values are different for each build configuration. You must set these environment values yourself if you don't use one of the shortcuts. For more information, see Use the MSVC toolset from the command line. Because the build environment is complex, we strongly recommend you use a developer command prompt shortcut instead of building your own. These instructions vary depending on which version of Visual Studio you're using. To see the documentation for your preferred version of Visual Studio, use the Version selector control. It's found at the top of the table of contents on this page. Open a developer command prompt in Visual Studio 2022 If you've installed Visual Studio 2022 on Windows 10 or later, open the Start menu, and choose All apps. Then, scroll down and open the Visual Studio 2022 folder (not the Visual Studio 2022 app). Choose Developer Command Prompt for VS 2022 to open the command prompt window. If you're using a different version of Windows, look in your Start menu or Start page for a Visual Studio tools folder that contains a developer command prompt shortcut. You can also use the Windows search function to search for "developer command prompt" and choose one that matches your installed version of Visual Studio. Use the shortcut to open the command prompt window. Next, verify that the developer command prompt is set up correctly. In the command prompt window, enter cl (or CL , case doesn't matter for the compiler name, but it does matter for compiler options). The output should look something like this: OutputC:\Program Files (x86)\Microsoft Visual Studio\2017\Enterprise>cl Microsoft (R) C/C++ Optimizing Compiler Version 19.10.25017 for x86 Copyright (C) Microsoft Corporation. All rights reserved. usage: cl [option...] filename... [/link linkoption...] There may be differences in the current directory or version numbers, depending on the version of Visual Studio and any updates installed. If the above output is similar to what you see, then you're ready to build C or C++ programs at the command line. 7 Note If you get an error such as "'cl' is not recognized as an internal or external command, operable program or batch file," error C1034, or error LNK1104 when you run the cl command, then either you are not using a developer command prompt, or something is wrong with your installation of Visual Studio. You must fix this issue before you can continue. If you can't find the developer command prompt shortcut, or if you get an error message when you enter cl , then your Visual Studio installation may have a problem. If you're using Visual Studio 2017 or later, try reinstalling the Desktop development with C++ workload in the Visual Studio installer. For details, see Install C++ support in Visual Studio. Or, reinstall the Build Tools from the Visual Studio downloads page. Don't go on to the next section until the cl command works. For more information about installing and troubleshooting Visual Studio, see Install Visual Studio. 7 Note Depending on the version of Windows on the computer and the system security configuration, you might have to right-click to open the shortcut menu for the developer command prompt shortcut and then choose Run as Administrator to successfully build and run the program that you create by following this walkthrough. Create a C source file and compile it on the command line 1. In the developer command prompt window, enter cd c:\ to change the current working directory to the root of your C: drive. Next, enter md c:\hello to create adirectory, and then enter cd c:\hello to change to that directory. This directory will hold your source file and the compiled program. 2. Enter notepad hello.c at the developer command prompt. In the Notepad alert dialog that pops up, choose Yes to create a new hello.c file in your working directory. 3. In Notepad, enter the following lines of code: C 4. On the Notepad menu bar, choose File > Save to save hello.c in your working directory. 5. Switch back to the developer command prompt window. Enter dir at the command prompt to list the contents of the c:\hello directory. You should see the source file hello.c in the directory listing, which looks something like: Output The dates and other details will differ on your computer. If you don't see your source code file, hello.c , make sure you've changed to the c:\hello directory you created, and in Notepad, make sure that you saved your source file in this directory. #include int main() { printf("Hello, World! This is a native C program compiled on the command line.\n"); return 0; } C:\hello>dir Volume in drive C has no label. Volume Serial Number is CC62-6545 Directory of C:\hello 10/02/2017 03:46 PM . 10/02/2017 03:46 PM .. 10/02/2017 03:36 PM 143 hello.c 1 File(s) 143 bytes 2 Dir(s) 514,900,566,016 bytes freedirectory. Also make sure that you saved the source code with a .c file name extension, not a .txt extension. 6. To compile your program, enter cl hello.c at the developer command prompt. You can see the executable program name, hello.exe, in the lines of output information that the compiler displays: Output c:\hello>cl hello.c Microsoft (R) C/C++ Optimizing Compiler Version 19.10.25017 for x86 Copyright (C) Microsoft Corporation. All rights reserved. hello.c Microsoft (R) Incremental Linker Version 14.10.25017.0 Copyright (C) Microsoft Corporation. All rights reserved. /out:hello.exe hello.obj 7 Note If you get an error such as "'cl' is not recognized as an internal or external command, operable program or batch file," error C1034, or error LNK1104, your developer command prompt is not set up correctly. For information on how to fix this issue, go back to the Open a developer command prompt section. If you get a different compiler or linker error or warning, review your source code to correct any errors, then save it and run the compiler again. For information about specific errors, use the search box at the top of this page to look for the error number. 7. To run your program, enter hello at the command prompt. The program displays this text and then exits: Output Hello, World! This is a native C program compiled on the command line. Congratulations, you've compiled and run a C program by using the command line.Next steps This "Hello, World" example is about as basic as a C program can get. Real world programs have header files and more source files, link in libraries, and do useful work. You can use the steps in this walkthrough to build your own C code instead of typing the sample code shown. You can also build many C code sample programs that you find elsewhere. To compile a program that has more source code files, enter them all on the command line: cl file1.c file2.c file3.c The compiler outputs a program called file1.exe . To change the name to program1.exe , add an /out linker option: cl file1.c file2.c file3.c /link /out:program1.exe And to catch more programming mistakes automatically, we recommend you compile by using either the /W3 or /W4 warning level option: cl /W4 file1.c file2.c file3.c /link /out:program1.exe The compiler, cl.exe, has many more options you can apply to build, optimize, debug, and analyze your code. For a quick list, enter cl /? at the developer command prompt. You can also compile and link separately and apply linker options in more complex build scenarios. For more information on compiler and linker options and usage, see C/C++ Building Reference. You can use NMAKE and makefiles, or MSBuild and project files to configure and build more complex projects on the command line. For more information on using these tools, see NMAKE Reference and MSBuild. The C and C++ languages are similar, but not the same. The Microsoft C/C++ compiler (MSVC) uses a basic rule to determine which language to use when it compiles your code. By default, the MSVC compiler treats all files that end in .c as C source code, and all files that end in .cpp as C++ source code. To force the compiler to treat all files as C no matter the file name extension, use the /TC compiler option. By default, MSVC is compatible with the ANSI C89 and ISO C99 standards, but not strictly conforming. In most cases, portable C code will compile and run as expected. The compiler provides optional support for the changes in ISO C11/C17. To compile with C11/C17 support, use the compiler flag /std:c11 or /std:c17 . C11/C17 support requires Windows SDK 10.0.20201.0 or later. Windows SDK 10.0.22000.0 or later isrecommended. You can download the latest SDK from the Windows SDK page. For more information, and instructions on how to install and use this SDK for C development, see Install C11 and C17 support in Visual Studio. Certain library functions and POSIX function names are deprecated by MSVC. The functions are supported, but the preferred names have changed. For more information, see Security Features in the CRT and Compiler Warning (level 3) C4996. See also Walkthrough: Creating a Standard C++ Program (C++) C Language Reference Projects and build systems CompatibilityWalkthrough: Compiling a C++/CX Program on the Command Line Article • 03/01/2023 7 Note For new UWP apps and components, we recommend that you use C++/WinRT, a standard C++17 language projection for Windows Runtime APIs. C++/WinRT is available in the Windows SDK from version 1803 (10.0.17134.0) onward. C++/WinRT is implemented entirely in header files, and is designed to provide you with first-class access to the modern Windows API. The Microsoft C++ compiler (MSVC) supports C++ component extensions (C++/CX), which has additional types and operators to target the Windows Runtime programming model. You can use C++/CX to build apps for Universal Windows Platform (UWP), and Windows desktop. For more information, see A Tour of C++/CX and Component Extensions for Runtime Platforms. In this walkthrough, you use a text editor to create a basic C++/CX program, and then compile it on the command line. (You can use your own C++/CX program instead of typing the one that's shown, or you can use a C++/CX code sample from another help article. This technique is useful for building and testing small modules that have no UI elements.) 7 Note You can also use the Visual Studio IDE to compile C++/CX programs. Because the IDE includes design, debugging, emulation, and deployment support that isn't available on the command line, we recommend that you use the IDE to build Universal Windows Platform (UWP) apps. For more information, see Create a UWP app in C++. Prerequisites You understand the fundamentals of the C++ language. Compiling a C++/CX ProgramTo enable compilation for C++/CX, you must use the /ZW compiler option. The MSVC compiler generates an .exe file that targets the Windows Runtime, and links to the required libraries. To compile a C++/CX application on the command line 1. Open a Developer Command Prompt window. For specific instructions, see To open a developer command prompt window. Administrator credentials may be required to successfully compile the code, depending on the computer's operating system and configuration. To run the command prompt window as an administrator, right-click to open the shortcut menu for the command prompt and then choose More > Run as administrator. 2. Change the current working directory in the command prompt window to a directory you can write to, such as your Documents directory. 3. At the command prompt, enter notepad basiccx.cpp. Choose Yes when you're prompted to create a file. 4. In Notepad, enter these lines: C++ using namespace Platform; int main(Platform::Array^ args) { Platform::Details::Console::WriteLine("This is a C++/CX program."); } 5. On the menu bar, choose File > Save. You've created a C++ source file that uses the Windows Runtime Platform namespace namespace. 6. At the command prompt, enter cl /EHsc /ZW basiccx.cpp /link /SUBSYSTEM:CONSOLE . The cl.exe compiler compiles the source code into an .obj file, and then runs the linker to generate an executable program named basiccx.exe. The /EHsc compiler option specifies the C++ exception-handling model, and the /link flag specifies a console application. 7. To run the basiccx.exe program, at the command prompt, enter basiccx.The program displays this text and exits: Output This is a C++/CX program. See also Projects and build systems MSVC Compiler OptionsWalkthrough: Compiling a C++/CLI Program on the Command Line Article • 02/24/2023 You can create Visual C++ programs that target the Common Language Runtime (CLR) and use the .NET Framework, and build them on the command line. Visual C++ supports the C++/CLI programming language, which has additional types and operators to target the .NET programming model. For general information about the C++/CLI language, see .NET Programming with C++/CLI (Visual C++). In this walkthrough, you use a text editor to create a basic C++/CLI program, and then compile it on the command line. (You can use your own C++/CLI program instead of typing the one that's shown, or you can use a C++/CLI code sample from another help article. This technique is useful for building and testing small modules that have no UI elements.) Prerequisites You understand the fundamentals of the C++ language. Compiling a C++/CLI Program The following steps show how to compile a C++/CLI console application that uses .NET Framework classes. To enable compilation for C++/CLI, you must use the /clr compiler option. The MSVC compiler generates an .exe file that contains MSIL code—or mixed MSIL and native code —and links to the required .NET Framework libraries. To compile a C++/CLI application on the command line 1. Open a Developer Command Prompt window. For specific instructions, see To open a developer command prompt window. Administrator credentials may be required to successfully compile the code, depending on the computer's operating system and configuration. To run the command prompt window as an administrator, right-click to open the shortcut menu for the command prompt and then choose More > Run as administrator.2. Change the current working directory in the command prompt window to a directory you can write to, such as your Documents directory. 3. At the command prompt, enter notepad basicclr.cpp . Choose Yes when you're prompted to create a file. 4. In Notepad, enter these lines: C++ int main() { System::Console::WriteLine("This is a C++/CLI program."); } 5. On the menu bar, choose File > Save. You've created a Visual C++ source file that uses a .NET Framework class (Console) in the System namespace. 6. At the command prompt, enter cl /clr basicclr.cpp . The cl.exe compiler compiles the source code into an .obj file that contains MSIL, and then runs the linker to generate an executable program named basicclr.exe. 7. To run the basicclr.exe program, at the command prompt, enter basicclr . The program displays this text and exits: Output This is a C++/CLI program. See also C++ Language Reference Projects and build systems MSVC Compiler Options ____ C++ Standard Library reference (STL) Article 08/17/2022 A C++ program can call on a large number of functions from this conforming implementation of the C++ Standard Library. These functions perform services such as input and output and provide efficient implementations of frequently used operations. For more information about linking with the appropriate Visual C++ runtime .lib file, see C runtime (CRT) and C++ Standard Library (STL) .lib files. Note Microsoft's implementation of the C++ Standard Library is often referred to as the STL or Standard Template Library. Although C++ Standard Library is the official name of the library as defined in ISO 14882, due to the popular use of "STL" and "Standard Template Library" in search engines, we occasionally use those names to make it easier to find our documentation. From a historical perspective, "STL" originally referred to the Standard Template Library written by Alexander Stepanov. Parts of that library were standardized in the C++ Standard Library, along with the ISO C runtime library, parts of the Boost library, and other functionality. Sometimes "STL" is used to refer to the containers and algorithms parts of the C++ Standard Library adapted from Stepanov's STL. In this documentation, Standard Template Library (STL) refers to the C++ Standard Library as a whole. In this section C++ Standard Library overview Provides an overview of the Microsoft implementation of the C++ Standard Library. iostream programming Provides an overview of iostream programming. Header files reference Provides links to reference topics about the C++ Standard Library header files, with code examples. Use the Microsoft C++ toolset from the command line Article 03/02/2023 In this article Download and install the tools How to use the command-line tools Path and environment variables for command-line builds Developer command prompt shortcuts You can build C and C++ applications on the command line by using tools that are included in Visual Studio. The Microsoft C++ (MSVC) compiler toolset is also downloadable as a standalone package. You don't need to install the Visual Studio IDE if you don't plan to use it. Note This article is about how to set up an environment to use the individual compilers, linkers, librarian, and other basic tools. The native project build system in Visual Studio, based on MSBuild, doesn't use the environment as described in this article. For more information on how to use MSBuild from the command line, see MSBuild on the command line - C++. Download and install the tools If you've installed Visual Studio and a C++ workload, you have all the command-line tools. For information on how to install C++ and Visual Studio, see Install C++ support in Visual Studio. If you only want the command-line toolset, download the Build Tools for Visual Studio. When you run the downloaded executable, it updates and runs the Visual Studio Installer. To install only the tools you need for C++ development, select the Desktop development with C++ workload. You can select optional libraries and toolsets to include under Installation details. To build code by using the Visual Studio 2015, 2017, or 2019 toolsets, select the optional MSVC v140, v141, or v142 build tools. When you're satisfied with your selections, choose Install. How to use the command-line tools When you choose one of the C++ workloads in the Visual Studio Installer, it installs the Visual Studio platform toolset. A platform toolset has all the C and C++ tools for a specific Visual Studio version. The tools include the C/C++ compilers, linkers, assemblers, and other build tools, and matching libraries and header files. You can use all of these tools at the command line. They're also used internally by the Visual Studio IDE. There are separate x86-hosted and x64-hosted compilers and tools to build code for x86, x64, ARM, and ARM64 targets. Each set of tools for a particular host and target build architecture is stored in its own directory. To work correctly, the tools require several specific environment variables to be set. These variables are used to add the tools to the path, and to set the locations of include files, library files, and SDKs. To make it easy to set these environment variables, the installer creates customized command files, or batch files, during installation. You can run one of these command files to set a specific host and target build architecture, Windows SDK version, and platform toolset. For convenience, the installer also creates shortcuts in your Start menu. The shortcuts open developer command prompt windows by using these command files for specific combinations of host and target. These shortcuts ensure all the required environment variables are set and ready to use. The required environment variables are specific to your installation and to the build architecture you choose. They also might be changed by product updates or upgrades. This variability is one reason why we recommend you use an installed command prompt shortcut or command file, instead of setting the environment variables yourself. The toolsets, command files, and shortcuts installed depend on your computer processor and the options you selected during installation. The x86-hosted tools and cross tools that build x86 and x64 code are always installed. If you have 64-bit Windows, the x64-hosted tools and cross tools that build x86 and x64 code are also installed. If you choose the optional C++ Universal Windows Platform tools, then the x86 and x64 tools that build ARM and ARM64 code also get installed. Other workloads may install these and other tools. Path and environment variables for command-line builds The MSVC command-line tools use the PATH, TMP, INCLUDE, LIB, and LIBPATH environment variables, and also use other environment variables specific to your installed tools, platforms, and SDKs. Even a simple Visual Studio installation may set twenty or more environment variables. This complexity is why we strongly recommend that you use a developer command prompt shortcut or one of the customized command files. We don't recommend you set these variables in the Windows environment yourself. To see which environment variables are set by a developer command prompt shortcut, you can use the SET command. Open a plain command prompt window and capture the output of the SET command for a baseline. Open a developer command prompt window and capture the output of the SET command for comparison. Use a diff tool such as the one built into Visual Studio to highlight the environment variables set by the developer command prompt. For more information about the compiler and linker environment variables, see CL environment variables. Developer command prompt shortcuts The command prompt shortcuts are installed in a version-specific Visual Studio folder in your Windows Start menu. Here's a list of the base command prompt shortcuts and the build architectures they support: Developer Command Prompt - Sets the environment to use 32-bit, x86-native tools to build 32-bit, x86-native code. x86 Native Tools Command Prompt - Sets the environment to use 32-bit, x86-native tools to build 32-bit, x86-native code. x64 Native Tools Command Prompt - Sets the environment to use 64-bit, x64-native tools to build 64-bit, x64-native code. x86_x64 Cross Tools Command Prompt - Sets the environment to use 32-bit, x86-native tools to build 64-bit, x64-native code. x64_x86 Cross Tools Command Prompt - Sets the environment to use 64-bit, x64-native tools to build 32-bit, x86-native code. The Start menu folder and shortcut names vary depending on the installed version of Visual Studio. If you set one, they also depend on the installation Nickname. For example, suppose you installed Visual Studio 2022, and you gave it a nickname of Latest. The developer command prompt shortcut is named Developer Command Prompt for VS 2022 (Latest), in a folder named Visual Studio 2022. Note Several command-line tools or tool options may require Administrator permission. If you have permission issues when you use them, we recommend that you open the developer command prompt window by using the Run as Administrator option. Right-click to open the shortcut menu for the command prompt window, then choose More, Run as administrator. To open a developer command prompt window On the desktop, open the Windows Start menu. In Windows 11, choose the All apps button to open the list of installed apps. In Windows 10, the list is open to the left. Scroll down the list to find and open the folder (not the app) for your version of Visual Studio, for example, Visual Studio 2022. In the folder, choose the Developer Command Prompt for your version of Visual Studio. This shortcut starts a developer command prompt window that uses the default build architecture of 32-bit, x86-native tools to build 32-bit, x86-native code. If you prefer a non-default build architecture, choose one of the native or cross tools command prompts to specify the host and target architecture. For an even faster way to open a developer command prompt, enter developer command prompt in the desktop search box. Then choose the result you want. Note By default, the current working directory in a developer command prompt is the root of your Visual Studio installation in the Program Files directory. This isn't an appropriate location for your code and projects. Change the current working directory to another location before you create a project. The IDE creates projects in your user directory, typically in %USERPROFILE%\source\repos. Developer command file locations If you prefer to set the build environment in an existing command prompt window, you can use one of the command files created by the installer. We recommend you set the environment in a new command prompt window. We don't recommend you later switch environments in the same command window. The command file location depends on the version of Visual Studio you installed, and on choices you made during installation. For Visual Studio 2019, the typical installation location on a 64-bit system is in \Program Files\Microsoft Visual Studio\2022\. The may be Community, Professional, Enterprise, BuildTools, or another nickname you supplied. The primary developer command prompt command file, VsDevCmd.bat, is located in the Common7\Tools subdirectory. When no parameters are specified, it sets the environment to use the x86-native tools to build 32-bit x86 code. More command files are available to set up specific build architectures. The command files available depend on the Visual Studio workloads and options you've installed. In Visual Studio 2017 and Visual Studio 2019, you'll find them in the VC\Auxiliary\Build subdirectory. These command files set default parameters and call VsDevCmd.bat to set up the specified build architecture environment. A typical installation may include these command files: Command File Host and Target architectures vcvars32.bat Use the 32-bit x86-native tools to build 32-bit x86 code. vcvars64.bat Use the 64-bit x64-native tools to build 64-bit x64 code. vcvarsx86_amd64.bat Use the 32-bit x86-native cross tools to build 64-bit x64 code. vcvarsamd64_x86.bat Use the 64-bit x64-native cross tools to build 32-bit x86 code. vcvarsx86_arm.bat Use the 32-bit x86-native cross tools to build ARM code. vcvarsamd64_arm.bat Use the 64-bit x64-native cross tools to build ARM code. vcvarsx86_arm64.bat Use the 32-bit x86-native cross tools to build ARM64 code. vcvarsamd64_arm64.bat Use the 64-bit x64-native cross tools to build ARM64 code. vcvarsall.bat Use parameters to specify the host and target architectures, Windows SDK, and platform choices. For a list of supported options, call by using a /help parameter. Caution The vcvarsall.bat file and other Visual Studio command files can vary from computer to computer. Do not replace a missing or damaged vcvarsall.bat file by using a file from another computer. Rerun the Visual Studio installer to replace the missing file. The vcvarsall.bat file also varies from version to version. If the current version of Visual Studio is installed on a computer that also has an earlier version of Visual Studio, do not run vcvarsall.bat or another Visual Studio command file from different versions in the same command prompt window. Use the developer tools in an existing command window The simplest way to specify a particular build architecture in an existing command window is to use the vcvarsall.bat file. Use vcvarsall.bat to set environment variables to configure the command line for native 32-bit or 64-bit compilation. Arguments let you specify cross-compilation to x86, x64, ARM, or ARM64 processors. You can target Microsoft Store, Universal Windows Platform, or Windows Desktop platforms. You can even specify which Windows SDK to use, and select the platform toolset version. When used with no arguments, vcvarsall.bat configures the environment variables to use the current x86-native compiler for 32-bit Windows Desktop targets. You can add arguments to configure the environment to use any of the native or cross compiler tools. vcvarsall.bat displays an error message if you specify a configuration that's not installed, or not available on your computer. vcvarsall syntax vcvarsall.bat [architecture] [platform_type] [winsdk_version] [-vcvars_ver=vcversion] [spectre_mode] architecture This optional argument specifies the host and target architecture to use. If architecture isn't specified, the default build environment is used. These arguments are supported: architecture Compiler Host computer architecture Build output (target) architecture x86 x86 32-bit native x86, x64 x86 x86_amd64 or x86_x64 x64 on x86 cross x86, x64 x64 x86_arm ARM on x86 cross x86, x64 ARM x86_arm64 ARM64 on x86 cross x86, x64 ARM64 amd64 or x64 x64 64-bit native x64 x64 amd64_x86 or x64_x86 x86 on x64 cross x64 x86 amd64_arm or x64_arm ARM on x64 cross x64 ARM amd64_arm64 or x64_arm64 ARM64 on x64 cross x64 ARM64 platform_type This optional argument allows you to specify store or uwp as the platform type. By default, the environment is set to build desktop or console apps. winsdk_version Optionally specifies the version of the Windows SDK to use. By default, the latest installed Windows SDK is used. To specify the Windows SDK version, you can use a full Windows SDK number such as 10.0.10240.0, or specify 8.1 to use the Windows 8.1 SDK. vcversion Optionally specifies the Visual Studio compiler toolset to use. By default, the environment is set to use the current Visual Studio compiler toolset. Use -vcvars_ver=14.2x.yyyyy to specify a specific version of the Visual Studio 2019 compiler toolset. Use -vcvars_ver=14.29 to specify the latest version of the Visual Studio 2019 compiler toolset. Use -vcvars_ver=14.0 to specify the Visual Studio 2015 compiler toolset. spectre_mode Leave this parameter out to use libraries without Spectre mitigations. Use the value spectre to use libraries with Spectre mitigations. To set up the build environment in an existing command prompt window At the command prompt, use the CD command to change to the Visual Studio installation directory. Then, use CD again to change to the subdirectory that contains the configuration-specific command files. For Visual Studio 2019 and Visual Studio 2017, use the VC\Auxiliary\Build subdirectory. For Visual Studio 2015, use the VC subdirectory. Enter the command for your preferred developer environment. For example, to build ARM code for UWP on a 64-bit platform, using the latest Windows SDK and Visual Studio compiler toolset, use this command line: vcvarsall.bat amd64_arm uwp Create your own command prompt shortcut Open the Properties dialog for a developer command prompt shortcut to see the command target used. For example, the target for the x64 Native Tools Command Prompt for VS 2019 shortcut is something similar to: %comspec% /k "C:\Program Files (x86)\Microsoft Visual Studio\2019\Community\VC\Auxiliary\Build\vcvars64.bat" The architecture-specific batch files set the architecture parameter and call vcvarsall.bat. You can pass the same options to these batch files as you would pass to vcvarsall.bat, or you can just call vcvarsall.bat directly. To specify parameters for your own command shortcut, add them to the end of the command in double-quotes. For example, here's a shortcut to build ARM code for UWP on a 64-bit platform, using the latest Windows SDK. To use an earlier compiler toolset, specify the version number. Use something like this command target in your shortcut: %comspec% /k "C:\Program Files (x86)\Microsoft Visual Studio\2019\Community\VC\Auxiliary\Build\vcvarsall.bat" amd64_arm uwp -vcvars_ver=14.29 Adjust the path to reflect your Visual Studio installation directory. The vcvarsall.bat file has additional information about specific version numbers. Command-line tools To build a C/C++ project at a command prompt, Visual Studio provides these command-line tools: CL Use the compiler (cl.exe) to compile and link source code files into apps, libraries, and DLLs. Link Use the linker (link.exe) to link compiled object files and libraries into apps and DLLs. When you build on the command line, the F1 command isn't available for instant help. Instead, you can use a search engine to get information about warnings, errors, and messages. You can also download and use the offline help files. To use the search in Microsoft Learn, enter your query in the search box at the top of any article. Command-line project management tools By default, the Visual Studio IDE uses native project build systems based on MSBuild. You can invoke MSBuild directly to build projects without using the IDE. You can also use the devenv command to use Visual Studio to build projects and solutions. Visual Studio also supports build systems based on CMake or NMake. MSBuild Use MSBuild (msbuild.exe) and a project file (.vcxproj) to configure a build and invoke the toolset without loading the Visual Studio IDE. It's equivalent to running the Build project or Build Solution command in the Visual Studio IDE. MSBuild has advantages over the IDE when you build at the command line. You don't have to install the full IDE on all your build servers and build pipelines. You avoid the extra overhead of the IDE. MSBuild runs in containerized build environments, and supports a binary logger. DEVENV Use DEVENV (devenv.exe) combined with a command-line switch such as /Build or /Clean to execute certain build commands without displaying the Visual Studio IDE. CMake CMake (cmake.exe) is a cross-platform, open-source tool for defining build processes that run on multiple platforms. CMake can configure and control native build tools for its supported platforms, such as MSBuild and Make. For more information about CMake, see the CMake documentation. NMAKE Use NMAKE (nmake.exe) to build C++ projects by using a traditional makefile. Note Starting in Visual Studio 2019 version 16.5, MSBuild and DEVENV don't use the command-line environment to control the toolset and libraries used. In this section These articles show how to build apps on the command line, and describe how to customize the command-line build environment. Some show how to use 64-bit toolsets, and target x86, x64, ARM, and ARM64 platforms. They also describe use of the command-line build tools MSBuild and NMAKE. Walkthrough: Compiling a native C++ program on the command line Gives an example that shows how to create and compile a C++ program on the command line. Walkthrough: Compile a C program on the command line Describes how to compile a program written in the C programming language. Walkthrough: Compiling a C++/CLI program on the command line Describes how to create and compile a C++/CLI program that uses the .NET Framework. Walkthrough: Compiling a C++/CX program on the command line Describes how to create and compile a C++/CX program that uses the Windows Runtime. NMAKE reference Provides links to articles that describe the Microsoft Program Maintenance Utility (NMAKE.EXE). MSBuild on the command line - C++ Provides links to articles that discuss how to use msbuild.exe from the command line. Related sections /MD, /MT, /LD (Use run-time library) Describes how to use these compiler options to use a Debug or Release run-time library. C/C++ compiler options Provides links to articles that discuss the C and C++ compiler options and CL.exe. MSVC linker options Provides links to articles that discuss the linker options and LINK.exe. Additional MSVC build tools Provides links to the C/C++ build tools that are included in Visual Studio. See also Azure Virtual Desktop Readiness Resources | Microsoft Partner Opportunity and Use Cases Azure Well-Architected Azure Virtual Desktop Workload Assessment AVD Stories ____ Training Resources Azure Virtual Desktop Academy AVD Academy Resources Azure Virtual Desktop Landing Zone Accelerator (LZA) ____ Roadmap and Best Practices AVD Community Blogs AVD/Citrix/VMware/Azure Stack HCI Bill of Materials AVD Level 300 Customer/Partner Deck ur overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-1 Critical: 0 to 1 MODERATE 1-2 Moderate: 1 to 2 EXCELLENT 2-3 Excellent: 2 to 3 Your result: 3/3 3 out of 3 Categories that influenced your results Azure Virtual Desktop Readiness Resources | Microsoft Partner EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. Azure Virtual Desktop | Microsoft Partner - Mar 4, 2025 - 11:55:56 AM Your overall results Excellent '3/3' Azure Virtual Desktop Readiness Resources | Microsoft Partner Excellent '3/3' Category Link-Text Link Priority ReportingCategory ReportingSubcategory Weight Context CompleteY/N Note Azure Virtual Desktop Readiness Resources | Microsoft Partner Azure Well-Architected Azure Virtual Desktop Workload Assessment https://learn.microsoft.com/en-us/assessments/1ef67c4e-b8d1-4193-b850-d192089ae33d/sessions/6356b690-ba16-4dec-80a3-1e99a2021723?mode=pre-assessment&id=1ef67c4e-b8d1-4193-b850-d192089ae33d&session=6356b690-ba16-4dec-80a3-1e99a2021723 High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner AVD Stories https://azure.microsoft.com/en-us/products/virtual-desktop/#Customerstories High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner Azure Virtual Desktop Academy https://microsoft.github.io/PartnerResources/skilling/microsoft-infrastructure-academy/avd High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner AVD Academy Resources https://microsoft.github.io/PartnerResources/skilling/microsoft-infrastructure-academy/resources/azure-virtual-desktop High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner Azure Virtual Desktop Landing Zone Accelerator (LZA) https://github.com/Azure/avdaccelerator High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner AVD Community Blogs https://techcommunity.microsoft.com/t5/azure-virtual-desktop-blog/bg-p/AzureVirtualDesktopBlog High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner AVD/Citrix/VMware/Azure Stack HCI Bill of Materials https://onedrive.live.com/?authkey=%21ACWW%2Deoxp2zM6FQ&id=D242F3D2FC2D88CC%21484&cid=D242F3D2FC2D88CC High 0 N Azure Virtual Desktop Readiness Resources | Microsoft Partner AVD Level 300 Customer/Partner Deck https://1drv.ms/p/s!AsyILfzS80LSiAa_HEmJ_F5WuZRl?e=Osgzmf High 0 N ---------- Category Question Answers Selected Answer Note Azure Virtual Desktop Readiness Resources | Microsoft Partner Opportunity and Use Cases Azure Well-Architected Azure Virtual Desktop Workload Assessment Azure Well-Architected Azure Virtual Desktop Workload Assessment Azure Virtual Desktop Readiness Resources | Microsoft Partner Opportunity and Use Cases AVD Stories AVD Stories Azure Virtual Desktop Readiness Resources | Microsoft Partner Training Resources Azure Virtual Desktop Academy Azure Virtual Desktop Academy Azure Virtual Desktop Readiness Resources | Microsoft Partner Training Resources AVD Academy Resources AVD Academy Resources Azure Virtual Desktop Readiness Resources | Microsoft Partner Training Resources Azure Virtual Desktop Landing Zone Accelerator (LZA) Azure Virtual Desktop Landing Zone Accelerator (LZA) Azure Virtual Desktop Readiness Resources | Microsoft Partner Roadmap and Best Practices AVD Community Blogs AVD Community Blogs Azure Virtual Desktop Readiness Resources | Microsoft Partner Roadmap and Best Practices AVD/Citrix/VMware/Azure Stack HCI Bill of Materials AVD/Citrix/VMware/Azure Stack HCI Bill of Materials Azure Virtual Desktop Readiness Resources | Microsoft Partner Roadmap and Best Practices AVD Level 300 Customer/Partner Deck AVD Level 300 Customer/Partner Deck hown below are the assessment's questions and how they were answered. Show all original responses available for each question. ____ Retail Readiness Resources Messaging and Use Cases Microsoft Cloud for Retail Partner Messaging Framework Microsoft Cloud for Retail through-partner AI Narrative Microsoft Retail Industry Priority Scenarios Microsoft Cloud for Retail Reference architectures ____ Training Resources Get started with Microsoft Cloud for Retail Self-Paced training Get started with Store Operations Assist in Microsoft Cloud for Retail Self-Paced Training Discover Microsoft AI for leaders in retail Self-Paced Training Get started with Smart Store Analytics in Microsoft Cloud for Retail Self-Paced Training Integrate Store Operations Assist with Microsoft Teams Self-Paced Training ____ Marketplace Offer Development Resources Marketplace Training and Support Resources Sell Through the Commercial Marketplace Microsoft Commercial Marketplace Publisher FAQ Mastering the Marketplace: Office Hours ____ Retail Cosell Acceleration Resources Go-To-Market Assets & Recommended Seller Training Retail Partner Industry Sales Kits Microsoft Cloud for Retail Partner Assets Recommended Sellers Training: Get started with Microsoft Cloud for Retail ____ Your overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-1 Critical: 0 to 1 MODERATE 1-2 Moderate: 1 to 2 EXCELLENT 2-4 Excellent: 2 to 4 Your result: 4/4 4 out of 4 Categories that influenced your results Retail Readiness Resources EXCELLENT Marketplace Offer Development Resources EXCELLENT Retail Cosell Acceleration Resources EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. Microsoft Cloud for Retail Adoption Guide | Microsoft Partners - Mar 4, 2025 - 11:59:59 AM Your overall results Excellent '4/4' Retail Readiness Resources Excellent '4/5' Marketplace Offer Development Resources Excellent '3/3' Retail Cosell Acceleration Resources Excellent '3/3' https://learn.microsoft.com Category Link-Text Link Priority ReportingCategory ReportingSubcategory Weight Context CompleteY/N Retail Readiness Resources Microsoft Cloud for Retail Partner Messaging Framework https://assetsprod.microsoft.com/mpn/en-us/microsoft-cloud-for-retail-through-partner-messaging-framework.docx High 0 N Retail Readiness Resources Microsoft Cloud for Retail through-partner AI Narrative https://assetsprod.microsoft.com/mpn/en-us/microsoft-cloud-for-retail-through-partner-ai-narrative.pptx High 0 N Retail Readiness Resources Microsoft Retail Industry Priority Scenarios https://learn.microsoft.com/en-us/azure/cloud-adoption-framework/industry/retail/industry-priority-scenarios High 0 N Retail Readiness Resources Overview of Microsoft Cloud for Retail reference architectures https://learn.microsoft.com/en-us/industry/retail/architecture/overview High 0 N Retail Readiness Resources Get started with Microsoft Cloud for Retail Self-Paced training https://learn.microsoft.com/en-us/training/paths/get-started-retail/ High 0 N Retail Readiness Resources Get started with Store Operations Assist in Microsoft Cloud for Retail Self-Paced Training https://learn.microsoft.com/en-us/training/paths/get-started-store-operations-assist/?source=recommendations High 0 N Retail Readiness Resources Discover Microsoft AI for leaders in retail Self-Paced Training https://learn.microsoft.com/en-us/training/paths/discover-microsoft-ai-leaders-retail/ High 0 N Retail Readiness Resources Get started with Smart Store Analytics in Microsoft Cloud for Retail Self-Paced Training https://learn.microsoft.com/en-us/training/paths/get-started-smart-store-analytics/ High 0 N Retail Readiness Resources Integrate Store Operations Assist with Microsoft Teams Self-Paced Training https://learn.microsoft.com/en-us/training/paths/retail-store-operations-assist-teams/ High 0 N Marketplace Offer Development Resources Sell Through the Commercial Marketplace https://learn.microsoft.com/en-us/training/paths/sell-through-commercial-marketplace/ High 0 N Marketplace Offer Development Resources Microsoft Commercial Marketplace Publisher FAQ https://learn.microsoft.com/en-us/partner-center/marketplace/marketplace-faq-publisher-guide High 0 N Marketplace Offer Development Resources Mastering the Marketplace: Office Hours https://aka.ms/MTMofficehours High 0 N Retail Cosell Acceleration Resources Retail Partner Industry Sales Kits https://partner.microsoft.com/en-us/asset/collection/retail-to-partner-industry-sales-kit#/ High 0 N Retail Cosell Acceleration Resources Microsoft Cloud for Retail Partner Assets https://partner.microsoft.com/en-us/asset/collection/microsoft-cloud-retail-partner-assets#/ High 0 N Retail Cosell Acceleration Resources Recommended Sellers Training: Get started with Microsoft Cloud for Retail https://learn.microsoft.com/en-us/training/paths/get-started-retail/ High 0 N ---------- Shown below are the assessment's questions and how they were answered. Show all original responses available for each question. ____ Sustainability Readiness Resources Opportunity and Use Cases This is AI … for Sustainability Microsoft Cloud for Sustainability: ESG and the Future of Business ____ Training Resources Microsoft Cloud for Sustainability Training Collection Pre-sales licenses for Sustainability Manager sandbox Environments for Microsoft Partners Fabric Technical Resources Microsoft Cloud for Sustainability Technical Summit ____ Roadmap and Best Practices Well-Architected for Microsoft Cloud for Sustainability What's new in Microsoft Cloud for Sustainability overview ____ Marketplace Offer Development Resources Marketplace Training and Support Resources Sell Through the Commercial Marketplace Microsoft Commercial Marketplace Publisher FAQ Mastering the Marketplace: Office Hours Your overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-1 Critical: 0 to 1 MODERATE 1-2 Moderate: 1 to 2 EXCELLENT 2-3 Excellent: 2 to 3 Your result: 3/3 3 out of 3 Categories that influenced your results Sustainability Readiness Resources EXCELLENT Marketplace Offer Development Resources EXCELLENT Sustainability Cosell Acceleration Resources EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. Microsoft Cloud for Sustainability Adoption Guide | Microsoft Partners - Mar 4, 2025 - 12:03:23 PM Your overall results Excellent '3/3' Sustainability Readiness Resources Excellent '3/4' Marketplace Offer Development Resources Excellent '3/3' Sustainability Cosell Acceleration Resources Excellent '2/2' Category Link-Text Link Priority ReportingCategory ReportingSubcategory Weight Context CompleteY/N Note Sustainability Readiness Resources This is AI … for Sustainability https://info.microsoft.com/ww-landing-this-is-AI-for-sustainability.html?ocid=cmmop4zodtb High 0 N Sustainability Readiness Resources Microsoft Cloud for Sustainability: ESG and the Future of Business https://www.linkedin.com/learning/microsoft-cloud-for-sustainability-esg-and-the-future-of-business High 0 N Sustainability Readiness Resources Microsoft Cloud for Sustainability Training Collection https://aka.ms/mcfslearningpaths High 0 N Sustainability Readiness Resources Pre-sales licenses for Sustainability Manager sandbox Environments for Microsoft Partners https://experience.dynamics.com/requestlicense/ High 0 N Sustainability Readiness Resources Well-Architected for Microsoft Cloud for Sustainability https://learn.microsoft.com/en-us/industry/well-architected/sustainability/ High 0 N Sustainability Readiness Resources Roadmap: What's new in Microsoft Cloud for Sustainability overview https://learn.microsoft.com/en-us/industry/sustainability/whats-new High 0 N Sustainability Readiness Resources Fabric Technical Resources https://learn.microsoft.com/en-us/credentials/certifications/fabric-analytics-engineer-associate/?practice-assessment-type=certification High 0 N Sustainability Readiness Resources Microsoft Cloud for Sustainability Technical Summit https://aka.ms/mcfstechsummit High 0 N Marketplace Offer Development Resources Sell Through the Commercial Marketplace https://learn.microsoft.com/en-us/training/paths/sell-through-commercial-marketplace/ High 0 N Marketplace Offer Development 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overview What's new in Microsoft Cloud for Sustainability overview Marketplace Offer Development Resources Marketplace Training and Support Resources Sell Through the Commercial Marketplace Sell Through the Commercial Marketplace Marketplace Offer Development Resources Marketplace Training and Support Resources Microsoft Commercial Marketplace Publisher FAQ Microsoft Commercial Marketplace Publisher FAQ Marketplace Offer Development Resources Marketplace Training and Support Resources Mastering the Marketplace: Office Hours Mastering the Marketplace: Office Hours Sustainability Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training Sustainability Marketing Campaigns Sustainability Marketing Campaigns Sustainability Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training Recommended Sellers Training: Get started with Microsoft Cloud for Sustainability Recommended Sellers Training: Get started with Microsoft Cloud for Sustainability Click on any field below to edit it Page Title *experimental career Page URL * https://archive.org/details/career-experimental-security-isc-microsoft-talk-brigth Description * career experimental Subject Tags * engineering Creator tshingombe Date 2025-02-03 Collection * Community texts Test Item No Language English License Creative Commons Attribution-NonCommercial-ShareAlike More Options Add additional metadata... : (remove) Drag and Drop More Files Here or Name Size x Subscriptions.csv 105 bytes Subscriptions(1).csv 105 bytes _Microsoft_Cloud_for_Retail_Adoption_Guide_Microsoft_Partners_Mar_4_2025_11_59_59_AM.csv 6.1 KB _Azure_Virtual_Desktop_Microsoft_Partner_Mar_4_2025_11_55_56_AM.csv 3.3 KB _Microsoft_Cloud_for_Sustainability_Adoption_Guide_Microsoft_Partners_Mar_4_2025_12_03_23_PM.csv 5.1 KB main.pdf 347 KB cpp-get-started-msvc-170.pdf 7.3 MB cpp-standard-library-msvc-170.pdf 107 MB isc tshingombe exam ims,, Access Control and Identity Management.docx 1.2 MB 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Actionable items to consider implementing to improve your workload across the five pillars of the Microsoft Azure Well-Architected Framework. Your overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-33 Critical: 0 to 33 MODERATE 33-67 Moderate: 33 to 67 EXCELLENT 67-100 Excellent: 67 to 100 Your result: 99/100 99 out of 100 Categories that influenced your results Azure Databricks: Performance Efficiency EXCELLENT Data Explorer: Reliability EXCELLENT Azure Databricks: Operational Excellence EXCELLENT Azure Databricks: Cost Optimization EXCELLENT Azure Databricks: Security EXCELLENT Azure Databricks: Reliability EXCELLENT ADLS Gen2: Performance Efficiency EXCELLENT Analysis Services: Performance Efficiency EXCELLENT Analysis Services: Operational Excellence EXCELLENT Analysis Services: Cost Optimization EXCELLENT Analysis Services: Security EXCELLENT Analysis Services: Reliability EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. Improve your results Our recommendations for improving your results are organized by category below. Azure Databricks: Performance Efficiency EXCELLENT 1 recommended action Data Explorer: Reliability EXCELLENT 0 recommended actions Azure Databricks: Operational Excellence EXCELLENT 2 recommended actions Azure Databricks: Cost Optimization EXCELLENT 0 recommended actions Azure Databricks: Security EXCELLENT 0 recommended actions Azure Databricks: Reliability EXCELLENT 1 recommended action ADLS Gen2: Performance Efficiency EXCELLENT 0 recommended actions Analysis Services: Performance Efficiency EXCELLENT 0 recommended actions Analysis Services: Operational Excellence EXCELLENT 0 recommended actions Analysis Services: Cost Optimization EXCELLENT 0 recommended actions Analysis Services: Security EXCELLENT 0 recommended actions Analysis Services: Reliability EXCELLENT 0 recommended actions Previous Versions Blog Contribute Privacy Terms of Use Trademarks © Microsoft 2025 Skip to main content Learn • • • • • • Assessments Learn Assessments Browse Recommendations for your workload. Actionable items to consider implementing to improve your workload across the five pillars of the Microsoft Azure Well-Architected Framework. Shown below are the assessment's questions and how they were answered. Show all original responses available for each question. ____ WAF analytics service selection Which analytics service(s) are you using? Azure Analysis Services Azure Data Explorer Azure Databricks Azure Synapse Analytics Azure Data Lake Storage Gen2 ____ What pillars would you like to evaluate? Reliability Security Cost Optimization Operational Excellence Performance Efficiency ____ Analysis Services: Reliability What reliability targets and metrics have you defined for your application? Azure Analysis Services RPO (Recovery Point Objective) and RTO (Recovery Time Objective) targets have been defined for the application and/or key scenarios. Availability SLAs (Service Level Agreements) have been defined for the solution and considered while architecting the solution. Composite SLA (including Azure Analysis Services) has been defined for the service and considered while architecting the solution. None of the above. ____ How have you ensured that your application architecture is resilient to failures? Backup databases from primary server can be restored on redundant servers. An alias is used for the primary server to avoid having to change the connection strings on reporting clients. The database can be restored using SSMS or PowerShell using backups located in a storage account configured for the server. We use asynchronous refresh with the REST API to prevent the need for long-running HTTP connections, auto retries, and batched commits. None of the above. ____ How have you ensured required capacity and services are available in targeted regions? We use the Azure Analysis Services resource and object limits as part of the resource governance mechanisms to enforce these limits. We verify that the Azure Analysis Services product is available in the target region in case that region is not the paired-region. We verify that the target region meets regulatory or governance requirements for the data stored in the data lake (HIPAA, PCI, etc.) None of the above. ____ How are you handling disaster recovery for this workload? We consider the incidents we want to be protected from when choosing the right redundancy options, and build the backup and disaster recovery plan accordingly: local outage, regional disaster, capacity limitations, and so on. We deploy models to redundant servers in other regions. We complete periodic disaster recovery exercises to ensure the procedure works as planned. We verify end-to-end system performance after failover occurs. None of the above. ____ How do you monitor and measure workload health? We use the available metrics, logs, and diagnostics with Azure Monitor. We use Azure Monitor metric alerts with dynamic thresholds detection. We use Azure Resource Health events to alert on resource health events. We use Azure Service Health events to alert on applicable service-level events (service issue, planned maintenance, health advisories, and security advisory). None of the above. ____ Analysis Services: Security What design considerations did you make in your workload with regard to security? We identify and classify business-critical datasets that might adversely affect operations if they're compromised or become unavailable. We list and document security requirements for the Azure Analysis Services instances. We limit access by following the principle of least privilege, protecting data, and monitoring activities offered by Azure Analysis Services. We define and test operational processes for incident response. We review data compliance requirements and choose the appropriate regulatory compliance controls for the data. None of the above. ____ What considerations for compliance and governance do you need to take? We use Azure policies to enforce security, compliance, and organizational standards. We activate diagnostic logs and store them in a log analytics workspace. None of the above. ____ How are you managing encryption for this workload? We rotate the storage key by specifying a key expiration period. We compress and encrypt tabular model backups. None of the above. ____ How are you managing permissions for this workload? User identities are registered within the Microsoft Entra tenant of the subscription. We use Azure Analysis Services role-based access control (RBAC). We use object-level security, which includes table-level security and column-level security. We implement row-level security as part of tabular model roles. None of the above. ____ How have you secured the network of your workload? We configured a server firewall to filter the inbound traffic. We use gateways for on-premises data sources. We use gateways for data sources on Azure Virtual Networks. We use DirectQuery mode, where only metadata is stored. None of the above. ____ Analysis Services: Cost Optimization What actions are you taking to optimize cloud costs? We're getting familiar with Analysis Services pricing, in particular, with elements that drive the price calculation: QPUs, memory (GB), presence of SLA, scale-out instances, tier, uptime, region. We use the Cost Management and Billing tools to analyse and manage costs. Our choice of region in which to deploy the instance in is driven by the data source's location, the users' location, the availability of the SKU and of the query replica feature (if it's planned to be used), and the price. We choose the right tier and plan for the instance. We use the right upgrade plan that will allow for more query processing units and more cache capacity. We pause the server when not in use, and resume when needed to only pay for what is used. As an existing Power BI Premium Capacity user, we evaluate the use of Power BI Premium that embeds an Analysis Services instance instead of a standalone Azure Analysis Services server. None of the above. ____ How is your organization modeling cloud costs? We use the cost control feature to set the budget as part of Cost Management for Azure Analysis Services. We lower costs by pausing or scaling the instance to meet performance demands. None of the above. ____ How are you monitoring your costs? We use the cost analysis feature of Azure Cost Management to monitor costs and create budgets. None of the above. ____ Analysis Services: Operational Excellence How are you designing your applications to take into account DevOps? We use source-control integration as the first step in building a continuous integration and deployment pipeline. We use continuous integration and deployment for Azure Analysis Services, and build continuous integration and deployment pipeline for data models. None of the above. ____ How are you managing the configuration of your workload? We automate creation of Azure Analysis Services instances with ARM templates, PowerShell scripts, or Bicep files. We use Dynamic Management Views (DMVs) in Analysis Services to monitor server instances. We monitor server metrics provided by Azure Monitor (memory, CPU usage, number of client connections, query resource consumption, etc.). We enable diagnostic logging for Azure Analysis Services to monitor and send logs to Azure storage, stream them to Azure Event Hubs, or export them to Azure Monitor logs. We add resource health alerts for metrics such as memory usage, memory limit High, and memory limit Hard. None of the above. ____ What operational considerations are you making regarding the deployment of your workload? We're becoming familiar with Azure Analysis Services resource and object limits to learn what happens when those resource limits are hit or exceeded, and describe the resource governance mechanisms used to enforce these limits. No routine and manual operational changes are performed outside of IaC (Infrastructure as Code) to prevent configuration drift by enforcing consistency representing desired environment states. Critical test environments have 1:1 parity with the production environment. None of the above. ____ What processes and procedures have you adopted to optimize workload operability? Specific methodologies, like DevOps, are used to structure the development and operations process. We leverage central Azure monitoring tools like Azure Monitor. Data analysts, data engineers, development teams, and the operations team collaborate to resolve production issues that are clearly defined and well understood. Operational shortcomings and failures are analyzed, post-mortems are performed and used to improve and refine operational procedures. There are tools or processes in place, such as Microsoft Entra Privileged Identity Management, to grant access to critical instances on a just-in-time basis. Azure Resource Tags are used to enrich our AAS instance with operational metadata. There are tools and processes, like Azure Policy, in place to govern available services, enforce mandatory operational functionality and ensure compliance. ____ How are you monitoring for a healthy workload? We use Azure Monitor to perform more in-depth diagnostics, track performance, and identify trends using the platform metrics. We use Azure Diagnostics to offload Platform logs. We use Extended Events. We use Dynamic Management Views (DMVs). ____ Analysis Services: Performance Efficiency How are you designing your workload to scale? We maintain a healthy workload by automating the scaling of the Azure Analysis Services instances. We use read-only replicas scale-out to have queries return consistent data while processing data. We separate the processing server from the query pool to ensure that client queries aren't affected by processing operations. None of the above. ____ How are you handling user load? We create a query pool with up to seven additional query replicas (eight total, including the server). We simplify the query or its calculations if the query is too memory intensive. ____ How are you ensuring that you have sufficient memory? We monitor datasets to not exceed available server resource memory. We monitor the memory usage broken out by database. None of the above. ____ How are you managing your data to handle scale? We use partitioning to take advantage of incremental loads. We refresh (process) in-memory models to update cached data from data sources. We keep the data model as simple as possible by removing unneeded columns and keeping the size to the minimum, paying attention to the data types. None of the above. ____ How are you monitoring to ensure the workload is scaling appropriately? With Azure service principal support, we perform unattended refresh operations using PowerShell, TOM, TMSL, or REST to make sure our model data is always up to date. We implement asynchronous refresh with the REST APIs to mitigate long-running operations. None of the above. ____ Data Factory: Reliability Data Factory: Security Data Factory: Cost Optimization Data Factory: Operational Excellence Data Factory: Performance Efficiency Azure Databricks: Reliability How do you implement reliability Best Practices? We deploy workspaces in multiple subscriptions based on service limits, including Databricks workspace limits and Azure subscription limits. We leverage clusters pools with TTL=60 min, or interactive clusters for job-based scenarios where we expect to spin up or down quickly. We stagger job-based clusters in the same workspace for scenarios requiring quick spin up and down of job clusters at less than 5 minutes as the recommended interval. We use Cluster Scoped Init scripts rather than global or named scripts. We ensure that we've configured an appropriate level of data redundancy for our use case. None of the above. ____ How do you implement disaster recovery scenarios? We disable RA-GRS stores in development subscriptions to reduce cost. We use RA-GRS storage accounts only when required to meet disaster planning. We enable soft delete, snapshot, and point in time recovery (PITR) for storage. We perform daily backups of Databricks configuration. We use the cluster log delivery feature to manage logs. ____ Azure Databricks: Security How do you implement security Best Practices? We store any production data in default Azure Databricks file system (DBFS) folders. We deploy the Databricks workspace in our virtual network. We review and plan to implement controls in Microsoft Blueprints for HiTrust / HIPAA and PCI/DSS. We have a process in place to periodically regenerate our account keys. We implement a security development lifecycle and threat model to assess risks in our application. We enable advanced threat protection for storage. ____ How do you implement authentication controls? We enable access control lists to configure permissions at the workspace, clusters, pools, jobs, and data tables. We use credential passthrough to authenticate automatically. We use Azure Key Vault (AKV) to store secrets, including credentials. We enable customer manage keys (CMK) for notebooks and root Databricks File System (DBFS). We enable Oauth authentication. ____ How do you implement encryption on your clusters? We encrypt traffic between clusters and worker nodes. We set up a minimum transport layer security (TLS) version for all storage accounts to TLS 1.2. We limit shared access signature (third-party tools) tokens to HTTPS connections only. None of the above. ____ How do you implement security at the networking level? We enable IP access lists to restrict access to certain IP addresses. We limit private IP addresses. We leverage Azure Private Endpoint. We leverage No Public IP (NPIP). We safelist service principals' names and personal access tokens. We enable virtual network (Vnet) injection. None of the above. ____ How do you audit and monitor your Databricks platform for security? We enable audit logging. We ingest log data into a security information and event manager (SIEM) for security monitoring. We review and reconcile user access. ____ Azure Databricks: Cost Optimization How do you implement cost optimization Best Practices? Users can share autoscaling clusters rather than each user having to create a separate cluster. We leverage the right SKU for the scenario, that is, Jobs Compute for data engineering and Batch ELT workload with single Jobs Compute cluster. We use chargeback scenarios. We review file formats and compute and network and identify areas for cost optimization. We regularly use the delta optimizer to merge small files into larger files. None of the above. ____ How do you implement cost savings? We pre-purchase commit units and reserve VM instances when possible. We choose Azure regions that offer the lowest cost while meeting performance requirements. None of the above. ____ How do you monitor Azure Databricks costs? We monitor costs of clusters using the cost analysis report. We set up budget alerts to monitor costs. We use Databricks Overwatch. None of the above. ____ Azure Databricks: Operational Excellence How do you implement operational Best Practices? We do regular performance, scalability, and stress testing. We build a process to review Azure Advisor and Azure Security Center recommendations on a regular cadence. We review and address platform changes from the release notes. We split workspaces for Dev, QA, and Production. We use automated clusters for production jobs instead of interactive clusters. We run auto-optimization to improve performance for the downstream. We optimize and curate delta tables (silver tables). We review the continuous integration and continuous deployment (CI/CD) automation framework. We run monthly log reviews to validate environment health. We terminate and rebuild clusters on a frequent basis to ensure Databricks clusters are patched by Microsoft. ____ How do you monitor your Databricks platform for operations? We enable logging and alerting for all components in the Databricks platform. We use dashboards to visualize metrics. We set up any cluster activity monitoring. We enable storage account logging. We put a single point of log aggregation in place. We use Network Watcher to collect and Monitor network activity. We ensure that all application-level monitoring is enabled. We use a single pane of glass with telemetry using Log Analytics logs to EventHub for consumption by other systems. We consider ingesting selected logs from Azure storage accounts to Azure Monitor. We monitor for 500 errors by Databricks, Blob storage, or other HTTP endpoints. We implement cluster secure management. ____ What components of your Azure environment do you monitor as part of your operations practice? We use approved time synchronization sources. We configure central security log management. We enable audit logging for Azure resources. We collect security logs from operating systems. We configure security log storage retention. We monitor and review logs. We enable alerts for anomalous activities. We centralize anti-malware logging. We enable DNS query logging. We enable command-line audit logging. ____ Azure Databricks: Performance Efficiency How do you implement performance Best Practices? We choose the correct cluster size by doing iterative performance testing. We regularly conduct rigorous quality and unit testing to validate performance that meets requirements. We leverage the auto-scaling feature with auto-terminate. We turn shuffle off for optimal performance. We check for data skew. We ensure that the file size and format are homogenous. We consistently use DataFrame API and SparkSQL. We avoid user-defined functions (UDFs) , especially in Python or R. We consider and test repartitioning if we need to join large tables. We ensure Azure limits are increased, for example, Public IP limits and so on. ____ How do you optimize performance efficiency? We reorder skew joins. We optimize for performance with Delta Lake format to get the best price to performance ratio. We partition our data. We check for large shuffle joins and try replacing them with broadcasts. We use Delta Lake with Z-order and optimize the latest Databricks Runtime (DBR) to get the best performance. We use Parquet file format. We use Delta-Cache. ____ How do you test performance efficiency on the Azure Databricks clusters? We run a proof of concept to determine how often to execute based on data ingestion and query patterns. We engage with Azure Engineers to ensure that capacity can be handled in the backend and limits get increased. We engage with the networking team during testing. We ensure throttling is not hit by setting up Azure Data Lake Storage Gen 2 limits. We review all Azure and Databricks limits. We develop a medium-sized cluster of 2-8 nodes, with VMs matched to the workload class, as explained earlier. We run end to end tests on larger representative data while measuring CPU, memory, and I/O used by the cluster at an aggregate level. We optimize the cluster to remove bottlenecks. ____ How do you monitor your Databricks platform for performance efficiency? We troubleshoot performance bottlenecks by using dashboards to identify job and stage latency and streaming throughput. We validate whether upstream components can sustain the load required to pass through them. We run scheduled optimization on delta tables. We tune shuffle for optimal performance. We use autoscaling methodologies whenever possible. We partition our data following Best Practices. None of the above. ____ How do you support interactive analytics using shared high-concurrency clusters? We deploy a shared cluster instead of letting each user create their cluster. We create the shared cluster in High Concurrency mode instead of Standard mode. We configure security on the shared high concurrency cluster. None of the above. ____ Data Explorer: Reliability What reliability targets and metrics have you defined for your application? Ensure that the average CPU is running at 80% capacity or less and cache utilization is 100%. Use Resource Health to monitor the status of Azure Data Explorer. ____ How have you ensured that your application architecture is resilient to failures? This question was left unanswered ____ How are you handling disaster recovery for this workload? This question was left unanswered ____ How do you monitor and measure application health? This question was left unanswered ____ Data Explorer: Security What action are you taking to meet your compliance and governance requirements? This question was left unanswered ____ How are you protecting data for this workload? This question was left unanswered ____ How are you managing identity for this workload? This question was left unanswered ____ How do you keep your Azure Data Explorer cluster from being exposed to the internet? This question was left unanswered ____ Data Explorer: Cost optimization What actions are you taking to optimize cloud costs? This question was left unanswered ____ How do you ensure that cloud resources are appropriately provisioned? This question was left unanswered ____ How is your organization modeling cloud costs? This question was left unanswered ____ How do you manage the storage footprint of your digital assets? This question was left unanswered ____ How are you monitoring your costs? This question was left unanswered ____ What tradeoffs have you made to optimize for cost? This question was left unanswered ____ Data Explorer: Operational excellence How are you designing your applications to take DevOps into account? This question was left unanswered ____ How are you managing the configuration of your workload? This question was left unanswered ____ What considerations are you making around the deployment of your infrastructure? This question was left unanswered ____ Are you using best practices for Kusto queries? This question was left unanswered ____ How are you monitoring your deployments and workload? This question was left unanswered ____ Data Explorer: Performance efficiency How are you designing your workload to scale? This question was left unanswered ____ How do you optimize Azure Data Explorer workloads for performance? This question was left unanswered ____ How are you ensuring that you have sufficient capacity? This question was left unanswered ____ How are you monitoring to ensure the workload is scaling appropriately? This question was left unanswered ____ Synapse: Reliability What reliability targets and metrics have you defined for your application? This question was left unanswered ____ How have you ensured that your application architecture is resilient to failures? This question was left unanswered ____ How have you ensured required capacity and services are available in targeted regions? This question was left unanswered ____ How are you handling disaster recovery for this workload? This question was left unanswered ____ What decisions have been taken to ensure the application platform meets your reliability requirements? This question was left unanswered ____ How does your application logic handle exceptions and errors? This question was left unanswered ____ What decisions have been taken to ensure networking and connectivity meets your reliability requirements? This question was left unanswered ____ What reliability allowances for scalability and performance have you made? This question was left unanswered ____ What reliability allowances for security have you made? This question was left unanswered ____ What reliability allowances for operations have you made? This question was left unanswered ____ How do you test the application to ensure it is fault tolerant? This question was left unanswered ____ How do you monitor and measure application health? 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This question was left unanswered ____ How do you make your data discoverable for users? This question was left unanswered ____ ADLS Gen2: Performance Efficiency How are you designing your workload to scale? This question was left unanswered ____ How do you optimize ADLS workloads for performance? This question was left unanswered ____ How are you managing your data to handle scale? This question was left unanswered ____ How are you ensuring you have sufficient capacity? Review ADLS Gen2 product limits. Monitor ADLS Gen2 resource utilization, query activity, and other metrics that have limitations. None of the above ____ Previous Versions Blog Contribute Privacy Terms of Use Trademarks © Microsoft 2025 our overall results LOW Room to improve. It looks like there are key items needing attention. Review the recommendations to see what actions you can take to improve your results. LOW 0-12 Low: 0 to 12 MODERATE 12-23 Moderate: 12 to 23 EXCELLENT 23-35 Excellent: 23 to 35 Your result: 10/35 10 out of 35 Categories that influenced your results Azure AI Fundamentals LOW Designing and Implementing a Microsoft Azure AI Solution MODERATE You can find out how to improve on individual categories by reviewing the recommendations below in the report. Azure AI Fundamentals Fundamental AI Concepts Azure AI Bot Service ____ Fundamentals of question answering with the Language Service "Create an empty knowledge base, and then manually copy and paste the FAQ entries into it. ____ Fundamentals of Azure AI Document Intelligence Azure AI Vision resource ____ Fundamentals of Azure OpenAI Service Azure OpenAI is Microsoft's version of ChatGPT, a chatbot that uses generative AI models. ____ Designing and Implementing a Microsoft Azure AI Solution Prepare to develop AI solutions on Azure Absolutely correct values based on conditional logic. ____ Secure Azure AI services Switch the app to use the secondary key ____ Deploy Azure AI services in containers Client applications must pass a subscription key to the Azure resource endpoint before using the container. ____ Make recommendations with Azure AI Personalizer In the Azure portal, go to the Monitor page for your AI Personalizer resource, and view the Personalizer average reward. ____ Analyze images Tags ____ Classify images "Image classification (multiclass) ____ Detect, analyze, and recognize faces Location ____ Analyze video Use the Azure AI Vision service to extract key frames from the video. ____ Build a question answering solution Create an empty knowledge base and manually enter the FAQ questions and answers. ____ Build a conversational language understanding model Intents ____ Develop an app with Azure AI Language Sentiment analysis ____ Create a custom text classification solution A multiple label classification project ____ Create a custom named entity extraction solution Recall ____ Translate text with the Azure AI Translator service Detect ____ Create speech-enabled apps with Azure AI services The location and one of the keys ____ Translate speech with the Azure AI Speech service SpeechConfig ____ Create an Azure Cognitive Search solution Add a JSON file that defines an Azure AI Search index to the blob container. ____ Create a custom skill for Azure Cognitive Search Create a custom skill that uses an Azure Machine Learning model to predict the sentiment for a document. ____ Create a knowledge store with Azure Cognitive Search Merge ____ Enrich a search index using Language Studio Conversational language understanding. ____ Implement advanced search features in Azure Cognitive Search ^ ____ Build an Azure Machine Learning custom skill for Azure Cognitive Search Real-time endpoint ____ Maintain an Azure Cognitive Search Solution Create an Azure Cognitive Search service with a Storage Optimized service tier and at least two replicas. ____ Use semantic search to get better search results in Azure Cognitive Search As many results as the BM25 ranking function returns. ____ Improve search results using vector search in Azure Cognitive Search To create a search to match text input. ____ Plan an Azure AI Document Intelligence solution A Composed model. ____ Use prebuilt Azure AI Document Intelligence models Read model. ____ Create a composed Form Recognizer model modelId ____ Generate code with Azure OpenAI Service Increase in efficiency and productivity ____ Generate images with Azure OpenAI Service GPT-35-Turbo ____ Fundamentals of Responsible Generative AI To make a legal case that indemnifies you from responsibility for AI Engineer Skill Assessment - Mar 4, 2025 - 1:05:49 PM Your overall results Low '10/35' Azure AI Fundamentals Low '0/4' Designing and Implementing a Microsoft Azure AI Solution Moderate '10/31' Category Link-Text Link Priority ReportingCategory ReportingSubcategory Weight Context CompleteY/N Note Azure AI Fundamentals https://learn.microsoft.com High 0 N Azure AI Fundamentals Microsoft Azure AI Fundamentals: Computer Vision https://learn.microsoft.com/en-us/training/paths/explore-computer-vision-microsoft-azure/ High 0 N Azure AI Fundamentals Microsoft Azure AI Fundamentals: Natural Language Processing https://learn.microsoft.com/en-us/training/paths/explore-natural-language-processing/ High 0 N Azure AI Fundamentals Microsoft Azure AI Fundamentals: Document Intelligence and Knowledge Mining https://learn.microsoft.com/en-us/training/paths/document-intelligence-knowledge-mining/ High 0 N Azure AI Fundamentals Microsoft Azure AI Fundamentals: Generative AI https://learn.microsoft.com/en-us/training/paths/introduction-generative-ai/ High 0 N Designing and Implementing a Microsoft Azure AI Solution https://learn.microsoft.com High 0 N Designing and Implementing a Microsoft Azure AI Solution Get started with Azure AI Services https://learn.microsoft.com/en-us/training/paths/get-started-azure-ai/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Develop decision support solutions with Azure AI Services https://learn.microsoft.com/en-us/training/paths/develop-decision-support/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Create computer vision solutions with Azure AI Vision https://learn.microsoft.com/en-us/training/paths/create-computer-vision-solutions-azure-ai/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Develop natural language processing solutions with Azure AI Services https://learn.microsoft.com/en-us/training/paths/develop-language-solutions-azure-ai/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Implement knowledge mining with Azure Cognitive Search https://learn.microsoft.com/en-us/training/paths/implement-knowledge-mining-azure-cognitive-search/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Develop solutions with Azure AI Document Intelligence https://learn.microsoft.com/en-us/training/paths/extract-data-from-forms-document-intelligence/ High 0 N Designing and Implementing a Microsoft Azure AI Solution Develop Generative AI solutions with Azure OpenAI Service https://learn.microsoft.com/en-us/training/paths/develop-ai-solutions-azure-openai/ High 0 N ----------- Category Question Answers Selected Answer Note Azure AI Fundamentals Fundamental AI Concepts Azure Machine Learning Azure AI Fundamentals Fundamental AI Concepts Azure AI Bot Service Azure AI Bot Service Azure AI Fundamentals Fundamental AI Concepts Azure AI Language Azure AI Fundamentals Fundamentals of machine learning Regression Azure AI Fundamentals Fundamentals of machine learning Classification Azure AI Fundamentals Fundamentals of machine learning Clustering Azure AI Fundamentals Fundamentals of Azure AI services A multi-service resource that includes all the AI services Azure AI Fundamentals Fundamentals of Azure AI services A single-service resource for each AI service Azure AI Fundamentals Fundamentals of Azure AI services It's not possible to see costs for individual AI services Azure AI Fundamentals Fundamentals of Computer Vision Timestamps in photograph metadata Azure AI Fundamentals Fundamentals of Computer Vision Pixels Azure AI Fundamentals Fundamentals of Computer Vision Image file names Azure AI Fundamentals Fundamentals of Facial Recognition A pair of coordinates for each face, indicating the center of the face Azure AI Fundamentals Fundamentals of Facial Recognition Two pairs of coordinates for each face, indicating the location of the eyes Azure AI Fundamentals Fundamentals of Facial Recognition A set of coordinates for each face, defining a rectangular bounding box around the face Azure AI Fundamentals Fundamentals of optical character recognition Azure AI Vision Azure AI Fundamentals Fundamentals of optical character recognition Azure AI services Azure AI Fundamentals Fundamentals of optical character recognition Azure AI Language Azure AI Fundamentals Fundamentals of Text Analysis with the Language Service Sentiment analysis Azure AI Fundamentals Fundamentals of Text Analysis with the Language Service Key phrase extraction Azure AI Fundamentals Fundamentals of Text Analysis with the Language Service Entity detection Azure AI Fundamentals Fundamentals of question answering with the Language Service "Create an empty knowledge base, and then manually copy and paste the FAQ entries into it. "Create an empty knowledge base, and then manually copy and paste the FAQ entries into it. Azure AI Fundamentals Fundamentals of question answering with the Language Service Import the existing FAQ document into a new knowledge base. Azure AI Fundamentals Fundamentals of question answering with the Language Service Import a pre-defined chit-chat data source. Azure AI Fundamentals Fundamentals of conversational language understanding Azure AI Speech Azure AI Fundamentals Fundamentals of conversational language understanding Azure AI Language Azure AI Fundamentals Fundamentals of conversational language understanding Azure AI services Azure AI Fundamentals Fundamentals of Azure AI Speech Speech Azure AI Fundamentals Fundamentals of Azure AI Speech Language Azure AI Fundamentals Fundamentals of Azure AI Speech Azure AI services Azure AI Fundamentals Fundamentals of Azure AI Document Intelligence Azure AI Vision resource Azure AI Vision resource Azure AI Fundamentals Fundamentals of Azure AI Document Intelligence Azure AI Document Intelligence or Azure AI services resource. Azure AI Fundamentals Fundamentals of Azure AI Document Intelligence Azure AI Language resource. Azure AI Fundamentals Fundamentals of Knowledge Mining with Azure Cognitive Search CSV Azure AI Fundamentals Fundamentals of Knowledge Mining with Azure Cognitive Search SQL Azure AI Fundamentals Fundamentals of Knowledge Mining with Azure Cognitive Search JSON Azure AI Fundamentals Fundamentals of Generative AI Models that only work with one language. Azure AI Fundamentals Fundamentals of Generative AI Models that only work with small amounts of data. Azure AI Fundamentals Fundamentals of Generative AI Models that use deep learning to process and understand natural language on a massive scale. Azure AI Fundamentals Fundamentals of Azure OpenAI Service Azure OpenAI is Microsoft's version of ChatGPT, a chatbot that uses generative AI models. Azure OpenAI is Microsoft's version of ChatGPT, a chatbot that uses generative AI models. Azure AI Fundamentals Fundamentals of Azure OpenAI Service ChatGPT and OpenAI are chatbots that generate natural language, code, and images. Azure OpenAI provides access to these two chatbots. Azure AI Fundamentals Fundamentals of Azure OpenAI Service OpenAI is a research company that developed ChatGPT, a chatbot that uses generative AI models. Azure OpenAI provides access to many of OpenAI's AI models. Azure AI Fundamentals Fundamentals of Responsible Generative AI To make a legal case that indemnifies you from responsibility for harms caused by the solution Azure AI Fundamentals Fundamentals of Responsible Generative AI To document the purpose, expected use, and potential harms for the solution Azure AI Fundamentals Fundamentals of Responsible Generative AI To evaluate the cost of cloud services required to implement your solution Designing and Implementing a Microsoft Azure AI Solution Prepare to develop AI solutions on Azure Absolutely correct values based on conditional logic. Absolutely correct values based on conditional logic. Designing and Implementing a Microsoft Azure AI Solution Prepare to develop AI solutions on Azure Randomly selected values with an equal chance of selection. Designing and Implementing a Microsoft Azure AI Solution Prepare to develop AI solutions on Azure Probabilistic values based on correlations found in training data. Designing and Implementing a Microsoft Azure AI Solution Create and consume Azure AI services The application must specify a valid subscription key for the Azure resource. Designing and Implementing a Microsoft Azure AI Solution Create and consume Azure AI services The user of the application must enter a user name and password associated with the Azure subscription. Designing and Implementing a Microsoft Azure AI Solution Create and consume Azure AI services Access to Azure AI Services is granted to anonymous users by default. Designing and Implementing a Microsoft Azure AI Solution Secure Azure AI services Switch the app to use the secondary key Switch the app to use the secondary key Designing and Implementing a Microsoft Azure AI Solution Secure Azure AI services Change the resource endpoint Designing and Implementing a Microsoft Azure AI Solution Secure Azure AI services Enable a firewall Designing and Implementing a Microsoft Azure AI Solution Monitor Azure AI services Create an alert. Designing and Implementing a Microsoft Azure AI Solution Monitor Azure AI services Configure diagnostic settings. Designing and Implementing a Microsoft Azure AI Solution Monitor Azure AI services Create a dashboard. Designing and Implementing a Microsoft Azure AI Solution Deploy Azure AI services in containers Client applications must pass a subscription key to the Azure resource endpoint before using the container. Client applications must pass a subscription key to the Azure resource endpoint before using the container. Designing and Implementing a Microsoft Azure AI Solution Deploy Azure AI services in containers The container must be able to connect to the Azure resource endpoint to send usage data for billing. Designing and Implementing a Microsoft Azure AI Solution Deploy Azure AI services in containers All data passed from the client application to the container is forwarded to the Azure resource endpoint. Designing and Implementing a Microsoft Azure AI Solution Make recommendations with Azure AI Personalizer In the Azure portal, go to the Monitor page for your AI Personalizer resource, and view the Personalizer average reward. In the Azure portal, go to the Monitor page for your AI Personalizer resource, and view the Personalizer average reward. Designing and Implementing a Microsoft Azure AI Solution Make recommendations with Azure AI Personalizer In the Azure portal, go to the Monitor page for your AI Personalizer resource, and view the Baseline average reward. Designing and Implementing a Microsoft Azure AI Solution Make recommendations with Azure AI Personalizer In the Azure portal, go to the Monitor page for your AI Personalizer resource, and view the Reward achievement ratio. Designing and Implementing a Microsoft Azure AI Solution Analyze images Tags Tags Designing and Implementing a Microsoft Azure AI Solution Analyze images Description Designing and Implementing a Microsoft Azure AI Solution Analyze images Categories Designing and Implementing a Microsoft Azure AI Solution Classify images "Image classification (multiclass) "Image classification (multiclass) Designing and Implementing a Microsoft Azure AI Solution Classify images Image classification (multilabel) Designing and Implementing a Microsoft Azure AI Solution Classify images Object detection Designing and Implementing a Microsoft Azure AI Solution Detect objects in images The location and class of specific classes of object in an image. Designing and Implementing a Microsoft Azure AI Solution Detect objects in images The class of the main subject of an image. Designing and Implementing a Microsoft Azure AI Solution Detect objects in images The file type of an image. Designing and Implementing a Microsoft Azure AI Solution Detect, analyze, and recognize faces Location Location Designing and Implementing a Microsoft Azure AI Solution Detect, analyze, and recognize faces Type of eye-glasses Designing and Implementing a Microsoft Azure AI Solution Detect, analyze, and recognize faces Occlusion Designing and Implementing a Microsoft Azure AI Solution Read Text in Images and Documents with the Azure AI Vision Service Only total content and pages of text. Designing and Implementing a Microsoft Azure AI Solution Read Text in Images and Documents with the Azure AI Vision Service Pages, words and lines of text. Designing and Implementing a Microsoft Azure AI Solution Read Text in Images and Documents with the Azure AI Vision Service Total content, pages, words and lines of text. Designing and Implementing a Microsoft Azure AI Solution Analyze video Use the Azure AI Vision service to extract key frames from the video. Use the Azure AI Vision service to extract key frames from the video. Designing and Implementing a Microsoft Azure AI Solution Analyze video Upload the video to Azure Video Indexer and index it. Designing and Implementing a Microsoft Azure AI Solution Analyze video Store the video file in an Azure blob store container. Designing and Implementing a Microsoft Azure AI Solution Analyze text with Azure AI Language Use the Azure AI Language service to extract key phrases. Designing and Implementing a Microsoft Azure AI Solution Analyze text with Azure AI Language Use the Azure AI Language service to perform sentiment analysis of the comments. Designing and Implementing a Microsoft Azure AI Solution Analyze text with Azure AI Language Use the Azure AI Language service to extract named entities from the comments. Designing and Implementing a Microsoft Azure AI Solution Build a question answering solution Create an empty knowledge base and manually enter the FAQ questions and answers. Create an empty knowledge base and manually enter the FAQ questions and answers. Designing and Implementing a Microsoft Azure AI Solution Build a question answering solution Create a new knowledge base, importing the existing FAQ document. Designing and Implementing a Microsoft Azure AI Solution Build a question answering solution "Create a new knowledge base, selecting only the Professional chit-chat source. Designing and Implementing a Microsoft Azure AI Solution Build a conversational language understanding model Intents Intents Designing and Implementing a Microsoft Azure AI Solution Build a conversational language understanding model Utterances Designing and Implementing a Microsoft Azure AI Solution Build a conversational language understanding model Entities Designing and Implementing a Microsoft Azure AI Solution Develop an app with Azure AI Language Sentiment analysis Sentiment analysis Designing and Implementing a Microsoft Azure AI Solution Develop an app with Azure AI Language Key phrase extraction Designing and Implementing a Microsoft Azure AI Solution Develop an app with Azure AI Language Entity recognition Designing and Implementing a Microsoft Azure AI Solution Create a custom text classification solution A single label classification project Designing and Implementing a Microsoft Azure AI Solution Create a custom text classification solution A multiple label classification project A multiple label classification project Designing and Implementing a Microsoft Azure AI Solution Create a custom text classification solution A varied label classification project Designing and Implementing a Microsoft Azure AI Solution Create a custom named entity extraction solution Recall Recall Designing and Implementing a Microsoft Azure AI Solution Create a custom named entity extraction solution Precision Designing and Implementing a Microsoft Azure AI Solution Create a custom named entity extraction solution F1 score Designing and Implementing a Microsoft Azure AI Solution Translate text with the Azure AI Translator service Detect Detect Designing and Implementing a Microsoft Azure AI Solution Translate text with the Azure AI Translator service Translate Designing and Implementing a Microsoft Azure AI Solution Translate text with the Azure AI Translator service Transliterate Designing and Implementing a Microsoft Azure AI Solution Create speech-enabled apps with Azure AI services The location and one of the keys The location and one of the keys Designing and Implementing a Microsoft Azure AI Solution Create speech-enabled apps with Azure AI services The primary and secondary keys Designing and Implementing a Microsoft Azure AI Solution Create speech-enabled apps with Azure AI services The endpoint and one of the keys Designing and Implementing a Microsoft Azure AI Solution Translate speech with the Azure AI Speech service SpeechConfig SpeechConfig Designing and Implementing a Microsoft Azure AI Solution Translate speech with the Azure AI Speech service SpeechTranslationConfig Designing and Implementing a Microsoft Azure AI Solution Translate speech with the Azure AI Speech service AudioConfig Designing and Implementing a Microsoft Azure AI Solution Create an Azure Cognitive Search solution Add a JSON file that defines an Azure AI Search index to the blob container. Add a JSON file that defines an Azure AI Search index to the blob container. Designing and Implementing a Microsoft Azure AI Solution Create an Azure Cognitive Search solution Enable anonymous access for the blob container. Designing and Implementing a Microsoft Azure AI Solution Create an Azure Cognitive Search solution In an Azure AI Services resource, and add a data source that references the container where the files are stored. Designing and Implementing a Microsoft Azure AI Solution Create a custom skill for Azure Cognitive Search Create a custom skill that uses an Azure Machine Learning model to predict the sentiment for a document. Create a custom skill that uses an Azure Machine Learning model to predict the sentiment for a document. Designing and Implementing a Microsoft Azure AI Solution Create a custom skill for Azure Cognitive Search Create a custom skill that calls the Azure AI Language service to predict the sentiment of each document. Designing and Implementing a Microsoft Azure AI Solution Create a custom skill for Azure Cognitive Search Add the built-in Sentiment skill to the skillset used by the indexer. Designing and Implementing a Microsoft Azure AI Solution Create a knowledge store with Azure Cognitive Search Merge Merge Designing and Implementing a Microsoft Azure AI Solution Create a knowledge store with Azure Cognitive Search Shaper Designing and Implementing a Microsoft Azure AI Solution Create a knowledge store with Azure Cognitive Search Split Designing and Implementing a Microsoft Azure AI Solution Enrich a search index using Language Studio Conversational language understanding. Conversational language understanding. Designing and Implementing a Microsoft Azure AI Solution Enrich a search index using Language Studio Analyze sentiment. Designing and Implementing a Microsoft Azure AI Solution Enrich a search index using Language Studio Custom text classification. Designing and Implementing a Microsoft Azure AI Solution Implement advanced search features in Azure Cognitive Search + Designing and Implementing a Microsoft Azure AI Solution Implement advanced search features in Azure Cognitive Search ^ ^ Designing and Implementing a Microsoft Azure AI Solution Implement advanced search features in Azure Cognitive Search ! Designing and Implementing a Microsoft Azure AI Solution Build an Azure Machine Learning custom skill for Azure Cognitive Search Real-time endpoint Real-time endpoint Designing and Implementing a Microsoft Azure AI Solution Build an Azure Machine Learning custom skill for Azure Cognitive Search Web service Designing and Implementing a Microsoft Azure AI Solution Build an Azure Machine Learning custom skill for Azure Cognitive Search Batch endpoint Designing and Implementing a Microsoft Azure AI Solution Search data outside the Azure platform in Azure Cognitive Search using Azure Data Factory You can only upload one document at a time. Designing and Implementing a Microsoft Azure AI Solution Search data outside the Azure platform in Azure Cognitive Search using Azure Data Factory The JSON can't contain complex data types like arrays. Designing and Implementing a Microsoft Azure AI Solution Search data outside the Azure platform in Azure Cognitive Search using Azure Data Factory You have to define the index in the Azure portal first. Designing and Implementing a Microsoft Azure AI Solution Maintain an Azure Cognitive Search Solution Create an Azure Cognitive Search service with a Storage Optimized service tier and at least two replicas. Create an Azure Cognitive Search service with a Storage Optimized service tier and at least two replicas. Designing and Implementing a Microsoft Azure AI Solution Maintain an Azure Cognitive Search Solution Create an Azure Cognitive Search service with any Standard service tier and at least three replicas. Designing and Implementing a Microsoft Azure AI Solution Maintain an Azure Cognitive Search Solution Create an Azure Cognitive Search service with a High-density service tier and one replica. Designing and Implementing a Microsoft Azure AI Solution Use semantic search to get better search results in Azure Cognitive Search Up to 50. Designing and Implementing a Microsoft Azure AI Solution Use semantic search to get better search results in Azure Cognitive Search As many results as the BM25 ranking function returns. As many results as the BM25 ranking function returns. Designing and Implementing a Microsoft Azure AI Solution Use semantic search to get better search results in Azure Cognitive Search Up to 25. Designing and Implementing a Microsoft Azure AI Solution Improve search results using vector search in Azure Cognitive Search To create a search to match text input. To create a search to match text input. Designing and Implementing a Microsoft Azure AI Solution Improve search results using vector search in Azure Cognitive Search When you need to find matches across different types of data. from a search index. Designing and Implementing a Microsoft Azure AI Solution Improve search results using vector search in Azure Cognitive Search To upload and index a document library. Designing and Implementing a Microsoft Azure AI Solution Plan an Azure AI Document Intelligence solution A Read model. Designing and Implementing a Microsoft Azure AI Solution Plan an Azure AI Document Intelligence solution A Layout model. Designing and Implementing a Microsoft Azure AI Solution Plan an Azure AI Document Intelligence solution A Composed model. A Composed model. Designing and Implementing a Microsoft Azure AI Solution Use prebuilt Azure AI Document Intelligence models Read model. Read model. Designing and Implementing a Microsoft Azure AI Solution Use prebuilt Azure AI Document Intelligence models General document model. Designing and Implementing a Microsoft Azure AI Solution Use prebuilt Azure AI Document Intelligence models ID document model. Designing and Implementing a Microsoft Azure AI Solution Extract data from forms with Azure Document Intelligence Train Model and Get Model Labels Designing and Implementing a Microsoft Azure AI Solution Extract data from forms with Azure Document Intelligence Analyze Invoice and Get Analyze Invoice Result Designing and Implementing a Microsoft Azure AI Solution Extract data from forms with Azure Document Intelligence Create Azure Document Intelligence and Get Analyze Invoice Result Designing and Implementing a Microsoft Azure AI Solution Create a composed Form Recognizer model modelId modelId Designing and Implementing a Microsoft Azure AI Solution Create a composed Form Recognizer model status Designing and Implementing a Microsoft Azure AI Solution Create a composed Form Recognizer model docType Designing and Implementing a Microsoft Azure AI Solution Build an Azure AI Document Intelligence custom skill for Azure Cognitive Search formUrl Designing and Implementing a Microsoft Azure AI Solution Build an Azure AI Document Intelligence custom skill for Azure Cognitive Search recordId Designing and Implementing a Microsoft Azure AI Solution Build an Azure AI Document Intelligence custom skill for Azure Cognitive Search formSasToken Designing and Implementing a Microsoft Azure AI Solution Get started with Azure OpenAI Service text-davinci-003 Designing and Implementing a Microsoft Azure AI Solution Get started with Azure OpenAI Service gpt-35-turbo Designing and Implementing a Microsoft Azure AI Solution Get started with Azure OpenAI Service text-embedding-ada-002 (Version 2) Designing and Implementing a Microsoft Azure AI Solution Build natural language solutions with Azure OpenAI Service Chat, Embedding, and Completion Designing and Implementing a Microsoft Azure AI Solution Build natural language solutions with Azure OpenAI Service Key, Endpoint, and Deployment name Designing and Implementing a Microsoft Azure AI Solution Build natural language solutions with Azure OpenAI Service Summary, Deployment name, and Endpoint Designing and Implementing a Microsoft Azure AI Solution Apply prompt engineering with Azure OpenAI Service By using complex instructions that are difficult to understand Designing and Implementing a Microsoft Azure AI Solution Apply prompt engineering with Azure OpenAI Service By providing clear and descriptive instructions Designing and Implementing a Microsoft Azure AI Solution Apply prompt engineering with Azure OpenAI Service By using vague prompts Designing and Implementing a Microsoft Azure AI Solution Generate code with Azure OpenAI Service Increase in efficiency and productivity Increase in efficiency and productivity Designing and Implementing a Microsoft Azure AI Solution Generate code with Azure OpenAI Service Increase in bugs and readability Designing and Implementing a Microsoft Azure AI Solution Generate code with Azure OpenAI Service Increase in time spent coding Designing and Implementing a Microsoft Azure AI Solution Generate images with Azure OpenAI Service DALL-E Designing and

Implementing a Microsoft Azure AI Solution Generate images with Azure OpenAI Service GPT-35-Turbo GPT-35-Turbo Designing and Implementing a Microsoft Azure AI Solution Generate images with Azure OpenAI Service Text-Davinci Designing and Implementing a Microsoft Azure AI Solution Use your own data with Azure OpenAI Service Create their own AI chat models Designing and Implementing a Microsoft Azure AI Solution Use your own data with Azure OpenAI Service Access Azure OpenAI without an approved subscription Designing and Implementing a Microsoft Azure AI Solution Use your own data with Azure OpenAI Service Use supported AI chat models that can reference specific sources of data Designing and Implementing a Microsoft Azure AI Solution Fundamentals of Responsible Generative AI To make a legal case that indemnifies you from responsibility for harms caused by the solution. To make a legal case that indemnifies you from responsibility for harms caused by the solution. Designing and Implementing a Microsoft Azure AI Solution Fundamentals of Responsible Generative AI To document the purpose, expected use, and potential harms for the solution. Designing and Implementing a Microsoft Azure AI Solution Fundamentals of Responsible Generative AI To evaluate the cost of cloud services required to implement your solution. Your overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-33 Critical: 0 to 33 MODERATE 33-67 Moderate: 33 to 67 EXCELLENT 67-100 Excellent: 67 to 100 Your result: 100/100 100 out of 100 Categories that influenced your results Azure Machine Learning: Cost Optimization EXCELLENT Azure Machine Learning: Operational Excellence EXCELLENT Azure Machine Learning: Performance Efficiency EXCELLENT Azure Machine Learning: Reliability EXCELLENT Azure Machine Learning: Security EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. Azure Machine Learning: Cost Optimization What steps are you taking to optimize cloud costs in Azure Machine Learning? We use cost management tools to plan and track costs. We identify and use the right-sized compute for machine learning models. We're considering the use of local compute or remote managed compute for automated machine learning to reduce costs. We optimize our cloud investment with cost management. We use an appropriately sized compute instance and compute cluster for training and inference. None of the above. ____ How does your organization model and monitor cloud costs for Azure Machine Learning? We plan and manage costs for Azure Machine Learning. We utilize cost alerts for Azure Machine Learning. We create and manage Azure budgets. None of the above. ____ What actions do you typically take for cost optimization in Azure Machine Learning? We configure our training clusters to autoscale. We set quotas on our subscription and workspaces. We set termination policies on our training job. We use low-priority virtual machines (VMs). We schedule compute instances to shut down and start up automatically. We use an Azure Reserved VM Instance. We train locally. We parallelize training. We set data retention and deletion policies. We deploy resources to the same region. ____ How do you ensure that you have sufficient capacity? We adhere to Azure Machine Learning subscription limits for compute and pipelines. We review service limits in Azure Machine Learning. We adhere to Azure Machine Learning subscription limits for storage. None of the above. ____ Azure Machine Learning: Operational Excellence How are you managing your machine learning lifecycle through automation using MLOps? We use machine learning pipelines to orchestrate the workflow. We use GitHub Actions with Azure Machine Learning. We use MLFlow to track and manage ML modeling projects. We use the Team Data Science Process for the data science project lifecycle. None of the above. ____ What considerations are you making around the deployment of your infrastructure? We segregate environments into development, test, and production workspaces. We understand the Azure subscription limits that might impact this workload. We use the Azure security baseline for Azure Machine Learning. We set up separate workspaces for each publish environment. None of the above. ____ How is development done on Azure Machine Learning workloads? We use Python SDK or CLI to develop machine learning jobs. We use low-code Azure Machine Learning designer to author experiments. We use the Azure Machine Learning Notebook or Jupyter Notebook to author the experiment. We use Azure Machine Learning automated GUI to author the experiment. We use ONNX and deep learning libraries, such as Tensorflow, PyTorch, Keras, and others. We use Responsible AI in our development practice. None of the above. ____ How do you monitor your Azure Machine Learning deployments? We monitor a deployed model by collecting and evaluating model data. We enable logging in machine learning training runs. We use alert rules and events in our application. We analyze Azure Machine Learning platform metrics and logs from Azure Monitor. None of the above. ____ How do you manage the configuration of Azure Machine Learning deployments? We use code-based (SDK or CLI) definitions of our training jobs. We use code-based definitions of our compute targets. None of the above. ____ How do you test your MLOps infrastructure? We use unit, regression, and integration testing with CI/CD for MLOps. None of the above. ____ Azure Machine Learning: Performance Efficiency How are you designing your Azure Machine Learning training workload to scale? We use data partitioning strategy to run experiments in parallel, if possible. We use autoscaling on clusters, where appropriate. We use Azure Machine Learning pipeline step to process large amounts of data asynchronously and in parallel. None of the above. ____ How are you designing your Azure Machine Learning service to meet performance requirements? We use appropriate compute SKUs and sizes for different machine learning workloads. We use the appropriate compute target types based on your workload requirements and environments. We use datastore and dataset mounts for reusability throughout workload. For unstructured files, we optimize performance by mounting data files to the compute target. We use advanced automated ML options to increase performance/ROI on experiment run time. ____ How do you optimize data processing speeds for Azure Machine Learning workloads? We set up Azure Machine Learning datastores/datasets to connect and access data from various storage services. We use distributed training with Azure Machine Learning, where possible. We use datasets/datastores to improve manageability, performance, and scale when working with data. ____ How do you monitor model performance and lifecycle activities? We leverage Azure Machine Learning monitoring capabilities, such as model run logs and metrics. We enable logging in Azure Machine Learning training runs. We use Azure Monitor to monitor the performance of our model. We leverage the Azure Machine Learning workspace job console to track workload progress. ____ How do you autoscale Azure Machine Learning compute resources to handle performance for training and inferencing? We leverage Azure Machine Learning capabilities to autoscale the training compute nodes based on our benchmarking. We leverage multinode scaling capabilities for model training. We leverage production-grade model deployment and autoscaling inference using Azure Kubernetes Service cluster. ____ Azure Machine Learning: Reliability What reliability considerations have you defined for your Azure Machine Learning workload? We use a Managed Batch Endpoint for parallel batch processing. We use a Managed Endpoint for scalable, self-managed service. We use Azure Kubernetes Service (AKS) for high-scale production deployments with fast response time. We manage and increase quotas for resources with Azure Machine Learning. None of the above. ____ How do you ensure that your application architecture is resilient to failures? We version and track Azure Machine Learning datasets. We enable logging in machine learning training runs to support handling exceptions and errors. We publish Azure Machine Learning components and environments. None of the above. ____ What decisions have you made to ensure the application platform meets your reliability requirements? We use scaling options for applications in Azure Kubernetes Service (AKS). We use a managed endpoint for scalable deployments. We manage a compute cluster in your Azure Machine Learning workspace. We built a failover plan for business continuity and disaster recovery to respond to failures and disasters. None of the above. ____ How do you monitor and measure both the health of a training run and the health of deployed service? We collect machine learning log files in Application Insights. We version and track Azure Machine Learning datasets. We use native application monitoring. None of the above. ____ What framework do you use to interpret ML models and help train unbiased models? We check trained models for fairness. We perform error analysis for trained models for reliability and safety. We interpret trained models for transparency. We perform causal analysis to understand how data impacts model decisions. None of the above. ____ Azure Machine Learning: Security What design considerations did you make in your workload in regard to security? We use role-based access control (RBAC) to manage access to Azure Machine Learning workspaces. We use Microsoft Entra ID for identity management and authentication of Azure Machine Learning users and processes for Azure Machine Learning resources and workflows. We use MLOps practices for security guidance, model management, deployment, and monitoring with Azure Machine Learning. We use appropriate recommendations for the Azure Machine Learning security baseline to improve security posture. We review and implement appropriate guidelines from Azure Machine Learning best practices for enterprise security. None of the above. ____ What considerations for compliance and governance have you made for your Azure Machine Learning workload? We implemented a security and governance plan in accordance with guidance. We audit and manage Azure Machine Learning using Azure Policy. None of the above. ____ How do you manage encryption for workloads? We use data encryption with Azure Machine Learning. None of the above. ____ How do you manage identity for Azure Machine Learning workloads? When running Azure Machine Learning workloads in Azure Kubernetes Service, we use Microsoft Entra Workload ID with Azure Machine Learning. We use managed identities with Azure Machine Learning for access control. None of the above. ____ How have you secured the network for your workload? We use virtual networks (VNets) to secure an Azure Machine Learning workspace during setup. We use virtual networks (VNets) to secure an Azure Machine Learning training environment. We configured Azure Private Link for Azure Machine Learning to enable private endpoint for inferencing. We secured an Azure Machine Learning inferencing environment with virtual networks (VNets). We use Azure Machine Learning studio in an Azure virtual network (VNet). We use TLS to secure web service through Azure Machine Learning. None of the above. ____ How do you adhere to responsible ML principles in your design? We use practices to protect users' data privacy in machine learning. We work on encrypted data with homomorphic encryption. We use model interpretability with Azure Machine Learning. We assess fairness in machine learning models using open-source packages in Azure Machine Learning. We perform causal inference on trained models. Your overall results EXCELLENT You are all set! Your results look strong and meet the necessary criteria for success. CRITICAL 0-2 Critical: 0 to 2 MODERATE 2-4 Moderate: 2 to 4 EXCELLENT 4-6 Excellent: 4 to 6 Your result: 6/6 6 out of 6 Categories that influenced your results AVS | Readiness Resources EXCELLENT AVS | Marketplace Offer Development Resources EXCELLENT AVS | Specialization Resources EXCELLENT AVS | Cosell Acceleration Resources EXCELLENT You can find out how to improve on individual categories by reviewing the recommendations below in the report. AVS | Readiness Resources Opportunity and Use Cases Migrating VMware vSphere workloads to Azure VMware Solution Extending hybrid and multi-cloud agility High availability and disaster recovery for VMware workloads Desktop virtualization Azure Migrate and Modernize and Azure Innovate Training Resources Introduction Learning Path Learning Resources Overview Video AVS Academy VMware TechZone VMware for Azure VMware Solution Master Specialist Exam AVS LAB Automation VMware AVS Hands-on Labs AVS Workshop Lab Guide Deployment Guidance Landing Zone Accelerator Landing Zone Accelerator GitHub Repository Landing Zone Assessment Review Landing Zone Assessment Network Design Guide Deployment Checklist Azure Well-Architected Assessment for AVS Azure Well-Architected Documentation for AVS Azure Proactive Resiliency Library for AVS AVS Updates AVS | Marketplace Offer Development Resources Marketplace Training and Support Resources Sell through the commercial marketplace Plan a Consulting Service Offer, applicable for AVS Service Partner Got-To-Market Toolbox AVS | Specialization Resources AVS Specialization details Specialization Overview Specialization Video Specialization Audit Checklist Specialization Assessment AVS | Cosell Acceleration Resources Go-To-Market Assets & Recommended Sellers Training AVS Customer Story IDC white paper: The Business Value of Azure VMware Solution Digital Marketing Campaign (On Demand) AVS Pricing Reference AVS Go Big for Partners AVS Partner Assets Collection AVS Pros (LinkedIn Group) Partners Incentives and Programs AVS Bootcamp Sales Track Azure VMware Solution (AVS) | Microsoft Partner - Mar 4, 2025 - 1:22:59 PM Your overall results Excellent '6/6' AVS | Readiness Resources Excellent '8/10' AVS | Marketplace Offer Development Resources Excellent '3/3' AVS | Specialization Resources Excellent '4/4' AVS | Cosell Acceleration Resources Excellent '9/9' Category Link-Text Link Priority ReportingCategory ReportingSubcategory Weight Context 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http://aka.ms/gtmtoolbox High 0 N AVS | Specialization Resources Specialization Overview https://aka.ms/AVSSpecial High 0 N AVS | Specialization Resources Specialization Video https://aka.ms/AVSAdvSpecVideo High 0 N AVS | Specialization Resources Specialization Audit Checklist https://aka.ms/AVSAdvSpecAudit High 0 N AVS | Specialization Resources Specialization Assessment https://aka.ms/AVSAdvSpecAssess High 0 N AVS | Cosell Acceleration Resources AVS Customer Story https://aka.ms/AVSCustomerSuccess High 0 N AVS | Cosell Acceleration Resources IDC white paper: The Business Value of Azure VMware Solution https://aka.ms/AVSIDC High 0 N AVS | Cosell Acceleration Resources Digital Marketing Campaign (On Demand) https://aka.ms/AVSDMK High 0 N AVS | Cosell Acceleration Resources AVS Pricing Reference https://aka.ms/AVSPricing High 0 N AVS | Cosell Acceleration Resources AVS Go Big for Partners https://aka.ms/AVSPartnerGoBig High 0 N AVS | Cosell Acceleration Resources AVS Partner Assets 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Objectives Timeline Review plan Past 7 days Mar 4 You created a plan plan Develop AI Solutions with Azure AI Services (1) 4 items Mar 4 You edited a plan plan Develop AI Solutions with Azure AI Services 4 items Mar 4 You created a Collection collection Develop AI Solutions with Azure AI Services 8 items Mar 4 You edited a plan plan Run data analytics solutions with Azure Databricks 9 items Mar 4 You started a plan plan Run data analytics solutions with Azure Databricks 9 items Mar 4 You edited a plan plan Help secure your data in the age of AI (1) 4 items Mar 4 You edited a plan plan Implementing data integration and model grounding with Azure AI Foundry and Microsoft Fabric 13 items Mar 4 You started a plan plan Implementing data integration and model grounding with Azure AI Foundry and Microsoft Fabric 13 items Mar 4 You edited a plan plan Build AI apps with Azure Services and best practices 20 items Mar 4 You started a plan plan Build AI apps with Azure Services and best practices 20 items Mar 4 You edited a plan plan Accelerate app development by using GitHub Copilot 23 items Mar 4 You started a plan plan Accelerate app development by using GitHub Copilot 33 items Mar 4 You edited a plan plan Help secure your data in the age of AI 4 items Mar 4 You started a plan plan Help secure your data in the age of AI 4 items Feb 28 You created a Collection collection 46307064's Collection 9 0 item Your activity feed shows up to 30 interactions over the past 30 days. Previo g data issue rural system information management system education 46307064 0 Reputation points Mar 4, 2025, 2:34 PM isc tshingombe exam ims,, Access Control and Identity Management.pdf Microsoft Authenticator experimental career by tshingombe editEdit gearManage timeHistory Publication date 2025-02-03 Usage Attribution-NonCommercial-ShareAlike 4.0 International Topics engineering Collection opensource Language English Item Size 7.7M this item is currently being modified/updated by the task: book_op career experimental Addeddate 2025-03-04 10:53:21 Engsecut 20000 Identifier career-experimental-security-isc-microsoft-talk-brigth Scanner Internet Archive HTML5 Uploader 1.7.0 plus-circle Add Review Reviews There are no reviews yet. Be the first one to write a review. 0 Views DOWNLOAD OPTIONS download 5 files COMMA-SEPARATED VALUES download 12 files PDF download 1 file TORRENT download download 1 file WEB VIDEO TEXT TRACKS download download 2 files WORD DOCUMENT download 24 Files download 24 Original SHOW ALL IN COLLECTIONS Community Texts Uploaded by Rdferz on March 4, 2025 Why get certified 13 reasons for seeking training and certification With testimonials from IT networkers who met the challenge Get started © 2022 Cisco and/or its affiliates. All rights reserved. Get certified eBook2 eBook Cisco Public Why get certified Summary Certification benefits We live in exciting times to be working in technology. While the words "digital transformation" can sometimes seem repetitive, we are indeed in a digital era, where so much of our technology is dramatically changing. Cloud has evolved from being a virtual non-entity to exerting a significant influence on networking, data center, security, analytics, and virtualization. At the same time, cybersecurity has become critical across all technology sectors and is constantly evolving to counter increasingly sophisticated cyberattacks. Other transforming technologies include the data center, which now plays a central role in the business landscape. The Internet of Things is now vitally important to our digital lives in its ability to connect a staggering amount of data and devices. And software-defined networking (SDN) has ushered in a sea change in how we can manage networks via automation. But through it all, routing and switching remain the core foundation of knowledge from which IT networking professionals can build their career as they learn to Connect, Secure, and Automate. These vibrant technological developments culminating all at once can seem overwhelming—you need to be able to catch the wave of change and ride it smoothly. This is precisely why we believe right now is the best time to explore how solid training and certification can keep you focused and help make you a technical superstar in your organization. © 2022 Cisco and/or its affiliates. All rights reserved. 23 eBook Cisco Public Pearson VUE surveyed more than 29,000 candidates who prepared for and earned IT certifications during the previous 12 months. Its resulting 2021 Value of IT Certification Report 1 features insights from North America, Latin America, Middle East and Africa (MEA), India, Greater China, Japan and the rest of Asia Pacific (APAC). Demand for IT certifications is growing, reflected by a 16 percent increase in the number of IT certification exams delivered from the previous year. And since employers were less likely to cover training and certification costs, those who earned a certification did so using their own time, money and effort—a strong indication that the desire to certify holds strong and is on the rise. Of candidates who earned certifications in 2020, 86 percent plan to pursue additional certifications over the next 12 months. 2 Cisco can offer you training and certification for all of the hot fields. But, first, you need more answers to the question of why it matters. With this eBook, we'd like to share with you our answers—gathered from interactions over the years with Cisco certification holders—to the basic question of "why get certified?" We interviewed your peers in the certification community about the personal value of Cisco certification to them, and arrived at a dozen great reasons to give training and certification some serious thought. Have a read through the following pages and be sure to follow the links for the fuller story on the various certification holders we have spotlighted here. We trust that you'll walk away with a sense of what training and certification can do for you in your career. Why get certified Summary Certification benefits © 2022 Cisco and/or its affiliates. All rights reserved. 3© 2022 Cisco and/or its affiliates. All rights reserved. 4 eBook Cisco Public Meet Ajet Ibraimoski Senior Infrastructure/Systems Analyst Ajet Ibraimoski has used Cisco's storehouse of knowledge to help ace his CyberOps Associate certification exam and add to his know-how on the job. Cisco Packet Tracer, online training, prerecorded videos, mentors, simulations, labs, Cisco Press books—Ajet has left no stone unturned in his quest to understand the security field. Why get certified Summary Certification benefits 73 percent cited the need to obtain particular skills, knowledge, or competencies as their reason for earning an IT certification.3 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Knowledge: The systematic study of your field via a certification program can help you understand it inside and out so that you are more adept at attacking technical and business problems at many levels to arrive at a solution. > Get the full story on Ajet. "Cisco is the biggest network vendor in the world, so if you want to learn networks, you turn to Cisco—with Cisco certification, you learn all different facets of security. It gives you an edge to design the right solution, right away—a solution that's more secure, available, and scalable." —Ajet Ibraimoski, Senior Infrastructure/Systems Analyst© 2022 Cisco and/or its affiliates. All rights reserved. 5 eBook Cisco Public Meet Randy Gates Randy Gates left the security of a military career for the improved job prospects and flexibility of life as a freelance network engineer. To realize this goal, Randy needed to ramp up his skill level fast. Picking up a couple Cisco certifications got him up to speed—and now companies continue to call him back for freelance jobs. > Learn more about Randy. "The core knowledge from Cisco helps me expand my knowledge of routing and switching, IP subnetting, IP addressing schemes, firewalls, the Internet of Things, Power over Ethernet, and more. When I run into different problems, I know what to expect, and can give my customers a layout of what's happening on-site." —Randy Gates, Network Engineer/Systems Engineer Skill: A good certification program offers discipline and repeated practice—with the structure to help you deeply ingrain a skill set, and perform tasks more effectively and efficiently. 52 percent of IT professionals agreed that certification training led to improved work quality.4 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Why get certified Summary Certification benefits© 2022 Cisco and/or its affiliates. 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It looks impressive on a resume that you were able to study for something challenging and then continue on to pass the certification exam." —Jenny Guay, Security Operations Center (SOC) Operator Validation: Think of certification as a recognized badge of honor that the rest of the world accepts and buys into. 60 percent of IT managers stated that job applications with IT certifications are significantly more likely to be reviewed.5 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Why get certified Summary Certification benefits© 2022 Cisco and/or its affiliates. All rights reserved. 7 eBook Cisco Public Meet Jose Bogarin While studying electrical engineering at his university, he learned about Cisco certifications. Jose is now the proud holder of 24 Cisco certifications, a member of DevNet 500 and the DevNet Class of 2020. Jose founded his own IT services company that employs 60 professionals throughout Costa Rica and was named the Grand Prize winner of Cisco's Platform Innovation Challenge. Jose continues to put customers first by developing innovative IT technology. > Explore Jose's path to success. "You prepare, learn new concepts, take a tough but fair exam; then use the certification to validate that you're ready to tackle all of the challenges a particular technology can throw at you." —Jose Bogarin, Chief Innovation Officer Credibility: With validation goes credibility. Achievement via a strong certification program helps to establish with peers, managers, and customers that you know what you're doing. 65 percent say certification enhances the ability to guide and mentor others.6 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Why get certified Summary Certification benefits© 2022 Cisco and/or its affiliates. All rights reserved. 8 eBook Cisco Public Meet DevonPatrick Adkins When Devon was introduced to Cisco switches and wireless controllers, it was love at first touch. He realized that all the super intelligent L2 and L3 engineers were Cisco certified and knew someday he would earn his certifications. After earning his CCENT certification, he became the go-to guy for all things Cisco at his company. And after receiving his CCNA certification, job offers started pouring in from around the world. > Read on for more details about DevonPatrick. "Cisco really changed my life and opened up a new world for me. The certifications have helped me grow academically, mentally, and professionally. I now see myself achieving quite a number of things in my life." —DevonPatrick Adkins, Network Engineer L2 Responsibility: We don't mean responsibility as in "obligation"— we mean the ability to take on added responsibility from your employer that will help you grow in your career. 74 percent of candidates reported greater work autonomy and independence after certification.7 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Why get certified Summary Certification benefits© 2022 Cisco and/or its affiliates. All rights reserved. 9 eBook Cisco Public Meet João Muniz Cisco certifications helped João build confidence to work in a real network with real issues. In addition, it gave João's employer trust that he was well-trained for the job and had a strong work ethic and passion for the profession. > Get the full story on João Muniz. "Cisco certifications give you the confidence that you know what needs to be done in a real-world job. And knowing you are Cisco certified, employers are confident that you will be successful on the job. They also know you have a strong work ethic and are up for challenges, as they understand it's not easy to get certified." —João Muniz, Edge Data Center Project Engineer Confidence: With the knowledge and increased skill gained from certification, and the rewards that accrue to that, comes increased confidence to do the job, which can build even further progress and self-assurance. 91 percent of candidates experienced increased confidence in their abilities after certification.8 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Why get certified Summary Certification benefits© 2022 Cisco and/or its affiliates. All rights reserved. 10 eBook Cisco Public Meet Kent Freeman Originally an electrician, Kent Freeman's true talent was in solving technology problems. So he transformed his career, climbed the ladder, and ultimately launched his own IT services business. Kent has his CCNA, his CCNP in the works, and his sights set on a CCIE—a direct reflection of his desire to push himself as well as his business to continue evolving. > Explore Kent's path to success. "You're never too experienced to learn, to grow, to become better. And you're never too old to get certified. Technology is a rapidly moving industry. Getting certified keeps you both relevant and competitive in the workforce." —Kent Freeman, Senior Collaboration Engineer Value: All those good things like knowledge, skill, validation, ability to take on added responsibility, and confidence translate to your increased value as a successful performer in the eyes of employers and customers. 94 percent of decision-makers worldwide say that certified team members provide added value above and beyond the cost of certification.9 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Why get certified Summary Certification benefits© 2022 Cisco and/or its affiliates. All rights reserved. 11 eBook Cisco Public Meet Keisha Richardson At first, Keisha got certified because obtaining your certifications was required as part of the program she joined. Once she got her first taste, however, she proceeded to study up and earn several additional certifications. She likes the fact that certifications are a stamp of approval. While she may not have extensive experience that others have, her certifications ensure she has the knowledge to discuss topics and tackle solutions. > Read on for more details about Keisha. "The time and effort that you put into earning a certification says more about you as a professional than the certification itself." —Keisha Richardson, Technical Solutions Specialist Versatility: A robust certification portfolio allows you to make forays into different technology arenas, using those added skills to enhance your current strengths and discover new interests. 75 percent of candidates were able to perform a task or fill a role that they were not able to before certification.10 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Why get certified Summary Certification benefits© 2022 Cisco and/or its affiliates. All rights reserved. 12 eBook Cisco Public Meet Ronald Boestfleisch, Jr. Eight years as a help desk rep had brought Ronald Boestfleisch's career to a standstill. But he was inspired to become a network engineer and used a bachelor's degree and four Cisco certifications to propel himself into his chosen field. It was a lot of hard work, but opportunity has knocked as a result. Ronald has now positioned himself for senior network engineering roles. Opportunity: Those who certify and gain new skills and knowledge in the process stand a greater chance of breaking out of possible job silos, taking advantage of cross-functional team roles, and being in better position for an exciting career change. There are almost a million networking job openings in the US alone.11 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge > Get the full story on Ronald. "Many employers offer incentives to employees who want to better themselves by getting certifications. That way, they gain employees who have more knowledge and skills, and really know what they're doing. When I say I'm certified, employers' ears perk up. It really helps with marketability and is a benchmark for a career." —Ronald Boestfleisch, Jr., Network Engineer 2, Managed Services Operations, Ops Control Why get certified Summary Certification benefits Employment of software developers is projected to grow 22 percent from 2019 to 2029.12© 2022 Cisco and/or its affiliates. All rights reserved. 13 eBook Cisco Public Meet John Warren Diagnosed with multiple sclerosis (MS) in 2014, John struggles with an inconsistent memory, hand spasms, delayed nerve responses and frequent debilitating exhaustion. Against all odds, Cisco certifications played a key role in helping him become the guy a multinational behavioral healthcare provider relies on at night to ensure their critical networks stay running. > Read on for more details about John. "I live with Multiple Sclerosis which is a very debilitating disease, however I have overcome all adversity to achieve my dreams." —John Warren, Service Desk Analyst II Hireability: Time and time again, we hear that certification is one of those assets that employers automatically look for when it comes time to seek out new talent. 66 percent of IT managers felt that candidates with IT certifications had a better chance of being selected for interviews.13 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Why get certified Summary Certification benefits© 2022 Cisco and/or its affiliates. All rights reserved. 14 eBook Cisco Public Meet Aaron Dubin Early on, Aaron knew that he wanted to expand his skills. But he didn't have any mentors to guide him along, telling him what to study and how to prepare. Through the certification process, he was able to get expert advice on how to apply his particular interests, and where he should focus his time. He learned how to avoid going down rabbit holes, and what type of preparation would ultimately help him the most in his career in technology. > Learn more about Aaron. "The value in certification is not in the piece of paper on your wall. It's in the skills and the confidence you need to take on new challenges or take that next step in your career." —Aaron Dubin, Systems Engineer Advancement: Being certified gets you noticed by your employer, who is more likely to remember your initiative when making decisions about your promotion. 56 percent of candidates earned IT certifications to increase their chances of advancing and being promoted in their current roles, by acquiring new skills and knowledge.14 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Why get certified Summary Certification benefits© 2022 Cisco and/or its affiliates. All rights reserved. 15 eBook Cisco Public Meet Shane Woolf Shane Woolf has a lot happening on the home front—he and his wife have built a blended family of two biological children and six foster children. A good salary has helped him with that commitment, and he credits his CCNA Routing and Switching and CCNA Collaboration certifications as helping to pay dividends and get him to his current level as a Senior Unified Communications Systems Engineer. > Explore further Shane's path to success. "Cisco certifications helped me springboard my career to senior level—with more responsibilities, a title, and a salary increase. And it helped my employer, too, by giving them one more person to do the function they're requesting." —Shane Woolf, Senior Unified Communications Systems Engineer Salary: As this list demonstrates, there is much more to certification than a fatter paycheck, but with advancement and career progression, more money can follow. 28 percent received a salary or wage increase after earning a certification.15 Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge Why get certified Summary Certification benefits© 2022 Cisco and/or its affiliates. All rights reserved. 16 eBook Cisco Public Benefit 2 | Skill Benefit 3 | Validation Benefit 4 | Credibility Benefit 5 | Responsibility Benefit 6 | Confidence Benefit 7 | Value Benefit 8 | Versatility Benefit 9 | Opportunity Benefit 10 | Hireability Benefit 11 | Advancement Benefit 12 | Salary Benefit 13 | Lifelong Learning Benefit 1 | Knowledge 86 percent of candidates are likely to recertify in the next 12 months.16 Why get certified Summary Certification benefits Each of the Cisco students we profiled has a different story, but they all have one thing in common: the will to take that important first step toward advancing their career. That first step was earning a Cisco certification. With this single act, they broadened their knowledge and skillset. They improved their understanding of networking. They earned more respect from their peers. And they became more marketable. Stake your claim to the future of technology—and the future you want to build for yourself—with Cisco certifications. Your Cisco certification shows the world you have what it takes to work on today's most advanced networks. Yet as technology evolves, so must the skills required to keep pace and maintain active certification. We call this the journey of lifelong learning. To learn more, visit Cisco Recertification Policy and Cisco Continuing Education. The 2020 IT Skills and Salary Report from Global Knowledge concludes that achieving a new certification, on average, leads to a $13,000 salary increase. Lifelong Learning: Since technology and innovation evolve so quickly, it's important that you stay ahead of the latest advances and keep your skills up to date. In the digital world, you can never automatically assume that you're completely caught up and know everything—what's new today can become outdated in seconds.© 2022 Cisco and/or its affiliates. All rights reserved. 17 eBook Cisco Public Summary We trust that at least some of the 13 reasons to get certified have resonated with you. Our digital era—with all of its excitement and change—dares us to keep up with it. As many of the individuals highlighted in this book have discovered, the pace of innovation in today's technology arenas makes it difficult to earn just a single certification and then rest on one's laurels. Just as businesses must always stay innovative and one step ahead of the curve to thrive, so must you. For many of us, the pace is motivating. Often the conquering of one certification challenge fires us up for the next one— part of a lifelong learning journey to be the best at what we do. If you're ready to learn more, we have some ideas for you. • Read Five Tips to Get DevNet Certified Now • Get an overview of our certifications, register for these webinar series: • CCNA Essentials • DevNet Associate Essentials • CyberOps Associate Essentials • Learn about Guided Study Groups • Join our communities on Cisco Learning Network and DevNet • Amp your self-study plan with these programs: • CCNA Prep • DevNet Associate Prep • CyberOps Associate Prep • Cisco Expert Prep Ask any of the certification holders we highlighted, and they'll tell you that training and certification transformed their careers. Their incomes. And their skill sets. But beyond that, training and certification transformed their lives. By learning the latest methods and skills to connect, secure, and automate, they gained the self-confidence from setting goals, then accomplishing them. And that self confidence continues to empower them on their career paths. We hope that training and certification empowers—and transforms—your career too. Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: www.cisco.com/go/trademarks. Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R) DEC21CS5955 01/22 References 1. 2021 Value of IT Certification Candidate Report, Pearson VUE 2. 2021 Value of IT Certification Candidate Report, Pearson VUE 3. 2021 Value of IT Certification Candidate Report, Pearson VUE 4. 2020 IT Skills and Salary Report, Global Knowledge 5. 2021 Value of IT Certification Employer Report, Pearson VUE 6. 2021 Value of IT Certification Employer Report, Pearson VUE 7. 2021 Value of IT Certification Candidate Report, Pearson VUE 8. 2021 Value of IT Certification Candidate Report, Pearson VUE 9. 2020 IT Skills and Salary Report, Global Knowledge 10. 2021 Value of IT Certification Candidate Report, Pearson VUE 11. U.S. Bureau of Labor Statistics, Occupational Outlook Handbook (Updated: March 2021) 12. U.S. Bureau of Labor Statistics, Occupational Outlook Handbook, Software Developers (Updated: September 2021) 13. 2021 Value of IT Certification Employer Report, Pearson VUE 14. 2021 Value of IT Certification Candidate Report, Pearson VUE 15. 2021 Value of IT Certification Candidate Report, Pearson VUE 16. 2021 Value of IT Certification Candidate Report, Pearson VUE Whether you're thinking about your first certification or are re-exploring the possibility of an additional credential, we hope that you have found some goal-setting inspiration in the stories of those who have gone the distance and gotten trained and certified. Why get certified Summary Certification benefits CCNA Certification Guide Top Cisco resources to plan and prepare for certification Get startedTable of Contents 02 Overview 04 Certifications path 06 Vocabulary 10 Training options 11 Exam overview 12 Resources 13 Next steps Overview Certifications path Vocabulary Training options Exam overview Resources Next steps ©2024 Cisco and/or its affiliates. All rights reserved. CCNA Certification Guide | Public 01CCNA certification overview If you're looking to embark on a rewarding and lucrative information technology (IT) career, obtaining your CCNA certification is a great place to start. Earning your CCNA gives you a solid foundation for any field, role, or specialty you want to pursue in IT. It covers the basics, from IP addressing to security, automation, and AI. A CCNA certification is the perfect start if you know you want to build or support IT infrastructure. You can specialize later. A CCNA can help you prepare for , includingC B Network engineer` B Network support technician` B Network administrator` B Business roles in IT organizations, from sales and marketing to the management track a wide variety of IT jobs Overview Certifications path Vocabulary Training options Exam overview Resources Next steps ©2024 Cisco and/or its affiliates. All rights reserved. CCNA Certification Guide | Public 02And while you build your skills, you're also building your income. Here's proof. Skillsoft's Global Knowledge 2023 IT Skills and Salary Report1 examined data from thousands of IT professionals. Eighteen percent estimated that the annual value of being certified is $30,000 or more. Training and certifications pay off— and organizations know it. Over 35% of respondents listed a boost in productivity as the top benefit of a certified staff. Even more, 34% of respondents believe that certifications close organizational skill gaps. That makes certified candidates stand out in a pool of applicants during the hiring process. The network needs you. The field of IT is full of rewarding, meaningful, challenging work. Earning your CCNA certification can make your resume stand out and gets your foot in the door. The CCNA arms you with a broad range of career skills. Get started today. Overview Certifications path Vocabulary Training options Exam overview Resources Next steps ©2024 Cisco and/or its affiliates. All rights reserved. CCNA Certification Guide | Public 03 7# Skillsoft, The 20 top-paying certifications going into 2024., https://www.skillsoft.com/ blog/top-paying-it-certifications, November 14, 2023. Automation and programmability IP services Network access Security fundamentals IP connectivity Network fundamentals CCNA ExamOverview Certifications path Vocabulary Training options Exam overview Resources Next steps ©2024 Cisco and/or its affiliates. All rights reserved. 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APIs enable developers to assemble a command or request for a service or data, to submit it, and to receive any output. They are published and maintained by the vendor. A collection of all the possible paths a hacker or a malware application might follow to compromise protected data. Authentication is how you control access to your network and prevent intrusions, data loss, and unauthorized users. Continuous Integration/Continuous Development (CICD) Data formats A CICD system provides automated builds and tests for creating software, making configuration changes, or completing other deployment tasks.When using a CICD pipeline, coders can continually merge their changes to a main branch of an existing application, run integration tests on changes, keep changes small, and minimize the potential for problems due to multiple, gated test result requirements. (XML, JavaScript Object Notation [JSON], YAML Ain t Markup Language [YAML]) Common data formats that are both machine readable and human readable for providing input to programs and applications using interfaces (APIs). Knowing these key terms will help you on your CCNA journey. Overview Certifications path Vocabulary Training options Exam overview Resources Next steps ©2024 Cisco and/or its affiliates. All rights reserved. CCNA Certification Guide | Public 07 DevOps DNS Infrastructure, containers, and virtual machines A combination of Development (Dev) and Operations (Ops), DevOps focuses on automation, regularly allowing failures that can be automatically fixed with mitigated risks, as well as connecting business outcomes to the availability goals for a given system. The DevOps movement makes developers responsible for deployment and also has teams use coding workflows and tools to manage infrastructure. The Domain Name Service (DNS) is like a phone book that translates IP addresses into human readable form. For example, www.facebook.com is 157.240.22.35 (IPv4), or 2001:558:feed::1. Infrastructure is a generic term for the underlying devices, physical or virtual, that provide computing power or storage capacity or networks, used to deliver software or applications. Virtual machines can emulate a computer system and are typically built as images, providing the same functionality as the physical computer. Containers package up software and dependencies into one descriptive file that contains everything to run an application, regardless of the underlying systems. IP Addresses are like street addresses. Every service or server on the internet has a unique address where it can be accessed. The process of determining the functionality, origin, and potential impact of a given malware. IPv4 is limited to approximately 4 billion unique addresses. NAT is a scheme that allows a single address for a network (such as a small business) to be shared by all the users and devices on your network. IP address (IPv4 and IPv6, classes, Open Systems Interconnection [OSI] and TCP/IP networking stack) Malware analysis Network Address Translation (NAT) Overview Certifications path Vocabulary Training options Exam overview Resources Next steps ©2024 Cisco and/or its affiliates. All rights reserved. CCNA Certification Guide | Public 08 Network data models (YANG, RESTCONF, NETCONF) Packet Python Role-based access control YANG is a data modeling language for configuration and state data for network devices. It stands for Yet Another Next Generation. RESTCONF and NETCONF are protocols defined by a standards body, so that you can manage configuration of network devices modeled with YANG. A unit of data that can be sent from one network endpoint to another. A packet has headers, footers, and a data payload, or some other information that it carries. The headers encode details about how to route the packet. A general-purpose, interpreted programming language. Python emphasizes code readability with whitespace requirements, so it is approachable and powerful. Many network automation applications and tutorials are centered around Python. Access to data given to a person based on their job function or role. Router Routing protocols such as Border Gateway Protocol (BGP), Enhanced Interior Gateway Routing Protocol (EIGRP), and Open Shortest Path First (OSPF) Security Incident and Event Management (SIEM) A router connects different networks together, providing a route between two computers (or servers) in different networks. Routers build the internet. Routing protocols provide the overall map and directions for a packet to find the proper destination. An approach to security management that gathers data from multiple sources (such as syslog, device events, and error logs), processes the data (including correlation to identify potential threats), and raises an alert or ticket for further investigation if the threat is deemed to be real.Overview Certifications path Vocabulary Training options Exam overview Resources Next steps ©2024 Cisco and/or its affiliates. All rights reserved. CCNA Certification Guide | Public 09 Security Orchestration and Automation Response (SOAR) Software Development Kit (SDK) Subnet Switch An approach that enables SOC teams to manage tickets raised through SIEM (Security Incident and Event Management) for threat response. SOAR enables automated workflows for responding to the threats. A platform for writing programs and applications targeting an API. It often includes documentation, configurations, and tools (such as compilers or linkers) to write and execute the code to interface with the API. Subnetting is a scheme for efficiently apportioning or assigning your IP addresses to systems in your organization. A switch is a component that is used to build a network and to connect hosts and servers within a network. A switch cannot route packets or data between networks. Threat intelligence Threat hunting Time-based access control VLAN Evidence-based knowledge, including context, mechanisms, indicators, implications, and action-oriented advice about an existing or emerging hazard to assets. The process of proactively and iteratively searching through networks to detect and isolate advanced threats. Temporary access to data given to a person on a need basis for a period of time. A Virtual Local Area Network is a simple scheme to build in access control and restrictions within a network. It allows you to keep “Sales” separate from “Engineering,” for example, and to prevent inappropriate access to data.Overview Certifications path Vocabulary Training options Exam overview Resources Next steps ©2024 Cisco and/or its affiliates. All rights reserved. CCNA Certification Guide | Public 10 Training options There are several training options to help you prepare¼ Cisco Learning Locator Cisco Press CCNA 200-301 Official Cert Guide, Volume 2 CCNA Preparation Bundle Implementing and Administering Cisco Solutions | CCNA Cisco Exam Review: CCNA D Use the to find instructor-led courses-both in-person and virtual. D If books are your thing, check out the , a perfect addition to your self-study plan. D The helps you prepare for the 200-301 CCNA exam. For a limited time, save 16 percent off the bundle price. D The Learning Path will build the skills you need to install, operate, configure, and verify basic networks, while you prepare to take the 200-301 CCNA exam.2 D The helps you prepare to take the CCNA exam. You will gain practical experience for exam topics by testing your key knowledge, skills, and abilities. Regardless of how you prepare for the exam, it s crucial to get your hands on the gear to practice. This is called labbing,” as in practicing in a lab environment. Your ability to execute critical tasks will be tested on the exam, so you need to practice. Lab early. Lab often. Then lab some more. Explore Cisco Modeling Labs. Keep this in mind: when the verb for a topic area is describe,” you won t need the same depth of knowledge for that topic as when the verbs are configure,” troubleshoot,” and design. This is where the real work happens. You ll need two things: the exam topics as well as a strategy for learning, studying, and practicing. The CCNA certification exam topics are the basis for the exam. They define the contents of both the exam and the official training course, and it should be your roadmap for studying. If you can successfully complete the tasks defined for each topic, you re ready for the exam. Overview Certifications path Vocabulary Training options Exam overview Resources Next steps ©2024 Cisco and/or its affiliates. All rights reserved. CCNA Certification Guide | Public 11 Exam overview The CCNA exam topics are the basis for the certification exam. They define the contents of both the exam and the official training course, and should be your roadmap for studying. If you can successfully complete the tasks defined for each topic, you’re ready for the exam. And you can take certification exams online, so you can stay on track, even when you can’t travel to a testing center. 200-301 CCNA Exam Topics Visit to perform a system check. www.cisco.com/go/ onlinetesting CCNA certification exams are administered by our testing partner, Pearson VUE, as proctored exams. When you take the exam, you’ll be in a controlled environment to ensure fairness and to give you the best, most consistent experience. To view a walk-through demonstration of the various exam question types and how they function, check out the page. Cisco Certification Exam Tutorial VideosOverview Certifications path Vocabulary Training options Exam overview Resources Next steps ©2024 Cisco and/or its affiliates. All rights reserved. CCNA Certification Guide | Public 12 Resources CCNA Essentials Still thinking about getting certified? Select CCNA Essentials for more details about the program. It will help you make the best decision. 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By learning the latest methods and skills in IT, you’ll gain the self- confidence that comes from setting goals, then accomplishing them. And that self-confidence will continue to empower your career. These are exciting times to be working in technology. The IT landscape evolves daily, but through it all, knowledge of routing and switching remain the core foundation on which you can build your career. Ask your manager to sponsor your training. Once they understand the benefits to your organization, they will be eager to learn more and support you with next steps. Download e-book ©2024 Cisco and/or its affiliates. All rights reserved. CCNA Certification Guide | Public 13Overview Certifications path Vocabulary Training options Exam overview Resources Next steps © 2024 Cisco and/or its affiliates. All rights reserved. Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. 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This aspect of the job requires the electricians installing the devices to be skilled in conduit bending procedures, too. 3. Industrial Wiring Because of the hazardous materials that exist in many industrial facilities, the installation and maintenance of electrical systems in these volatile environments must follow strict requirements. Conduit systems in volatile environments must be sealed to outside vapors and gases, and any potential sparking or arcing device must be enclosed within a special enclosure or casing to prevent the ignition of hazardous vapors that might be present. Industrial electricians are generally split into two groups: installers and maintenance personne esidential Wiring Residential electrical system includes an electrical supply, electrical service, nonmetallic-sheathed cable, nail-on device boxes, panel boards, and fixtures. Phases of residential electrical wiring include rough-in, trim out, testing, and troubleshooting. 2. Commercial Wiring Electrical installations in commercial structures contain many of the same elements as residential installations. The only difference is that in commercial electrical installations, conductors are typically installed in metal raceways. This aspect of the job requires the electricians installing the devices to be skilled in conduit bending procedures, too. 3. Industrial Wiring Because of the hazardous materials that exist in many industrial facilities, the installation and maintenance of electrical systems in these volatile environments must follow strict requirements. Conduit systems in volatile environments must be sealed to outside vapors and gases, and any potential sparking or arcing device must be enclosed within a special enclosure or casing to prevent the ignition of hazardous vapors that might be present. Industrial electricians are generally split into two groups: installers and maintenance personne Job Requirements in the Electrical Trade Click on the tabs to find out more about them: Residential Electricans Commercial Electricians Industrial Electricians Residential Electricians provide the complete electrical system in a residential structure, keeping in mind the safety precautions. A lack of safety measures may contribute to injury due to shock or fires. Elements of a residential wiring installation include installing the electrical s The key points from this module are: The electrical trade offers many job opportunities to work in residential, commercial, and industrial construction. Electricians are responsible for the installation and maintenance of electrical systems and equipment. Electricians working on residential and commercial projects require the same basic set of knowledge and skills. Industrial electricians must know the installation procedure for various types of conduit, large conductors, motors, and controls, as well as possess strong troubleshooting skills. The electrical wiring system for residential, commercial, and industrial projects varies, and a thorough knowledge of the requirements for each sector is a vital part of the job. Electricians working with industrial wiring and equipment are also required to know the safety procedures for handling hazardous materials. ervice entrance equipment, branch circuit conductors, device boxes, panel enclosures, over-current protective devices (circuit breakers), and fixtures such as lighting and smoke detectors. ____ Re: Release resultat statement and finalize award diploma./irregularilarity case .re marker ____ tshingombe fiston Mon, Feb 12, 2024 at 11:05 AM To: TSHINGOMBEKB TSHITADI , centraloffice@qcto.org.za, secretarydrr@saqa.co.za, Qualification@qcto.org.za, Mahlangu.L@qcto.org.za, learnerenrolments@qcto.org.za, csd@treasury.gov.za, callcentre@dhet.gov, modiba.d@dhet.co.za, saqainfo@saqa.org.za, dfqeas@saqa.co.za, DGRegistry@treasury.gov.za, deregistrations@cipc.co.za, DSI-Notification , tshingombe fiston , confirmations@saqa.co.za Application Ref :Applications letter number : 2023/1226 ____________________________________ ADRESS:PRIVATE BAG X 174 ,PRETORIA 0001 123 FRANCIS BAARD STREET PRETORIA TEL:0123235618 ____________________________________ ENQUIRY NUMBER: DHET : DOCKET NUMBER :2023/1226 INFORMATION MANAGEMENT SYSTEM - INSTITUT COLLEGE NAME :ST PEACE COLLEGE -ID: NUMBER: TIRC0G000910610 -REGISTRATION NUMBER: STUDENT -CO70040101099 -SARS VAT NUMBER: 923228238 -MERSETA : 17_QA/ACC/1311/17 -SAQA REGISTRAR STUDENT NUMBER:210020223812,2004007064382. -email adress: tshingombekb@gmail.com -Alternate email address: tshingombefiston@gmail.com ____ APPEAL DECISSION RESULT RELEASE: APPLICATION NUMBER: Saqa: institut foreign .saqa transcription meeting 71638 dr congo requirements grasuate award diploma nqf .high certificate no meeting .leave school .expended assessments .exam d etat diploma .certificate professionek .certificate informatics mathematicsvoffics ; result outcom primaryb status registration saqa asset 09121 .saqa institut 30_ 39 nc assess policy.IE099 ,saqa id 67q0 certificate advance phase teach .n1 saqa id 63375.id 67491 entrance .n diplomat -Qualification title national N diplomat engineering. -nqf level:6 . -date submitted to dhet :1105/2023 -date process . 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100% ,100% 0.30 Electrotechnichnics n4 - 100% ; 100% 0.30 Industrial electronics n4 - 100% ; 100% 0.30 Enginering science n4 - 100% ; 100% 0.30 Mathematics n4 -- 100% , 100% 0.30 Electrotechnichnics n5 - 100% , 100% 0.30 Industrial electronics n5 - 100% ; 100% 0.30 Enginering science n5 - 100% ; 100% 0.30 Mathematics n5 - 100% ; 100% 0.30 Electrotechnichnics n6 - 100% ; 100% 0.30 Industrial electronics n6 - 100% ; 100% 0.30 Enginering science n6 - 100% ; 100% 0.30 Mathematics n6 - 100% ; 100% 0.30 Total rate For certificate Full tie equivalente 1300% +1800; 1300+1751 3051 % 1900 0,30 X 29 =9,57 PRATICAL PANEL WIRING ELECTRICAL , PLUMBING Total 100% 100% 200% Total pratical theorethical euivalent N diploma engineering electrical value Record academic ACREDITTION N DIPLOMA , ID 67109 N , N1 ID 673575.N3 ID 66881, ID 66960, ID 67005 Required information Submitted yes not Institut comment For officer only Annuel report form yes Good years Award Termination of agreemnt with othor institut yes Good years Award The disclosure certificate as issued by the CIPC for Directors who have yes Good years Award - INSTITUT COLLEGE NAME :ST PEACE COLLEGE -ID: NUMBER: TIRC0G000910610 -REGISTRATION NUMBER: STUDENT -CO70040101099 -SARS VAT NUMBER: 923228238 -MERSETA : 17_QA/ACC/1311/17 -SAQA REGISTRAR STUDENT NUMBER:210020223812,2004007064382 Yes Yes Yes Yes Yes Yes yes Good years Award Show Navigation Menu Completed Training: Tshingombe fiston Title Type Completion Date Score Status Maximize Profitability and Operations Efficiency 2/3 Video 9/20/2024 Completed SDL V2 Developer Role Video 9/20/2024 Completed DirQ_GL13R7 Managing Offer Safety Risks External Content 9/20/2024 Completed Discover Zelio Control Relays Video 8/12/2024 Completed Schneider Electric's Vision Edge 2022: Powering Digital Transformation Video 3/5/2024 Completed Secure Power_Virtual Certification_on demand 2021_sesion 4 Video 1/24/2024 Completed Cooling Virtual Certificaion_on demand 2021_sesion 2 Video 1/24/2024 Completed Technical Expert Assessment Video External Content 1/23/2024 Completed DirQ_GL36R00 Technical Expert Assessment External Content 1/23/2024 Completed Technical Expert Assessment Workflow External Content 1/23/2024 Completed Technical Expert Assessment GuideBook External Content 1/23/2024 Completed Schneider Electric Information Technology guide Material 1/23/2024 Completed Heating, Ventilation and Air Conditioning (HVAC): Discover the Machines Online Class 1/23/2024 0 Completed Room Ventilation And Airborne Disease Transmission In A Healthcare Setting Online Class 1/22/2024 Completed Ecostruxure Power: Energy Modeling and Verification (SSOW) Video 1/22/2024 Completed Vérification de la facture /EcoStruxure Power: Utility Bill Verification (French) Online Class 1/22/2024 Completed Discover Telemecanique Sensors Curriculum 1/22/2024 Completed EcoStruxure Power Operation: Ch7 - Add Mechanical Graphincs and Controls Video 1/21/2024 Completed ASCO: Fundamentals in Technical Document Review Online Class 1/18/2024 Completed EBO 2023: Introduction to Docker Online Class 1/18/2024 Completed EcoStruxure Security Expert: Biometric Reader Integration 4.3 Video 1/15/2024 Completed Discover Harmony XB5S Biometric Switches Video 1/15/2024 Completed EcoStruxure Building: LonWorks Introduction Part 3 Online Class 1/15/2024 Completed Innovation Talk: Why Alarm Management is the tip of the iceberg- and the best indicator of a poorly performing control system Video 1/15/2024 Completed PowerTalks: Equipment Performance Video 1/15/2024 Completed EcoStruxure Building: Script Programming (Self-Study) Material 1/15/2024 Completed Drives: Fundamentals of Kinematics: Calculation Centrifuge Video 1/15/2024 Completed Gestion de la Capacité /EcoStruxure Power: Capacity Management (French) Online Class 1/15/2024 Completed ASCO: Low Voltage Construction Fundamentals Online Class 1/15/2024 Completed Migrate from Legacy Graphics Video 1/15/2024 Completed Physical Infrastructure Management Basics Online Class 1/14/2024 Completed Fundamentals of Physical Security Online Class 1/14/2024 Completed Schneider Electric Approved EV Installers : IT Architecture Material 1/13/2024 Completed Advanced Lighting Control with KNX and DALI Online Class 1/13/2024 0 Completed ASCO: Application of Circuit Breakers in Power Control Systems Online Class 1/13/2024 Completed Security Expert Transition Guide Material 1/13/2024 Completed Discover Wiring Devices: Technical Structure and Applications Online Class 1/12/2024 0 Completed Internet: 50+ Years of Innovations and Inventions that Made It Curriculum 1/12/2024 Completed Computer History in a Photo Album Curriculum 1/12/2024 Completed Digital Economy: Movers and Shakers Curriculum 1/12/2024 Completed Your Computer's Secrets Curriculum 1/12/2024 Completed Trending Digital Technologies Curriculum 1/12/2024 My Courses: Tshingombe fiston Use the transcript to manage all active training. 0 HRS AGGREGATE TRAINING COMPLETED FISCAL YEAR ENDING 12/31/2025 COST R0.00 Filter by Training Status Completed Sort by Completion Date Filter by Training Type All Types Search by Keyword Search Search Results (42) Maximize Profitability and Operations Efficiency 2/3 Completed : 9/20/2024 Status : Completed Training Type : Video Training Status : Completed SDL V2 Developer Role Completed : 9/20/2024 Status : Completed Training Type : Video Training Status : Completed raining Details Training Type: Curriculum Provider: Home and Distribution Academy Version: 30.0 Structure History Training Hours: 3 Hours 39 Minutes Description: Schneider Home Certification training is designed to equip installers with the knowledge and skills required to successfully deploy Schneider Electric's newest innovation in home energy management, the Schneider Home energy management system. This course delivers in-depth and comprehensive instruction on everything you need to know on how to properly install and commission Schneider Home suite of products. It covers the following topics: • Installing and wiring Schneider Inverter, and Boost, Pulse Backup Controller - wall mount. • Installing Schneider Energy Monitor and Square D Relays (if installing Schneider Energy Monitor in Pulse Backup Controller) • Commissioning with eSetup App and Smart Panel Setup App • Using Schneider Electric Installer Portal • Preparing for Handoff to the Homeowner • Accessing Schneider Home Resources • RMA Instructions and Warranties • Contacting Technical Support At the end of the course, you will take a 25-point Certification Test. You must obtain an 80% passing score to receive your Schneider Home Certification. This course offers 3 NABCEP CEU credits. Course Code: HDAPRDCS0001005 Status: In Progress Training Purpose: Due Date: None Expiration Date: Curriculum Select a training view (Selection will cause the page to refresh) All Training Activated Training Not Activated Training Show Expired Training Title (Click on to see course description) Type Due Date Excused Required Status Options Details Schneider Home Certification courses (Min. required: 10) Section None Introduction to Schneider Home Online Class None No Completed (Equivalent) Launch | Register Schneider Inverter Online Class None No Not Activated Activate None Schneider Boost Online Class None No Pending Prior Training None None Pulse Backup Controller Online Class None No Pending Prior Training None None Load Control Online Class None No Pending Prior Training None None Commissioning with Schneider Smart Panel Setup App Online Class None No Pending Prior Training None None Commissioning with eSetup App Online Class None No Pending Prior Training None None Schneider Home Handoff to Homeowners Online Class None No Pending Prior Training None None Schneider Electric Installer Portal Online Class None No Pending Prior Training None None Schneider Home Support for Installers Online Class None No Pending Prior Training None None Schneider Home Certification Test (Min. required: 1) Section None Schneider Home Certification Test Online Class None No Pending Prior Training None None TRAINING TRANSCRIPT FOR TSHINGOMBE TSHITADI List of completed activities from 3/10/2024 to 3/10/2025 Username: tshingombefiston@gmail.com E-mail: TSHINGOMBEFISTON@GMAIL.COM Primary domain: Global SCM Primary organization: Primary job: User number: tshingombefiston@gmail.com ACTIVITIES Activity Signature Status Start Date Completion Date Learner Signature Date Score Attended Duration Completion Status e-Learning Course: Microgrid Modeling and Analysis 3/5/2025 3/5/2025 Day(s): 0, Hour(s): 0, Minute(s): 1, Second(s): 40 Attended e-Learning Course: Eaton: Supporting Your CDP Disclosure 2/23/2025 2/23/2025 Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 53 Attended e-Learning Course: Eaton's Low-Voltage Switchgear 2/22/2025 2/22/2025 Day(s): 0, Hour(s): 0, Minute(s): 2, Second(s): 26.3 Attended e-Learning Course: Eaton Electrical - SEM + Addendum 2/22/2025 2/22/2025 16.67 Failed Day(s): 0, Hour(s): 0, Minute(s): 2, Second(s): 23 Attended e-Learning Course: Sales Training Exam: Eaton G4 Rack PDUs 2/22/2025 2/22/2025 55.55 Failed Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 59.2 Attended e-Learning Course: Sales Training Exam: How to Sell More Cables and Connectivity 2/22/2025 2/22/2025 80 Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 42.6 Attended e-Learning Course: Surge Solutions 2/22/2025 2/22/2025 25 Failed Day(s): 0, Hour(s): 0, Minute(s): 2, Second(s): 10.3 Attended e-Learning Course: Power press Training Module 1 - PPE & Housekeeping 10/27/2024 2/22/2025 Day(s): 0, Hour(s): 0, Minute(s): 1, Second(s): 14 Attended e-Learning Course: Functional Skills Workshop: Human Resources [eLearning] 2/21/2025 2/21/2025 Day(s): 0, Hour(s): 0, Minute(s): 1, Second(s): 19 Attended e-Learning Course: Power press Training Module 1 - PPE & Housekeeping 10/27/2024 10/27/2024 Day(s): 0, Hour(s): 0, Minute(s): 0, Second(s): 17 Attended Transcript Records may take up to 24 hours to update. Transcript Legal name: Tshingombe Tshitadi Fiston 46307064 Edit display name in settings Username: 46307064 Edit user name in settings Contact email: tshingombefiston@gmail.com Edit contact email in settings Modules completed 924 Training hours completed 738 hr 43 min Modules completed N/A in the module assessment result column means either the module assessment doesn't exist or there's no pass record for it. All modules in this table are complete. Module title Description Completed on Duration Module Assessment Result Introduction to Azure Load Balancer This module explains what Azure Load Balancer does, how it works, and when you should choose to use Load Balancer as a solution to meet your organization's needs. Jan 10, 2025 18 min N/A Enhance your service availability and data locality by using Azure Traffic Manager Discover how Azure Traffic Manager provides DNS load balancing for your application to improve the performance and availability of your application. Jan 10, 2025 29 min N/A Improve your reliability with modern operations practices: An introduction Discover a map for navigating reliability challenges and sustainably achieving the appropriate level of reliability in your systems, services, and products. Jan 10, 2025 10 min N/A diploma./irregularilarity case .re marker Inbox The Internet Archive Team (Internet Archive) Sun, Oct 20, 8:07 AM to me, Tshingombetshitadi, MMA, Msedusales ##- Please type your reply above this line -## You are registered as a CC on this request (1135821). Reply to this email to add a comment to the request. The Internet Archive Team (Internet Archive) Oct 19, 2024, 23:07 PDT It's dispiriting to see that even after being made aware of the breach 2 weeks ago, IA has still not done the due diligence of rotating many of the API keys that were exposed in their gitlab secrets. As demonstrated by this message, this includes a Zendesk token with perms to access 800K+ support tickets sent to info@archive.org since 2018. Whether you were trying to ask a general question, or requesting the removal of your site from the Wayback Machine—your data is now in the hands of some random guy. If not me, it'd be someone else. Here's hoping that they'll get their shit together now. TSHINGOMBEKB TSHITADI Oct 15, 2024, 09:19 PDT On Fri, 12 Jul 2024, 20:34 tshingombe fiston, wrote: Good morning On Fri, 12 Jul 2024, 14:47 tshingombe fiston, wrote: 2 ltter tshingombe self asseme Incident logged on 2024.docx 3formsubmission-request-ip-licence-mip-327-24-0100-000 sale force emet tshingombe.pdf 3letter explanation theoretical assessment learne application course topics textbook.docx 4formsubmission-request-ip-licence-mip-329-24-0100-000, assessment scotland,,theoretical pratical... 5formsubmission-request-ip-licence-mip-349-24-0100-000.pdf 6formsubmission-request-ip-licence-mip-350-24-0100-000.pdf academic_transcript20240703-7-9m1civ met tableau record tshingombe.pdf Acrobat Document.pdf ah-engineering-science-data-booklet.pdf asses bigade tableau 2.pdf asses worsale.pdf assesment low become , question.pdf assess engi worksale.pdf assess engi worksale.pdf traffic.pdf assess engi worksale.pdf traffic.pdf 3.pdf assess engi worksale.pdf traffic.pdf 3.pdf4.pdf assess engi worksale.pdf traffic.pdf 3.pdf4.pdf5.pdf assess engi worksale.pdf traffic.pdf 3.pdf4.pdf5.pdf6.pdf assess engi worksale.pdf traffic.pdf 3.pdf4.pdf5.pdf6.pdf7.pdf assess engi worksale.pdf traffic.pdf 3.pdf4.pdf5.pdf6.pdf7.pdf8.pdf assess engi worksale.pdf traffic.pdf 3.pdf4.pdf5.pdf6.pdf7.pdf8.pdf8.pdf assess engi worksale.pdf traffic.pdf 3.pdf4.pdf5.pdf6.pdf7.pdf8.pdf8.pdf microsoft office1.pdf assess engi worksale.pdf traffic.pdf 3.pdf4.pdf5.pdf6.pdf7.pdf8.pdf8.pdf microsoft office1.pdfr ... assess wor sale.pdf assess worsale,.pdf assessement help memo data ritgh tableaux, workforce, microsoft skill, alison,,,career path , sic... assessement licenseengineering printed sceen license ip,tableaux,.pdf assessm worksale tshing.pdf assessment engineering electrical scoth.pdf assessment engineering electrical scoth.pdf tshingombe.docx assessment tableau tshingombe staus1.pdf assesworsale asses.pdf Assignment Cover Page - 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Candidate does not qualify for an N3 certificate as he did not pass all subjects. For a candidate to be awarded with a diploma (as per the below complaint), they must achieve N4, N5 and N6 certificates plus relevant work experience then then may submit the application at the college. Regards Gugu Nhleko Helpdesk

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Complains about : Service delivery Person / Ministry / Municipality: Department of Higher Education Preferred contact number : N/A Any other contact number : N/A E-mail : tshingombefiston@gmail.com Fax Number : N/A ID number : N/A Ref number : N/a Office where you complained : N/A Street : N/A Building name : N/A City : Johannesburg Office Contact Number : N/A Province : Gauteng Date of complaint : N/A Names of people not delivering service: N/A Where did it happen town / site / municipality: N/A Type of service : Citizen is requesting about the release of results statement and to award a diploma. Student ID: 2100002023812 Student name.tshingombe Tshitadi College instituts name St peace college Exam :external shalom technical : 899993812 Afric policing instituts Memorandum :2023/0508 See attachment for more information Citizen requests the Presidency to assist them Re: letter explanation theoretical pratical base work , n diplomat award engineering electrical JXL6JWJL31FNJY17GWWMWQ Inbox dfqeas Tue, Nov 5, 2:38 PM (12 days ago) to me Dear Mr/Ms Fiston, Thank you for your email. Please note that application for evaluation of foreign qualification is done online. Kindly use the link below for the application of evaluation of foreign qualifications. All applications are done online. https://dfqeas.saqa.co.za/dfqeas/user/home Attached are the guidelines for applications and the country specific requirements. Be aware that the maximum turnaround time for completion of the evaluation process is 90 working days. Kindly note that our system is not compatible with the iPhone, iPad, and MacBook; you are advised to use other devices. Ensure that your default internet browser is Google Chrome and that you are connected to mobile data rather than Wi-Fi. Kind regards, Ms. Malebo Ngobeni From: tshingombe fiston To: Confirmations , , tshingombe fiston , , dfqeas , , Microsoft EDU Sales Date: 2024-10-23 09:12:08 Subject: Re: letter explanation theoretical pratical base work , n diplomat award engineering electrical On Sat, Sep 28, 2024 at 4:22 PM tshingombe fiston wrote: Hello dear how can gate my graduation ceremony certificate diploma engineering study n On Sat, 14 Sep 2024, 16:24 tshingombe fiston, wrote: hello dear i need help for my qualification issue rd congo saqa framework qualification supplementaire n diploma send to saqa Nhleko, Gugu Tue, Mar 19, 12:39 PM to me On Thu, Sep 12, 2024 at 11:47 PM Confirmations wrote: Good day How can i assist you? ____ From: tshingombe fiston Sent: Sunday, June 23, 2024 12:07 PM To: tshigombekb@gmail.com ; tshingombe fiston ; dfqeas ; Lundt, Sonnika ; lutuka.m@shet.go.za ; careerhelp@dhet.gov.za ; maraba.a@dhet.gov.za ; callcentre@dhet.gov ; dmandaha@csir.co.za ; esther.rammultla@dst.gov.za ; Confirmations ; President Hotline(DPME) ; modiba.d@dhet.co.za ; tena.m@dhet.gv.za ; QCTO Verification ; sonnika.s@dhet.gov.za ; SAQAInfo ; Microsoft EDU Sales ; sarb-graduaterecruit@resbank.co.za ; Nhleko, Gugu ; DSI-Notification ; Central Office ; Central Supplier Database System ; SARB Talent Acquisition ; study@stpeacecollege.co.za ; Secretarydrr ; sarb-procurement@resbank.co.za ; csd@treasury.gov.za ; info@stpeacecolllege.co.za ; ISCDSupport@dhet.gov.za Subject: re: letter explanation theoretical pratical base work , n diplomat award engineering electrical Re:/ award diplomat certificate,markshet transcript letter experience theoretical practical engineering n studies outcome Inbox Address:postal. -Francis bard Pretoria Department of Higher Education and Training 123 Francis Baard Street, Pretoria Central Room 506_012 312 5440 To:St peace college and instituts, tvet Dhet -Date :subject :completion letter : Practice experimental log book. ____ -1. To concerne This letter serves confirm .Mr was participations in the work integrated learning programme of department : Dhet research assessment irregularity national examination nated n4 to additional information and workbased on visited circular practice external on line job work practice on department of energy minimal compagny career CVS and industrial portal council work city power day visited on line Facebook,Gmail badges,Eskom career day 28day appointment,sarb career engineering artisan electrical electronics engineering,Microsoft Scheiner career certificate training, Eaton electrical dtic day project engineering ,sasseta saps psira career mil engineering career metropolitan ,log back project isita DBE and participate assessment engineering electrical for n studies engineering n diploma national framework work qualifications NQF saqa subject research engineering electrical at St peace college 20days work ,circulum on line computer practice topics research engineering electrical at St peace college practice CVS computer aid .from 20 february 2022to 20 april 2024 in the area of engineering it expected following subjects. -Computer and information management system in education learn engineering assessment police and safety 1,and engineering safety security.class orientation guidelines./technical documentation libraries engineering lea Automatic reply: letter explanation theoretical pratical base work , n diplomat award engineering electrical Inbox CallCentre via dhetgovza.onmicrosoft.com Wed, Oct 23, 9:16 AM to me Please note that this is an automated response, do not reply to it. Thank you for contacting the Department of Higher Education and Training Call Centre. We appreciate your inquiry. Regarding NN Diploma, Nated, and NCV certificate enquiries: All applications for new issues, replacements, or combination requests must be submitted directly to the relevant college. Please note that there is a minimum waiting period of 3-6 months for diploma applications. The issuance of NN Diploma is currently paused. We have communicated this to all colleges. In the meantime, students whose diplomas are finalized but awaiting printing can obtain a confirmation letter from their college. We apologize for any inconvenience this may cause and appreciate your understanding. tshingombe fiston ____ (no subject) ____ tshingombe fiston Mon, Mar 17, 2025 at 1:57 PM To: tshingombe fiston Product Selector Tool This tool is designed to assist you through the product selection process. 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Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 10 234,04 001 license, EcoStruxure Control Engineering, verification, basic, node locked, 1 shot R 5 582,20 View Details 002 license, EcoStruxure Control Engineering, documentation, basic, node locked, 1 shot R 4 651,84 View Details mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025 Product Selector Tool This tool is designed to assist you through the product selection process. 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Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 331 172,31 001 licence, Ecostruxure Automation Expert, standard engineering buildtime, v23 R 65 100,00 View Details 002 license, EcoStruxure Automation Expert, professional engineering, buildtime, v23 R 157 500,00 View Details 003 license, EcoStruxure Automation Expert, standard device runtime, add on, v23 R 378,00 View Details 004 license, EcoStruxure Automation Expert, high availability option, runtime, add on, v23 R 840,00 View Details 005 license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for ATV dPac R 777,00 View Product 006 license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M251, M262 dPAC R 6 216,70 View Product 007 license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M580 dPAC R 15 540,00 View Product 008 license, EcoStruxure Automation Expert, run time, application, permannet, 1 user, for M580 dPAC with extensions R 56 448,56 View Product 009 license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony ST6 R 2 625,00 View Product 010 license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony iPC R 12 600,35 View Product 011 Status Unavailable Price Unavailable View Details mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider El Product Selector Tool This tool is designed to assist you through the product selection process. 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Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 64 222,36 001 Motion controller LMC100 0 axis - Acc kit - Basic End of commercialisation: 12/01/2024 Price Unavailable View Details 002 Regulated switch power supply, modicon power supply, 3 phases, 380 to 500V AC, 24V, 20A R 13 112,60 View Product 003 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 20A, for regulated SMPS R 11 849,78 View Product 004 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 40A, for regulated SMPS R 17 709,70 View Product 005 redundancy module, phaseo ABL7 ABL8, 40A, for regulated SMPS R 5 529,38 View Product 006 electronic protection module, phaseo ABL7 ABL8, 28 to 28.8V DC, 10A, for regulated SMPS, 2 pole breaking by channel R 8 177,54 View Product 007 buffer module, phaseo ABL7 ABL8, 24 to 28.8V DC, 40A, for power supply R 7 843,36 View Product mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric Product Selector Tool This tool is designed to assist you through the product selection process. 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Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 13 327,65 001 Bus coupler, TeSys island, 24VDC, Ethernet switch (EtherNet IP / Modbus TCP) R 8 961,41 View Product 002 Voltage interface module, TeSys island, 690VAC 47-63 Hz, Isolated switching input for safe stop R 4 366,24 View Product mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric Product Selector Tool This tool is designed to assist you through the product selection process. 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Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 385 363,62 001 redundant processor, Modicon M580, 8MB, 61 Ethernet devices, 8 local racks, 8 remote IO racks R 177 037,09 View Product 002 power supply module, Modicon X80, 24V DC, 16.8W R 7 707,26 View Product 003 connector kit, Modicon M340, 2 removable connectors, cage clamp, for power supply module R 527,05 View Product 004 connector kit, Modicon M340, 2 removable connectors, spring type, for power supply module R 561,57 View Product 005 rack, Modicon X80, 8 slots, Ethernet backplane R 6 848,84 View Product mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric Product Selector Tool This tool is designed to assist you through the product selection process. 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Capítulo 1/Sustainability School for Partners. Chapter 1 (Portuguese) Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active Motion Block : Part I (Test) Due : No Due Date Status : Failed Training Type : Test Training Status : Active Transformers and motor applications in industries Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active EBO 2023: Engineering Upgrade Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active PowerLogic P5: Protection Engineering Due : No Due Date Status : In Progress Training Type : Curriculum Training Status : Active EVlink ProAC Calibration Law Compliant Basic (German) Due : No Due Date Status : Registered Training Type : Online Class Training Status : Active 1 2 3 4 5 Next Last 1 to 25 of 134 Scroll Version: 17.3.0.171 Powered by Cornerstone OnDemand, Inc. ©2000-2017 All Rights Reserved. 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Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 1 Total: R 30 687,22 001 Controller, Modicon M171/M172/M173, optimized display 22 IO, Modbus R 9 888,63 View Product 002 Modicon M171 Optimized LV Connector 1m cable R 555,78 View Product 003 Modicon M171 Optimized AO Connector 1m cable R 140,86 View Product 004 Modicon M171 Optimized AO Connector 2m cable R 201,24 View Product 005 Modicon M171 Optimized Display LED R 1 802,40 View Product 006 Modicon M171 Optimized Display LCD End of commercialisation: 12/01/2024 R 3 104,58 View Product 007 Modicon M171 Optimized Wall thermostat without backlight R 2 170,34 View Product 008 NTC 1,5m IP68 5x20 -50+110°C Grey R 143,76 View Product 009 NTC 1,5m IP68 5x20 -50+110°C Grey R 136,69 View Product 010 NTC 3,0m IP68 5x20 -50+110°C Grey End of commercialisation: 12/01/2024 R 229,99 View Product 011 EEV Driver, Actuator End of commercialisation: 01/23/2021 R 3 449,54 View Product 012 EEV Driver, Autonomous & Hardwired End of commercialisation: 01/23/2021 R 3 737,01 View Product 013 EEV Driver, Autonomous & Modbus End of commercialisation: 12/01/2024 R 4 570,62 View Product mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric Product Selector Tool This tool is designed to assist you through the product selection process. 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Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 51 005,44 001 Motion controller LMC216 16 axis - Acc kit - Basic End of commercialisation: 12/01/2024 Price Unavailable View Details 002 Regulated switch power supply, modicon power supply, 3 phases, 380 to 500V AC, 24V, 20A R 13 112,60 View Product 003 Motor circuit breaker, TeSys Deca, 3P, 1 to 1.6A, thermal magnetic, screw clamp terminals, button control R 1 709,72 View Product 004 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 20A, for regulated SMPS R 11 849,78 View Product 005 battery control module, phaseo ABL7 ABL8, 24 to 28.8V DC, phaseo ABL7 ABL8, 24V, 40A, for regulated SMPS R 17 709,70 View Product 006 Easy UPS control module, 24V DC-DC, DIN Rail, Industrial, 20A R 3 679,82 View Product 007 Easy UPS battery module, 24V DC-DC, DIN Rail, Industrial, 4.5Ah R 2 943,82 View Product mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric Product Selector Tool This tool is designed to assist you through the product selection process. Try our Product Selector Content Training Installed Base Programs Overview All Projects Project details Project-25 Untitled open Created: 9/3/2025 Last Modified: 9/3/2025 Project Owner: Tshingombe fiston End User Company: Tshingombe engineering BOM Manager Activity Log Documents Add products to Bill of Materials By product reference number # By Excel/CSV file (Download sample template) Bill of Materials Total items selected: 0 Total: R 400 547,09 001 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A R 14 080,25 View Product 002 Contactor body,TeSys F,3P(3NO)-AC-3, <=440V 265A without coil End of commercialisation: 12/31/2023 R 28 920,36 View Product 003 variable speed drive, Altivar Process ATV900, ATV930, 160kW, 380 to 480V, with braking unit, IP20 R 334 238,57 View Product 004 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type R 1 005,92 View Product 005 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type R 1 005,92 View Product 006 Low level auxiliary contact, circuit breaker status OF/SD/SDE/SDV, 1 changeover contact type R 1 005,92 View Product 007 torque limiting screws, ComPact NSX400/630, power connections, set of 12 parts End of commercialisation: 12/01/2024 R 489,96 View Product 008 TeSys F - suppressor module - RC circuit - 127...240 V AC End of commercialisation: 12/31/2023 R 1 344,07 View Product 009 Time delay auxiliary contact block, TeSys Deca, 1NO+1NC, on delay 0.3-3s, front, screw clamp terminals R 2 151,05 View Product 010 Time delay contact block,TeSys Deca,1NO+1NC,on-delay 1-30s,front R 2 151,05 View Product 011 TeSys F - main contact set - 3P End of commercialisation: 12/31/2023 R 14 154,02 View Product mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric Product Selector Tool This tool is designed to assist you through the product selection process. Try our Product Selector Content Training Installed Base Programs Overview All Projects Project details Project-24 Untitled open Created: 9/3/2025 Last Modified: 9/3/2025 Project Owner: Tshingombe fiston End User Company: Tshingombe engineering BOM Manager Activity Log Documents Add products to Bill of Materials By product reference number # By Excel/CSV file (Download sample template) Error adding products View BOM By product segments / selection tools Programmable controllers and I/Os PLC, PAC, IOs and Power supplies Motor Protection & Control VSD, Soft Starter, Direct Starter and protections Human-machine interfaces HMI panels, controllers, software and Industrial PCs Interface, Safety and Control Relays Electromechanical, Control, Timing and Solid State Relays Enclosures and Accessories Enclosures, thermal management, accessories and cabling Push Buttons, Switches, Pilot Lights and Joysticks Harmony ranges Motion Control and Robotics Move the machine tooling or the part itself in a controlled, rotary or linear manner. Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 110 098,24 001 Circuit breaker, ComPacT NSX400H, 70kA/415VAC, 3 poles, MicroLogic 1.3M trip unit 320A R 14 080,25 View Product 002 Contactor body,TeSys F,3P(3NO)-AC-3, <=440V 265A without coil End of commercialisation: 12/31/2023 R 28 920,36 View Product 003 soft starter for asynchronous motor, Altistart 22, control 230V, 230 to 440V, 75 to 132kW R 65 378,96 View Product 004 torque limiting screws, ComPact NSX400/630, power connections, set of 12 parts End of commercialisation: 12/01/2024 R 489,96 View Product 005 Auxiliary contact block, TeSys Deca, 1NC, front mounting, screw clamp terminals R 277,79 View Product 006 Auxiliary contact block, TeSys Deca, 1NO+1NC, front mounting, screw clamp terminals R 350,84 View Product 007 Auxiliary contact block, TeSys Deca, 1NO+3NC, front mounting, screw clamp terminals R 600,08 View Product mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric mySchn Product Selector Tool This tool is designed to assist you through the product selection process. Try our Product Selector Content Training Installed Base Programs Overview All Projects Project details Project-23 Untitled open Created: 9/3/2025 Last Modified: 9/3/2025 Project Owner: Tshingombe fiston End User Company: Tshingombe engineering BOM Manager Activity Log Documents Add products to Bill of Materials By product reference number # By Excel/CSV file (Download sample template) Error adding products View BOM By product segments / selection tools Programmable controllers and I/Os PLC, PAC, IOs and Power supplies Motor Protection & Control VSD, Soft Starter, Direct Starter and protections Human-machine interfaces HMI panels, controllers, software and Industrial PCs Interface, Safety and Control Relays Electromechanical, Control, Timing and Solid State Relays Enclosures and Accessories Enclosures, thermal management, accessories and cabling Push Buttons, Switches, Pilot Lights and Joysticks Harmony ranges Motion Control and Robotics Move the machine tooling or the part itself in a controlled, rotary or linear manner. Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 17 164,53 001 Motor circuit breaker, TeSys GV4, 3P, 115A, Icu 50kA, thermal magnetic, Everlink terminals Price Unavailable View Product 002 Contactor, TeSys Deca, 3P(3NO), AC-3/AC-3e, <=440V, 115A, 230V AC 50/60Hz coil, screw clamp terminals R 9 642,90 View Product 003 Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC R 606,49 View Product 004 Auxiliary contact, TeSys GV4, 690VAC, 1 NO/NC R 606,49 View Product 005 Time delay auxiliary contact block, TeSys Deca, 1NO+1NC, on delay 10-180s, front, screw clamp terminals R 2 393,92 View Product 006 Contactor coil, TeSys Deca, LX1D8, 230V AC 50/60Hz for 115 and 150A contactor R 3 914,73 View Product mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric mySchneider eider mySchneider mySchneider mySchneider 25, Schneider Electric mySchneider mySchneider Product Selector Tool This tool is designed to assist you through the product selection process. Try our Product Selector Content Training Installed Base Programs Overview All Projects Project details Project-22 Untitled open Created: 9/3/2025 Last Modified: 9/3/2025 Project Owner: Tshingombe fiston End User Company: Tshingombe engineering BOM Manager Activity Log Documents Add products to Bill of Materials By product reference number # By Excel/CSV file (Download sample template) Error adding products View BOM By product segments / selection tools Programmable controllers and I/Os PLC, PAC, IOs and Power supplies Motor Protection & Control VSD, Soft Starter, Direct Starter and protections Human-machine interfaces HMI panels, controllers, software and Industrial PCs Interface, Safety and Control Relays Electromechanical, Control, Timing and Solid State Relays Enclosures and Accessories Enclosures, thermal management, accessories and cabling Push Buttons, Switches, Pilot Lights and Joysticks Harmony ranges Motion Control and Robotics Move the machine tooling or the part itself in a controlled, rotary or linear manner. Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 261 204,87 001 License, EcoStruxure Control Expert, service pack base, small S, 1 user, node locked, digital license R 14 435,28 View Product 002 License, EcoStruxure Control Expert, with Topology Manager and M580 safety, for XL, node locked, 10 users, digital R 246 769,59 View Product 003 Status Unavailable Price Unavailable View Details mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric Product Selector Tool This tool is designed to assist you through the product selection process. Try our Product Selector Content Training Installed Base Programs Overview All Projects Project details Project-21 Untitled open Created: 9/3/2025 Last Modified: 9/3/2025 Project Owner: Tshingombe fiston End User Company: Tshingombe engineering BOM Manager Activity Log Documents Add products to Bill of Materials By product reference number # By Excel/CSV file (Download sample template) Error adding products View BOM By product segments / selection tools Programmable controllers and I/Os PLC, PAC, IOs and Power supplies Motor Protection & Control VSD, Soft Starter, Direct Starter and protections Human-machine interfaces HMI panels, controllers, software and Industrial PCs Interface, Safety and Control Relays Electromechanical, Control, Timing and Solid State Relays Enclosures and Accessories Enclosures, thermal management, accessories and cabling Push Buttons, Switches, Pilot Lights and Joysticks Harmony ranges Motion Control and Robotics Move the machine tooling or the part itself in a controlled, rotary or linear manner. Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 10 234,04 001 license, EcoStruxure Control Engineering, verification, basic, node locked, 1 shot R 5 582,20 View Details 002 license, EcoStruxure Control Engineering, documentation, basic, node locked, 1 shot R 4 651,84 View Details mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric Product Selector Tool This tool is designed to assist you through the product selection process. Try our Product Selector Content Training Installed Base Programs Overview All Projects Project details Project-20 Untitled open Created: 9/3/2025 Last Modified: 9/3/2025 Project Owner: Tshingombe fiston End User Company: Tshingombe engineering BOM Manager Activity Log Documents Add products to Bill of Materials By product reference number # By Excel/CSV file (Download sample template) Error adding products View BOM By product segments / selection tools Programmable controllers and I/Os PLC, PAC, IOs and Power supplies Motor Protection & Control VSD, Soft Starter, Direct Starter and protections Human-machine interfaces HMI panels, controllers, software and Industrial PCs Interface, Safety and Control Relays Electromechanical, Control, Timing and Solid State Relays Enclosures and Accessories Enclosures, thermal management, accessories and cabling Push Buttons, Switches, Pilot Lights and Joysticks Harmony ranges Motion Control and Robotics Move the machine tooling or the part itself in a controlled, rotary or linear manner. Power Control and Protection Power supplies and transformers Software License Configurator Software License Configurator Bill of Materials Total items selected: 0 Total: R 331 172,31 001 licence, Ecostruxure Automation Expert, standard engineering buildtime, v23 R 65 100,00 View Details 002 license, EcoStruxure Automation Expert, professional engineering, buildtime, v23 R 157 500,00 View Details 003 license, EcoStruxure Automation Expert, standard device runtime, add on, v23 R 378,00 View Details 004 license, EcoStruxure Automation Expert, high availability option, runtime, add on, v23 R 840,00 View Details 005 license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for ATV dPac R 777,00 View Product 006 license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M251, M262 dPAC R 6 216,70 View Product 007 license, EcoStruxure Automation Expert, run time, application, permanent, 1 user, for M580 dPAC R 15 540,00 View Product 008 license, EcoStruxure Automation Expert, run time, application, permannet, 1 user, for M580 dPAC with extensions R 56 448,56 View Product 009 license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony ST6 R 2 625,00 View Product 010 license, EcoStruxure Automation Expert, run time, HMI, permanent, 1 user, for Harmony iPC R 12 600,35 View Product 011 Status Unavailable Price Unavailable View Details mySchneider Terms of Use Privacy Policy Cookie Notice Change your cookie settings ©2025, Schneider Electric mySchneider mySchneider On Mon, Mar 17, 2025 at 11:43 AM tshingombe fiston wrote: Help Settings Project List Project 2025.03.17#17898 Help Project 2025.03.17 Total Count: 1 Project 2025.03.17 ATS22C59S6U soft starter for asynchronous motor, Altistart 22, control 110V, 230 to 575V, 200 to 500hp Datasheet Warning: material list is maintained in your browser's 'local storage'. All information will be lost if you clear/reset your browser cookies. en_US.json 2017/10/19 09:44:14 1 item(s) selected: Help Settings Project List Project 2025.03.17#17898 Help Project 2025.03.17 Total Count: 1 Project 2025.03.17 ATS22C59S6U soft starter for asynchronous motor, Altistart 22, control 110V, 230 to 575V, 200 to 500hp Datasheet Warning: material list is maintained in your browser's 'local storage'. All information will be lost if you clear/reset your browser cookies. en_US.json 2017/10/19 09:44:14 1 item(s) selected:Fundamentals of Health Care Facility Electrical Power Systems Course Outline © 2015 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Course Description With daunting aspects such as ever-changing codes and standards, increasing medical complexity, and dwindling capital budgets, hospitals and health care facilities are among the most challenging building projects. Health care facility electrical systems are complex, difficult to design, expensive to build and subject to a plethora of codes and standards as well as intensely regulated by authorities having jurisdiction over their design and construction. With new medical technologies continuing to arrive on the scene, healthcare facility electrical systems are ever changing. This course provides an introduction to the topic of healthcare facility electrical systems. Course Outline Course Objectives • Recognize the importance of electrical distribution to health care facilities, and how it differs from other types of buildings • Identify the codes, standards and guidelines which govern the design of health care facility electrical systems • Describe the elements of a health care facility's Essential Electrical System Course Content or Material 1) Introduction 2) Different types of health care facilities have differing needs and code requirements for electrical distribution a. Hospitals b. Long-term care facilities c. Ambulatory surgery facilities d. Outpatient therapy facilities e. Outpatient facilities f. Clinics and physician offices 3) The importance of electrical distribution to hospitals a. Life support i. Patients on ventilators ii. General anesthesia b. Medical procedures c. Medical records d. Comfort e. Life Safety (fire safety) i. Illumination of the means of egress f. Without electrical power, a medical facility will close and/or be evacuated. 4) Codes, standards and guidelines a. NFPA 101 Fundamentals of Health Care Facility Electrical Power Systems Course Outline © 2015 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. b. NFPA 99 c. NFPA 110 and 111 d. NFPA 70 e. NFPA 70E i. Electrical safety for those who work on electrical gear f. FGI Guidelines g. CMS h. OSHA 5) Essential Electrical System a. Alternate source of power i. Classification of the emergency power source b. Branches of the essential electrical system i. Example: Type I systems 1. Life Safety Branch 2. Critical Branch 3. Equipment Branch ii. Type 2 and Type 3 systems c. Potential failure points within the essential electrical system 6) Assessing the need for providing an alternate source of power 7) Summary Course Assessment: Test Your Knowledge Course Survey: We Value Your Opinion Leaderboard 2350 points 4732nd 1st level 32nd 4 badges 28th 3 completed courses223rd 3 certificates235th On Mon, Mar 17, 2025 at 11:18 AM tshingombe fiston wrote: 0% completed Rate this course Course rating is 4.76 stars

____ By Language / English Applying Safety Rules Student Duration: 20 minutes Outline: In this course, you will learn how to avoid electrical hazards as a professional by ensuring safety on the job site. You will learn about safety equipments and rules to follow to protect the installation, its users and yourself. You will also learn about some of the fundamental concepts of electricity to better understand its dangers and the importance of product sizing. At the end of this course, you will be able to: - To define principles safety rules - To know standard safety equipment and specific PPE - To memorize gestures and habits to be safe during an intervention To achieve it, you will get access to a composition of materials as procedure block, flashcards, podcasts, interactive images and professional case studies. Have a good journey! This course was made possible thanks to an international collaboration: • Schneider Electric education team ; • Eric Dupont, a teacher affiliated with the French Ministry of National Education ; • ItyCom, a leading provider of digital learning solutions ; • Cécile Lienaux, a graphic designer ; "Electrical equipment should be installed, operated, services or maintained only by qualified electrical maintenance personnel. To the extent permitted by applicable law, no responsibility or liability is assumed by Schneider Electric and its subsidiaries for any type of damages arising out of or in connection with (i) informational content of this course not conforming with or not reaching requirements, expectations or purpose of any person making use thereof, or (ii) any error contained in this course, or (iii) any use, decision, act or omission made or taken on basis of or in reliance on any information contained or referred to in this course." Course content Additional content has been loaded Discover personal protective equipment Top of page Applying safety rules 0% COMPLETE Discover personal protective equipment Practical case Electricity risks Safety rules for working with electrical equipment Test your knowledge Conclusion This lesson is currently unavailable Must pass quiz before continuing: "Test your knowledge" Home Lesson content Discover personal protective equipment Lesson 1 of 6 We are happy to have you with us! To start your safety training, you will learn how to choose the appropriate personal protective equipment in order to reduce the risks of injury and accidents, whether you're at work or at home. Continued Personal Protective Equipment (PPE) What is a Personal Protective Equipment (PPE)? Personal protective equipment (PPE) is an important aspect of electrical safety, as it helps protect workers from electrical hazards. Wearing PPE can help prevent injuries and fatalities due to electrical accidents. It is important for workers to use the appropriate PPE for the task they are performing, and to ensure that it is in good condition and properly maintained. What to wear to be safe during an installation? Here is a list of basic personal protective equipment: Click on each tab below to learn about the different types of personal protective equipment: Protect the upper body. When working on energized systems, do not pull up your sleeves. This equipment is the standard, but it can change depending on the activities. 63% Completed Unstarted Unstarted Unstarted Unstarted Must pass quiz before continuing: "Test your knowledge" Lesson 3 of 6 In this chapter you will learn more about electricity to better understand safety issues. Continued Electricity and its dangers Why is it risky? Electricity is a form of energy resulting from the presence and movement of charged particles, such as electrons. It is a fundamental force of nature that is responsible for lightning, electric currents, and electromagnetic radiation. It is generated by the movement of charged particles. For example, in a battery, chemical reactions create a flow of electrons from the negative terminal to the positive terminal, creating a voltage difference. Electricity can be dangerous: In most businesses and households, the voltage of the electricity and the available electrical current have sufficient power to cause death by electrocution. Even changing a light bulb without first disconnecting the lamp can be dangerous because coming into contact with the "hot", "energized", or "live" part of the outlet could kill a person. Analyzing Reliability in the Data Center Outline Course Description: The growing reliance on information systems that operate 24 hours per day, 7 days per week, has spawned a rapidly growing and developing industry that supplies products and services on demand. The need for these types of information services now reaches into every business office in the world. Unfortunately, events of all kinds including hardware failure, human error, environmental changes, structural failure and external events, can lead to the possibility of unanticipated systems downtime. Modern data centers do not tolerate planned downtime and strive for no outages in a 10-year mission. Data center operations staffs are faced with the dilemma of either downtime as a result of insufficient physical infrastructure, or incurring extensive costs by designing in more redundancies than is necessary. Targeted reliability solutions allow businesses to meet individual requirements of the data center, while minimizing the total cost of ownership. In fact, very high reliability is difficult to attain and redundant hardware is only part of the answer. This course will demonstrate some important performance success factors and overviews best practices for analyzing and optimizing reliability. Course Outline: Learning Objectives At the completion of this course, you will be able to: □□Define key terms associated with analyzing reliability risks □□Identify some common cause failures in the data center □□Describe the benefits of conducting a Probabilistic Risk Assessment (PRA) □□Recognize the reliability advantages of utilizing scalable, modular architecture in the data center Agenda □□Introduction □□Analyzing risk □□Redundancy □□Common cause failures □□Probabilistic Risk Assessment (PRA) □□Case study example □□Summary ©2013 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners.Course Content or Material: 1) Introduction a) Information systems need to operate 24 / 7 b) Growing and developing industry supplies products and services on-demand c) Modern data centers do not tolerate planned downtime and strive for no outages in a 10- year mission d) Data center operations staffs are faced with e) The dilemma of downtime as a result of insufficient physical infrastructure f) Incurring extensive costs by factoring in unnecessary redundancies g) Targeted reliability solutions allow businesses to meet individual requirements of the data center, while minimizing the total cost of ownership 2) Reliability a) Understanding how to best define downtime risk i) Is important to optimizing its reliability ii) Decreases total cost of ownership iii) Increases agility b) Reliability metrics statistically analyze the likelihood of a failure occurring 3) Redundancy a) While redundancy can increase reliability, there are significant costs and potentially serious drawbacks b) A redundant system has more components c) In general, systems with more components will experience more failures 4) Discussing Best Practices a) The design, manufacture, operation, maintenance and repair of equipment b) The gathering of data, and the review and publication of component benchmarking results c) Consistent deployment of the language of reliability, both definitions and assumptions d) A philosophy addressing the constant pursuit of root causes, common cause failures and relevant data 5) Modularity and Component Count a) Reliability can be increased through standardization b) Modularity is a powerful concept c) Modularizing a system can increase the number of internal components d) Reliability analysis of modular systems must consider i) Component design ii) Function iii) Dependencies ©2013 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners.6) Benefits and Drawbacks a) Data center testing and maintenance practices often have a significant impact on systems reliability b) Testing and diagnosis can improve reliability, but may also degrade it 7) UPS: Historical Perspective a) In most UPSs, utility AC power is rectified to DC b) The inverter synthesizes an AC voltage free from the effects of spikes, sags, harmonics, and brief utility outages 8) Assessing Reliability a) Product support engineers i) Track the products' performance in actual use ii) Identify and implement changes necessary to correct deficiencies or defects iii) Benefit from a road map identifying components most likely to fail b) Deviations from the predictions of the road map would identify new areas for more intensive investigation and possible remedial action 9) The Correct Course of Action: PRA a) The process of building the logical model results in a comprehensive review b) The mathematical nature of the calculation limits the logical fallacies that tend to dominate qualitative evaluation of reliability c) The implication is that if N components are required for success, there is one, two, twice as many, or even twice plus one as many units available d) Not all redundancy makes the same contribution to reliability 10) Reliability Assessment Case Study a) The mathematical models that resulted from the analysis were used to answer some key questions b) The scalable, modular system utilizes redundancy in nearly all components as a means of achieving high reliability c) MTechnology, Inc's analysis showed that d) There are both costs and benefits to redundancy e) Some sub-systems benefit less from redundancy than others f) Complex mathematical formulas were utilized to calculate the case study failure rates and common cause failures 11) Case study goals a) To identify potential sources of failure ©2013 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners.b) To evaluate the potential for further improvement in the scalable, modular power system's reliability and availability 12) Target of Case Study Analysis a) Subjects of analysis i) 14 - 40 kW Scalable, modular, rack based power system with PDU and static bypass ii) 500 kW central UPS b) Tools utilized i) Probabilistic Risk Assessment (PRA) ii) Fault tree iii) Event tree analysis iv) Bayesian updating 13) Reliability Assessment Case Study a) All actions have both beneficial and negative affects on reliability b) It helps to support the uptime of the servers but also can represent a point of failure 14) Comparing Modularity to the Central UPS a) The scalable, modular system loses power to all loads only when i) The main entrance bus fails ii) The transfer switch fails to open b) The probability of all 14 scalable, modular units failing simultaneously due to internal failures is extremely low c) PDU failure will cause partial load drop d) Only one circuit breaker after the transfer switch will cause all critical loads to fail 15) Central UPS data a) Battery failure is a significant contributor of failure in central UPS b) The central UPS can fail internally, and bypass can fail, causing all loads to fail c) PDU failure will cause partial load drop 16) Reliability Assessment Case Study: The Findings a) The calculated reliability of the scalable, modular power system is comparable to data published by vendors of large, central UPSs b) The scalable, modular power system is significantly less likely to suffer a complete system failure c) The redundancy provided in the scalable, modular power system definitely improves the product's reliability ©2013 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners.17) Conclusions a) Overall, the scalable, modular architecture had a system failure rate was approximately 40% lower than that of the central UPS system b) Failure is defined as the loss of power for all critical loads c) Discounting battery failures, the scalable, modular failure rate is still approximately 18% less than that of a comparable central UPS architecture d) If failure is defined to include dropping of any single load due to a branch circuit failure, but not UPS failure, the scalable, modular architecture is 6% less likely to fail e) Scalable, modular power system architecture proved more reliable than the single module UPS with a single battery string f) The redundant subsystems within the scalable, modular power system successfully reduced the probability of UPS failure g) The performance of the ATS is often the limiting factor in achieving higher reliability 18) Summary a) Understanding how to best define downtime risk is important to optimizing its reliability, while decreasing TCO and increasing agility b) While redundancy can in principle increase reliability, there are significant costs and potentially serious drawbacks c) Data center professionals need to understand which processes are most critical, and target reliability accordingly d) PRA is a powerful tool when applied carefully Course Assessment: Test Your Knowledge Course Feedback: We Value Your Opinion ©2013 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. An Introduction to Medical Gas and Vacuum Systems Course Outline © 2019 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Course Outline Course Description This course introduces plumbing and medical gas systems for medical treatment facilities. We will discuss the various types of medical gas and vacuum systems used in health care facilities. The chief purpose of these systems is to provide safe and reliable support to the medical mission. Codes and standards are also discussed. Course Objectives • Discuss the purpose of plumbing and medical gas systems for medical treatment facilities • Identify the various types of medical gas and vacuum systems used in health care facilities • Review the important codes and standards used for medical gas and vacuum systems Course Content or Material 1. Introduction a. Introduction to Medical Gas and Vacuum Systems 2. Types of medical gas and vacuum systems a. Medical gas systems i. Oxygen ii. Medical Air iii. Nitrous Oxide iv. Nitrogen v. Carbon Dioxide vi. Mixed Gases vii. Instrument air b. Vacuum Systems c. Medical/Surgical Vacuum d. Waste Anesthetic Gas Disposal e. Dental Vacuum Systems (Tim will write a script) 3. Codes, standards, regulations and authorities having jurisdiction a. NFPA 99 b. FGI Guidelines c. Local or state regulations d. Enforcement i. Certificate of occupancy ii. CMS and accreditation e. ASSE Standards 4. Categories of medical gas and vacuum systems a. Introduction to NFPA 99 Categories b. Category 1 An Introduction to Medical Gas and Vacuum Systems Course Outline © 2019 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. c. Category 2 d. Category 3 Course Assessment: Test Your Knowledge Course Survey: We Value Your Opinion On Mon, Mar 17, 2025 at 10:39 AM tshingombe fiston wrote: ____ We will be conducting system maintenance Sunday March 16, 2025 9:00 p.m.-11:00 p.m. EDT. Please note that you will not be able to login at this time. Course Assessment - Results page 1 2 3 4 5 6 7 8 9 10 Question A/n _____ measures the amount of electrical current flowing through a circuit during a specific time interval. Ampere Volt Ohm Watt Question Materials with _____ resistance require more voltage to make the electricity flow. Lower Higher Slower Faster Question True or false? The electrical load in a data center is the sum of the various pieces of data center equipment which consume and are supplied with electrical power T F Question The power in Watts is the _____ power drawn by the equipment, while Volt-Amps is called the _____ power. Electrical, real Apparent, real Real, apparent Real, solar Question A circuit breaker may need to switch short circuit currents as high as _____ times its rated current. 30 15 10 5 Question Circuit breakers can fail in which of the following ways: Failure to close, or failure to open under fault conditions Spurious trip Failure to operate with the time-current specifications for the unit All of the above Question This form of standby power uses electromagnetism to produce electricity a, Electrochemical generator Battery Fuel cell Mechanical generator Question _____ occur when there is a varying quality of connections to the earth at different points in an electrical installation Ground loops Power factor corrected power supplies Ground Fault Circuit Interrupters Thermal-magnetic circuit breakers Question An approach to solve the problem of impulsive transients includes the utilization of which device? Power Line Conditioners Uninterruptible Power Supply (UPS) Voltage Surge Suppressor (TVSS) Modern harmonic-correction equipment Question According to M Technology, Inc., what percentage of the time are circuit breakers involved in a power system failure in data center electrical infrastructure? 10% 40% 70% 50% Course Assessment - Test Course Assessment ____ Number of questions: 10 Questions are shown: One by one So far you have done this test 1 time Previous unit: Online Course 1.4% completed Lesson Fundamentals of Power Course Overview - Passed Online Course Course Assessment - Current unit Reference Materials Course Transcript Lesson Going Green: Energy Efficiency in the Data Center Course Overview Online Course Course Assessment Course Feedback Reference Materials Course Transcript Lesson Building Controls I: An Introduction to Building Controls Course Overview Online Course Course Assessment Reference Materials Course Transcript Lesson Combined Heat and Power Course Overview Online Course Course Assessment Reference Materials Course Transcript Lesson Compressed Air Systems I: An Introduction Course Overview Online Course Course Assessment Course Feedback Reference Materials Course Transcript Lesson Energy Efficiency with Building Automation Systems I Course Overview Online Course Course Assessment Reference Materials Course Transcript Lesson Energy Procurement I: Options in Regulated and Deregulated Markets Course Overview Online Course Course Assessment Reference Materials Course Transcript Lesson Energy Procurement II: Introduction to Hedging in Deregulated Markets Course Overview Online Course Course Assessment Reference Materials Course Transcript Lesson Energy Procurement III: Balanced Hedging Strategies Course Overview Online Course Course Assessment Reference Materials Course Transcript Lesson Energy Rate Structures I: Concepts and Unit Pricing Course Overview Online Course Course Assessment Reference Materials Course Transcript Lesson Going Green with Leadership in Energy and Environmental Design Course Overview Online Course Course Assessment Reference Materials Course Transcript Lesson Maintenance Best Practices for Energy Efficient Facilities Course Overview Online Course Course Assessment Reference Materials Course Transcript Lesson Steam Systems I: Advantages and Basics of Steam Course Overview Online Course Course Assessment Reference Materials Course Transcript Lesson Waste Heat Recovery Course Overview Online Course Course Assessment Reference Materials Course Transcript Previous unit: Online Course ©2021 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. 16) Calculating Efficiency and Operating Costs a) The technical design of the modular, scalable system results in a much higher efficiency rate running on lightly loaded UPS units b) The Fortune 500 firm in our case study: i) Chooses to implement redundant UPS systems and operates each of them at 40% capacity ii) Chooses the "install as you grow" approach which accounts for the significant differences in energy savings, and therefore, lower electrical bills 17) Total Cost of Ownership a) Capital costs i) Allow for an initial build out of 27 watts per square foot for the first 5 years ii) Assume a build-out to 80 watts per square foot for an additional 5 years b) Electrical costs i) Load levels will be at 80% of 2 (N+1) capacity ii) The maximum loading on any one system is 40% c) Service costs i) Customer requires 7x24 ii) 4 hour response iii) 100% coverage on parts and labor iv) Battery maintenance will not be included 18) Key TCO Components of Payback 19) Summary a) The green data center features a safe and healthy work environment and operates in an energy efficient manner b) Five examples of green approaches in the data center include the proper use of batteries, UPSs, rightsized solutions, cooling management, and alternative energy sources. c) TCO analyses can justify investments in green technologies Course Assessment: Test Your Knowledge Course Feedback: We Valu ©2021 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Fundamentals of Power Outline Course Description Power is the foundational cornerstone in the data center. Many instances of equipment failure, downtime, software and data corruption, are the result of a problematic supply of power. It is imperative that servers are insulated against utility power failures, surges, and other potential electrical problems. This course will explore the topic of power, and how it is utilized within the data center. Course Outline: Learning Objectives • Identify basic electricity concepts • Describe electrical power and its generation • Differentiate between various power usages in a data center • Define power factor • Recognize the importance of electrical safety measures in a data center • Identify potential problem areas in the data center Agenda • Electrical power key terms • AC and DC power • Power factor • Volt configurations, plugs and receptacles • Circuit breakers and convenience outlets • Seven common electrical problems • Components in a data center Introduction 1) Key Terms a) Volt (V) b) Ampere (Amp) c) Ohm (Ω) d) Hertz (Hz) e) Alternating Current (AC) f) Direct Current (DC) g) Load 2) Single-phase and 3-phase Power 3) Watts and Volt-Amps ©2021 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. 4) Power Factor Correction a) Power factor of nearly 1 b) Method of offsetting inefficiencies created by electrical loads 5) Plugs and Receptacles a) The most common plug/receptacle combination for IT equipment is of an IEC design b) Also common are plugs and receptacles of the twist lock variety 6) International Electro-technical Commission Plugs 7) National Electric Manufacturers Association Plugs 8) Circuit Breakers a) A type of switch b) Designed to protect electrical equipment from damage caused by overload or short circuit c) Designed to trip at a given current level 9) Circuit Breaker Protection 10) Circuit Breaker Sizing 11) GFCI, ELCB, and RCD a) Ground Fault Circuit Interrupters (GFCI), Earth Leakage Circuit Breakers (ELCI), or Residual-Current Devices (RCD) trip a circuit if they detect a small amount of ground current b) Larger data centers use resistor banks instead of GFCI, ELCB, or RCD 12) Convenience Outlets a) Used for non-computer devices b) Allows for other non-computer equipment to be plugged in without taxing the critical load 13) Grounding a) Safety measure to protect against electric shock 14) 7 Power Problems a) Impulsive Transients b) Interruptions c) Sags and Undervoltages d) Swells and Overvoltages e) Waveform Distortion f) Voltage Fluctuations g) Power Frequency Variation 15) Standby Power and Distribution ©2021 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. a) Any power source available to the data center that supplies power when utility power is unavailable 16) Power Distribution Components a) Primary power source (Utility) b) Emergency power source (Generator) c) Circuit/Branch Circuit d) Uninterruptible Power Supply (UPS) e) Automatic Transfer Switch f) Power Distribution Units (PDU) g) Outlet Strips h) Server Plug 17) Summary a) Power infrastructure is critical to uptime b) Understanding basic power terms helps to better evaluate the interaction between the utility, standby power equipment, and load c) Failures can occur at various points in the power infrastructure, but special care should be given to the condition and coordination of circuit breakers d) Numerous power anomalies exist that can impact the uptime of data center equipment e) Understanding the threats and applying practical power solutions can help to minimize risk Course Assessment: Test Your Knowledge Course Feedback: We Value Your Opinion©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. i. The controlling variable is affected by the actions of the controlled device upon the controlled variable c. Cascading i. Used to modify the performance of closed control loops when required 5) Red Wire & Direct Digital Controls a. DDC i. More sophisticated system ii. Use electronic controllers that support multiple control loops b. Enable / disable control i. Another form of electronic control ii. Simply turns another controller on or off iii. One controller will determine when another controller is able to perform its function 6) Summary a. For an environmental control system to effectively manage the environment in a building, thereby increasing energy efficiency and occupant comfort, three things must take place: i. Data must be measured and provided as input to the system ii. Measured data then can be compared to a set of desired outcomes or instructions iii. An output is produced based on the measured data to change or maintain the environment b. A simple control loop is defined as one input to a controller housing the control logic, which provides an output to one controlled device c. Inputs and outputs may be analog or digital d. A controller may contain many control loops, and a control system may contain many controllers e. There are three types of control loops i. Open ii. Closed iii. Cascading f. And there are three common control technologies i. Pneumatic ii. Electrical, and iii. Electronic g. Electronic controls may be i. Direct Digital Control, called DDC, or ii. Enable / Disable Contro©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Combined Heat and Power (Cogeneration) Course Description: Cogeneration today is widely used throughout the world for efficient production of heat and power. Cogeneration is the simultaneous production of heat and power in a single thermodynamic process. The purpose of this course is to review the different approaches for applying technologies to the function of cogeneration. We'll also explore the various issues and considerations for deployment of the two main types of cogeneration concepts: "Topping Cycle" plants (including "Combined Cycle" plants), and "Bottoming Cycle" plants. Pre-Requisites for this course include: Energy Rate Structures I and II. Learning Objectives: At the completion of this course, you will be able to: • Define what cogeneration is along with the primary fuels used in its creation • Identify the different approaches for applying technology to the function of cogeneration • Discuss the various factors to consider when evaluating the use of a CHP plant Course Content or Material 1) Introduction a) Technology overview b) Defining "cogeneration" i) How cogeneration occurs ii) Primary fuels used 2) Two main approaches for cogeneration technology applications a) Topping Cycle plants (including Combined Cycle plants) i) Examples ii) Overview b) Bottoming Cycle Plants i) Examples ii) Overview 3) Environmental Issues a) Benefits b) Concerns 4) Things to Consider When Applying CHP Plant a) Steam load versus electric load b) Capital utilization / productivity c) Reliability requirements (steam and electric) d) Local electricity rates e) Efficiency gains versus fuel prices f) Fuel availability and selection g) Staffing and training 5) Comparing CHP Technologies a) Diesel engine b) Natural gas engine c) Steam Turbine d) Gas Turbine©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Compressed Air Systems I: An Introduction Course Description Compressed air is widely used throughout industry. It is sometimes called the "fourth utility", after electricity, gas and water. From mining, lumber and paper mills, petroleum, chemical, textile and glass production to small manufacturing plants and hotels, compressed air provides critical services and can often represent the majority of the facility energy costs. Since many facilities cannot function without compressed air, reliability is paramount, but given that sound operating practices can reduce energy consumption by 20% to 50%, efficiency is high on the agenda. This is the first in a series of compressed air system courses offered by Energy University. In this course, we will look at the relative inefficiency of compressed air and examine the components of a compressed air system. Course Outline Course Objectives Objectives • Explain basic compressed air terms and concepts • Describe the relative inefficiency of compressed air as a power source • Define the supply and demand sides of a compressed air system and • Identify the components of a compressed air system and explain what they do Course Content or Material 1) Introduction 2) Supply & Demand a. Divided into a supply side and a demand side 3) Compressed Air Pros & Cons 4) Compressed Air Inefficiency Examples a. Metric Unit Example b. US Customary Unit Example 5) Compressed Air Systems Optimization a. The efficiency of compressed air systems typically receives little attention i. Systems are not well understood by plant operations staff ii. Modifying a system is perceived as a risk to production iii. Vendors compete in a market where equipment is typically sold on a "lowest first bid", without regard for the cost of operation b. Optimization leads to i. Reduced costs ii. Reduced maintenance iii. Less downtime iv. Increased production v. Improved product quality 6) Equipment Descriptions a. Fan b. Blower c. Compressor 7) Pressure Terminology ©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. a. Pressure b. Absolute Pressure c. Gauge Pressure 8) Standard Volume of Air a. Metric b. US Customary 9) Volume Flow a. Inlet flow b. Actual flow c. FAD d. Standard flow e. Capacity 10) Operating cost a. Proportional to volume b. Proportional to pressure ratio 11) Dew Point a. The temperature at which condensation begins to occur 12) Compressed Air Requirements a. Cleanliness b. Dryness c. Oil content 13) Compressed Air System Components a. Interactive element 14) Summary a. Basic compressed air terms and concepts; b. Compressed air as a source of power is relatively inefficient. However, it can be very useful and necessary at times; c. Compressed air systems are normally broken down into supply and demand side components; d. You should now be able to identify basic components of a compressed air system and explain what they do©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Energy Efficiency with Building Automation Systems Part 1 Course description: In this course we will focus on what a building automation system (BAS) is as well as some of the commonly used terminology. We will also look at some of the HVAC strategies used in building automation systems. Course Outline: Learning objectives At the completion of this course you will be able to: • Define what a building automation system is • Review the main terminology and components of a Building Automation System and HVAC system • List the most common HVAC strategies that may be controlled by a Building Automation System Course content or material 1) Introduction a. What is building automation b. What are the functions of building automation systems (BAS) 2) Parts of a BAS 3) Terminology a. Set point b. Air 4) Review of HVAC systems a. Equipment i. Air handling unit ii. Chiller iii. Cooling tower iv. Flow controller v. Boiler vi. Dual duct vii. Constant volume/variable temperature viii. Variable air volume ix. Terminal reheat©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Energy Procurement I Course Description: The procurement of energy (electricity, natural gas, fuel oil, etc.) is becoming a major part of the energy manager's job. Cost effective energy procurement requires understanding of the market, regulatory limitations and opportunities, and contingency planning. The purpose of this course is to raise awareness of the available options for energy procurement. Learning Objectives: • Define the roles of the main players in the energy supply chain • Explain the major differences in regulated and deregulated markets • List the main options available for optimizing energy procurement Course Content or Material: 1) Introduction 2) Types of Energy Typically Procured a) Most common electricity and natural gas b) Coal, Oil-based fuels, Steam, Compressed air 3) Energy Supply Chain a) Production, Transmission, Distribution, Supply b) Gas supply chain c) Electricity supply chain 4) Regulated and deregulated markets a) Regulated Markets b) De-regulated Markets c) Wholesale versus Retail d) Equal access to transmission and distribution e) Drivers of Deregulation f) Pricing i) in a regulated market ii) in a deregulated market g) Options in a regulated market i) Natural gas contracts ii) Power contracts h) Options in a deregulated market i) Supplier Options i) Local distributor ii) Gas or power marketers iii) Brokers iv) LDC Marketing Departments v) Aggregator vi) Power Pool and Exchange Operators vii) Overview of Supplier Options viii) Pipeline Connects for Large Consumers 5) Procurement pitfalls a) Exposure to energy price volatility that has not been identified or quantified b) Energy that is managed locally with no corporate oversight c) Procurement decisions that are made by personnel without knowledge of the energy market d) Contracts renewed based on expiration, not market conditions ©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. e) Contract renewals that embed long term risk premiums to vendors f) A conviction that hedging is speculative in nature 6) Deregulation Growing and Prices are Volatile a) Hedging b) Avoiding pitfalls of lowest price and highest risk©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Energy Procurement II Course Description: Unprecedented volatility in today's energy markets has wreaked havoc on the profit margins and bottom lines of many industrial companies. In order to successfully manage costs in this market, it is critical to apply commodity-based market purchasing strategies—or as it is commonly known in the industry: "hedging". Energy price risk management and hedging programs quantify exposure to adverse events and mitigate the impact of those events on financial results. An on-going Energy Risk Management program can provide for more predictable budgeting and insulate future earnings from the unpredictable effects of volatile energy prices. The purpose of this course is to address the hedging process. We will also cover the spot and forward markets as well as fixed and index linked contracts. Pre-requisites: Energy Procurement I: Options in Regulated and Deregulated Markets. Learning Objectives: At the completion of this course, you will be able to: • Explain the difference between spot and forward markets • Describe how hedging reduces your risk, and you will be able to • Define the meaning of fixed and index-linked contracts Course Content or Material 1) Introduction a) Brief overview of gas and electricity markets b) Energy procurement 2) Procurement Pitfalls a) Common pitfalls in a deregulated market b) How energy managers remedy common errors in energy procurement 3) Commodity Markets for Energy a) Commodity exchanges i. The New York Mercantile Exchange (NYMEX) ii. The Singapore Commodity Exchange (SICOM) iii. The former International Petroleum Exchange (IPE) based in London is now part of Intercontinental Exchange (ICE) iv. Over The Counter b) Energy buyer options i. Spot market ii. Forward market i. Fixed contract ii. Index-linked contract 4) Determining Energy Prices a) Total energy costs b) Regulated cost components c) Commodity-based market purchasing strategies ©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. 5) Avoiding Pitfalls of Lowest Price and Highest Risk a) Define energy purchasing strategy i) Spot purchasing versus fixed price purchasing ii) Hedging 6) Implementing Hedging a) Forward contracts b) Futures market c) Flattening a position d) Trading forward contracts e) Permutations f) Contract expiration g) Imbalances upon delivery 7) Hedging Examples a) Hedging on the forward market b) Settling contracts on the spot market 8) Fundamental Concept of Hedging a) Shaves off the extremes b) Provides predictability 9) Adopting a Balanced Approach to Hedging a) Full requirements fixed-price b) Partial fixed-price c) Partial spot market d) Staggered fixed-price commitments©2021 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Energy Procurement III: Balanced Hedging Strategies Course Description: Managing energy costs is the key to a successful profit margin and bottom line for many industrial companies. In order to successfully manage costs in this market, it is helpful to apply a balanced hedging strategy. A balanced hedging approach will quantify exposure to adverse events and mitigate the impact of those events on financial results. The purpose of this course is to describe a variety of hedging strategies, and identify the main drivers of energy prices. We will also cover how the commodity market functions to support energy trading. Pre-requisites: Energy Procurement I and Energy Procurement II. Learning Objectives: At the completion of this course, you will be able to: • Describe a variety of balanced hedging strategies • List the main drivers of energy price • Describe how commodity markets function to support energy trading Course Content or Material 1) Adopt a Balanced Hedging Strategy a) Brief overview of concepts covered in Energy Procurement II i) Full requirements fixed-price ii) Partial fixed-price iii) Partial spot market iv) Staggered fixed-price commitments b) Determination requirements i) Commitment term ii) Tolerable price levels iii) Range of tolerable cost fluctuation and iv) Minimum/maximum time horizons for making the next commitment v) Plan of action to mitigate damage for when prices change rapidly 2) Risk Tolerance a) Definition of hedge ratio b) Defining risk tolerance 3) Defining a Hedge Ratio and Strategy a) Riverbanks analogy b) Examples of hedge ratio and energy purchasing strategies 4) Exchange Operation a) How commodity exchanges function b) Commodity exchange regulation c) Commodity-based market purchasing strategies 5) Terms and Mechanisms a) The short position – which means you are agreeing to sell b) The long position – which means you are agreeing to buy c) The price of the contract d) The daily account adjustment ©2021 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. e) The final settle price f) The strip g) Futures market versus the stock market h) Final settle 6) Drivers of Energy Prices a) Supply b) Demand c) Seasonality d) News and Rumors e) Speculators 7) Commodity Risk Analysis a) Role of gas and power marketers b) Role of independent market analysis service providers 8) The Forward Curve a) Definition b) Examples 9) Price Forcasting a) Definition b) Examples 10) Other Procurement Considerations a) Price, dependability and service b) Importance of considering 11) Best Practices a) Integrates on a continual basis i) Data ii) Risk management iii) Procurement b) Employs i) Data driven decisions ii) Management approach that identifies and quantifies risk before determining the best way to manage it iii) Procurement optimisation with operations 12) Summary 10) Summary ©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Energy Rate Structures Part 1: Concepts and Unit Pricing Course description: Understanding the forms of energy used at a facility, and the rate structure for each, is key to understanding energy costs and implementing an energy efficiency program. By understanding what you are paying for energy, and how the rate structure controls your bill, you can adopt different strategies for reducing your energy costs. You may even be able to move to a different rate structure that is more cost effective for you. In this course, we will focus primarily on gas and electricity concepts and unit pricing. Course Outline: Learning objectives At the completion of this course you will be able to: • Define and recognize the difference between consumption and demand • Identify different forms of energy pricing including • flat rates, block rates, seasonal pricing, time of use rates, and real time pricing Course content or material 1) Introduction a. Understanding different forms of energy 2) Consumption and Demand a. Difference between consumption and demand b. Example 3) Energy Pricing a. Types of energy pricing i. Flat rate ii. Block rate 1. Declining 2. Inverted iii. Seasonal rates iv. Time-of-Use rates 1. On-peak 2. Off-peak 3. Shoulder/Mid-peak v. Time of use rates vi. Real Time Pricing vii. Other forms of pricing©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Going Green with Leadership in Energy and Environmental Design Course Outline Course Description: This course defines green buildings, explains the mission of the US Green Building Council and the requirements of the Leadership in Energy and Environmental Design (LEED) rating system. Schneider Electric solutions for meeting the LEED requirements will also be explained. Course Outline: Learning Objectives At the completion of this course, you will be able to: • Define the characteristics of Green Buildings • Explain the mission of the US Green Building Council • Identify the Leadership in Energy and Environmental Design rating system • Describe Schneider Electric products and services which satisfy LEED requirements Agenda • Introduction • Impacts of US Buildings on the Environment • Advantages of building green • Review the Mission of the US Green Building Council • Discuss the LEED rating system • Discuss Schneider Electric products and services that satisfy LEED requirements • Introduce Case Studies • Summary Course Content or Material 1) Introduction a) Green Building b) Design of Leadership in Energy and Environmental Design (LEED) c) Who makes up the LEED team d) LEED reach e) Point of the LEED point based system f) Why is there a demand 2) Impacts of US Buildings on the Environment a) Impacts of US buildings on resources b) US Energy Consumption c) US Electricity Consumption 3) Advantages of Building Green ©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. a) Demand for Green Building b) Perceived Business Benefits c) Predictions in growth of Green d) Next Generations impact of perceptions of green build 4) Mission of USGBC a) Mission statement for USGBC b) What the USGBC does c) Membership 5) LEED Rating System a) LEED addresses complete lifecycle of buildings b) 4 Levels of LEED c) 6 Credit Categories d) Steps to LEED Certification e) A sample checklist f) Available resources on line 6) Schneider Electric products and services that satisfy LEED requirements a) Maximizing LEED points b) Building Automation and Control c) Critical Power and Cooling d) Engineering Services e) Field Services f) Lighting and Lighting Controls g) Power monitoring h) Variable Frequency Drives i) Renewable Energy Systems j) Available Solutions for Compliance 7) Case Studies a) Great River Energy Headquarters b) Genzyme Center c) Duke Universtiy Smart Home©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Maintenance Best Practices for Energy Efficient Facilities Course Outline Course Description Good maintenance saves energy costs! Properly maintained facilities and equipment produce quality products, reduce downtime and have lower energy costs. This adds up to real money! This course will address the importance of maintenance in facilities, discuss the savings proper maintenance can contribute, and identify techniques that can lead to the energy efficient maintenance of facilities. Course Outline Course Objectives • List organizational problems that lead to inadequate maintenance • Identify the characteristics of an effective maintenance system • List examples of energy efficiency costs caused by insufficient maintenance • Calculate the energy costs associated with various types of maintenance failure (eg in compressed air, steam, etc) • Identify simple ways that infrared, vibration analysis, and ultrasonic surveys can contribute to identifying maintenance needs Course Content or Material 1) Introduction 2) Organizational problems i) Common maintenance problem areas (1) Lack of work order system (2) Poor reporting of work orders / problems (3) Poor analysis of work orders – (Pareto analysis) (4) Inadequate preventative maintenance program (5) Inadequate maintenance training (6) Poor control of maintenance efforts (7) Lack of management attention 3) Characteristics of an effective maintenance system i) Bring discipline to the maintenance process by ensuring • Definition of responsibilities • Adequate training • Sufficient tools and equipment • Clear procedures, including evaluation of results, and an emphasis on identifying and reinforcing best practices ii) These systems can be simple, manual arrangements, or they can include capability for inputs from sensors such as differential pressure across filters, equipment temperatures and vibration iii) In either case, there are basic requirements for a work order system, work order analysis, generation of maintenance orders, and performance records of equipment. 4) Examples of energy efficiency costs i) Steam leaks ii) Steam trap failures iii) Compressed air leaks ©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. iv) Uninsulated pipes 5) Tables and charts – Calculating the cost 6) Steam Systems The steam system maintenance should include: Steam Trap Survey and Repair Leak Repair Insulation Repair 7) Compressed Air Systems i) An efficient compressed Air System must include a regularly scheduled ultrasonic leak survey for air leaks. 8) Lighting . Once your solution is defined, your maintenance program should cover: (a) Cleaning (b) Relamping (c) Monitoring compliance with expectations (d) Maintaining standard IESNA light levels 9) Motors a) Use Premium Energy Efficient motors where possible particularly for replacement of failed motors b) Use Variable Speed or Variable Frequency drives c) Use cogged belts or synchronous belts i) Properly align motors and drives (1) Use laser alignment tools for both direct drive and belt drives (a) This step is crucial to extend motor life. (i) Design motor bases for easy adjustment 10) Ultrasonic, Infrared and Vibration Analysis In the last section of this class, let's look at some specific tools and techniques and see how they can be usefully applied to the energy-efficiency maintenance of the systems we have been discussing a) Ultrasonic Leak detectors i) Air leaks (1) Survey for air leaks during full production periods ii) Steam Traps (1) Survey steam traps during winter heating season iii) Specialty gas leaks – especially for high cost gases – Nitrogen, Argon, Carbon Dioxide iv) Vacuum system leaks v) Duct work Leakage– particularly insulated duct work vi) ID and FD fan duct leakage – particularly behind insulation blankets vii) Can be used in some production leak testing processes b) Infrared i) Infrared inspection equipment is widely available and is astonishing cheap ii) Electrical gear inspection iii) Insulation hot spots ©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. iv) Roof inspections - Aerial Infrared inspection is a cheap effective method of built up roof inspection especially identifying leak points / saturated insulation v) Boiler Lagging / Flue Gas Leaks (1) Infrared inspection can determine point where the leak starts. c) Vibration Analysis i) Motors and Bearings (1) Motor / Drive bases should have a mass that is 3 times the mass of the rotating element. Concrete is a cheap method of adding mass. ii) Fans (1) Always dynamically balance fans in place upon installation. Although fans are balanced at the factory, it is common for fans to become damaged and or out of balance during shipment or installation. iii) Production machinery (1) Vibration problems usually have one of three solutions - increase mass of the machinery, increase rigidity of the machinery, or dynamically balance the rotating element. Any or all of these methods can be used to reduce or control vibration. iv) Vibration problems once resolved usually cease to be a problem. v) Large rotating machinery – Often include vibration sensors for continuous condition monitoring Course Assessment: Test Your Knowledge Course Survey: We Value Your Opinion©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Steam Systems I: Advantages and Basics of Steam Course description: Steam has come a long way from its traditional associations with locomotives and the Industrial Revolution. Today, it serves as an integral and essential part of modern technology. This course will introduce the benefits of utilizing steam in numerous processes and discuss t selecting the appropriate pressures for each of these different processes. Course Outline: Learning objectives At the completion of this course you will be able to: ● List the advantages of steam ● Describe the formation of steam ● Understand the relationship between pressure, temperature, and energy Course content or material 1) Introduction a. Advantages of steam b. What is steam c. Definitions i. Joules ii. BTUs iii. Temperature iv. Saturation v. Enthalpy vi. Absolute pressure vii. Gauge pressure viii. Differential pressure ix. Sensible heat x. Latent heat xi. Total heat 2) Formation of Steam a. How steam is created b. Heat energy transfer i. Example c. How a boiler makes steam 3) Relationship between pressure, tem©2023 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Waste Heat Recovery Course Description: Waste heat is present in almost all industries and processes. Opportunities exist to put this waste heat to use economically in order to reduce the energy consumption in the plant. The purpose of this course is to identify opportunities to recover waste heat, and the equipment used to recover waste heat. The process for calculating waste heat recovery will also be addressed, along with the factors that influence the feasibility of waste heat recovery. Learning Objectives: At the completion of this course, you will be able to: • List the factors that influence the feasibility of waste heat recovery • Identify opportunities to recover waste heat, the temperature ranges of heat recovered and the possible uses • Perform calculations of waste heat recovery • Categorize and explain the general operation of the main equipment used to recover waste heat Course Content or Material 1) Introduction 2) Benefits of Waste Heat Recovery a) Direct benefits i) Reduced energy consumption ii) Consequent increase in energy efficiency b) Indirect benefits i) Reduction in pollution ii) Reduction in equipment size iii) Reduction in auxiliary energy consumption 3) Factors Influencing Waste Heat Recovery Feasibility a) Sufficient quantity b) Sufficient quality c) Used economically d) Location e) Availability f) Compatibility g) Concerns h) Limits on heat recovery 4) Waste Heat a) Quality i) Dependent upon the temperature of waste heat available ii) Economic recovery would depend upon following factors: b) Quantity Of Waste Heat i) Quantity of heat (in kcal) = V x ρ x Cp x Δt c) Typical Sources Of Waste Heat i) Heat in waste gases from industrial processes (High temperature) ii) Combustion flue gas (Medium temperature) iii) Low temperature heat recovery ©2023 Schneider Electric. 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All trademarks provided are the property of their respective owners. iv) Other sources of waste heat d) Uses of Waste Heat i) Waste heat can be put to use depending upon the type of plant and category of heat available particularly with relation to temperature and quantity ii) Pre heating of combustion air: iii) Pre heating of boiler feed water: iv) Vapour Absorption Refrigeration: v) Pre heating for process requirements: 5) Development Of Waste Heat Recovery System a) Compatibility of waste heat quality: b) Scheduling: c) Location 6) Waste Heat Recovery Devices a) Recuperators b) Economizers c) Waste heat boilers d) Heat pumps e) Regenerators f) Heat Wheels g) Heat Pipes h) Other Waste Heat Recovery Devices 7) Sources and Utilization of Waste Heat Summary Chart 8) Matrix of Waste Heat Recovery Devices/Applications 9) Calculating Waste Heat Recovery a) Overview b) Case Study Examples 10) Summary Course Assessment: Test Your Knowledge Course Survey: We Value Your Opinionperature, and energy 4) Summary d) Schneider Electric and LEEDs 8) Summary 4) Summary 7) Summary 5) Summary e) Micro-turbine f) Fuel cells 6) Summary Skip to main content My Courses Tshingombe fiston (tshingombefiston@gmail.com) ____ Tshingombe fiston Learner | tshingombefiston@gmail.com Signins / Completions USER SINCE 16 Mar, 2025 Last login: 37 minutes ago ____ COMPLETED COURSES 0 / 2 PASSED TESTS 0 / 14 CEUs 0 / 0 CERTIFICATES 0 POINTS 550 Change your cookie settings — 550 On Sun, Mar 16, 2025 at 1:43 PM tshingombe fiston wrote: ©2021 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. Fundamentals of Power Outline Course Description Power is the foundational cornerstone in the data center. Many instances of equipment failure, downtime, software and data corruption, are the result of a problematic supply of power. It is imperative that servers are insulated against utility power failures, surges, and other potential electrical problems. This course will explore the topic of power, and how it is utilized within the data center. Course Outline: Learning Objectives • Identify basic electricity concepts • Describe electrical power and its generation • Differentiate between various power usages in a data center • Define power factor • Recognize the importance of electrical safety measures in a data center • Identify potential problem areas in the data center Agenda • Electrical power key terms • AC and DC power • Power factor • Volt configurations, plugs and receptacles • Circuit breakers and convenience outlets • Seven common electrical problems • Components in a data center Introduction 1) Key Terms a) Volt (V) b) Ampere (Amp) c) Ohm (Ω) d) Hertz (Hz) e) Alternating Current (AC) f) Direct Current (DC) g) Load 2) Single-phase and 3-phase Power 3) Watts and Volt-Amps ©2021 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. 4) Power Factor Correction a) Power factor of nearly 1 b) Method of offsetting inefficiencies created by electrical loads 5) Plugs and Receptacles a) The most common plug/receptacle combination for IT equipment is of an IEC design b) Also common are plugs and receptacles of the twist lock variety 6) International Electro-technical Commission Plugs 7) National Electric Manufacturers Association Plugs 8) Circuit Breakers a) A type of switch b) Designed to protect electrical equipment from damage caused by overload or short circuit c) Designed to trip at a given current level 9) Circuit Breaker Protection 10) Circuit Breaker Sizing 11) GFCI, ELCB, and RCD a) Ground Fault Circuit Interrupters (GFCI), Earth Leakage Circuit Breakers (ELCI), or Residual-Current Devices (RCD) trip a circuit if they detect a small amount of ground current b) Larger data centers use resistor banks instead of GFCI, ELCB, or RCD 12) Convenience Outlets a) Used for non-computer devices b) Allows for other non-computer equipment to be plugged in without taxing the critical load 13) Grounding a) Safety measure to protect against electric shock 14) 7 Power Problems a) Impulsive Transients b) Interruptions c) Sags and Undervoltages d) Swells and Overvoltages e) Waveform Distortion f) Voltage Fluctuations g) Power Frequency Variation 15) Standby Power and Distribution ©2021 Schneider Electric. All rights reserved. All trademarks provided are the property of their respective owners. a) Any power source available to the data center that supplies power when utility power is unavailable 16) Power Distribution Components a) Primary power source (Utility) b) Emergency power source (Generator) c) Circuit/Branch Circuit d) Uninterruptible Power Supply (UPS) e) Automatic Transfer Switch f) Power Distribution Units (PDU) g) Outlet Strips h) Server Plug 17) Summary a) Power infrastructure is critical to uptime b) Understanding basic power terms helps to better evaluate the interaction between the utility, standby power equipment, and load c) Failures can occur at various points in the power infrastructure, but special care should be given to the condition and coordination of circuit breakers d) Numerous power anomalies exist that can impact the uptime of data center equipment e) Understanding the threats and applying practical power solutions can help to minimize risk Course Assessment: Test Your Knowledge Course Feedback: We Value Your Opinion On Sun, Mar 16, 2025 at 1:38 PM tshingombe fiston wrote: Skip to main content My Courses Course catalog System Maintenance: Sunday March 3/16 Time: 9pm-11pm EDT ____ We will be conducting system maintenance Sunday March 16, 2025 9:00 p.m.-11:00 p.m. EDT. Please note that you will not be able to login at this time. By Language / English A Comparison of AC and DC Power Distribution in the Data Center (DC0014EN) Course rating is 4.559724828017511 stars By Language / English A Four-Step Path to a Comprehensive Energy Management Action Plan Course rating is 4.49519890260631 stars Uncategorized Abbott Laboratories Energy Efficiency Development Path Course rating is 4.434782608695652 stars By Language / English Accor Energy Awareness Modules Course rating is 4.595744680851064 stars By Language / English Active Energy Efficiency Using Speed Control Course rating is 4.63265306122449 stars By Language / English AI-Driven Data Centers: Revolutionizing Decarbonization Strategies Course rating is 4.535714285714286 stars By Language / German Aktive Energieeffizienz durch Drehzahlregelung Course rating is 4.571428571428571 stars By Language / English Allergan-GENIUS Team Lead Advanced Training Course rating is 4.666666666666667 stars By Language / English Allergan-GENIUS Team Lead Basic Training Course rating is 4.625 stars By Language / English Allergan-Site Energy Team Member Training Course rating is 4.954545454545454 stars By Language / English Alternative Power Generation Technologies (DC0003EN) Course rating is 4.5764944275582575 stars By Language / English American Hotel & Lodging Educational Institute Course rating is 4.866666666666666 stars By Language / English An Introduction to Medical Gas and Vacuum Systems (HC0015) Healthcare Course rating is 4.6521739130434785 stars By Language / English An Overview of Data Center Physical Infrastructure (DC0004EN) Course rating is 4.717684377478192 stars By Language / French Analyse financière des projets I Course rating is 4.607843137254902 stars By Language / English Analyzing Reliability in the Data Center (DC0005EN) Course rating is 4.670731707317073 stars By Language / Brazilian Portuguese Análise Financeira de Projetos I Course rating is 4.655737704918033 stars By Language / Spanish Aplicación de las normas de seguridad - AEA Standards (YT00014SP) Course rating is 4.8 stars By Language / Spanish Aplicación de las normas de seguridad: México (YT00032ES) Course rating is 4 stars By Language / Brazilian Portuguese Aplicando regras de segurança (YT00026BP) Course rating is 5 stars By Language / French Application des règles de sécurité (YT00022FR) Course rating is 5 stars By Language / English Applying Safety Rules (YT00001EN) Student Course rating is 4.764444444444444 stars By Language / French Approvisionnement en énergie I Course rating is 4.295454545454546 stars By Language / French Approvisionnement en énergie II Course rating is 4.636363636363637 stars By Language / Spanish Aprender los fundamentos de la electricidad (YT00019ES) Course rating is 4.631578947368421 stars Course Catalog College of Data Center College of Energy Efficiency Youth Impact Through Learning Courses by Topic Resources Courses by Language auf Deutsch Brasileira In English en Espanol en FranÃ§ais Nederlands nell'Italiano PÑƒÑ Ñ ÐºÐ¸Ð¹ TÃ¼rkÃ§e Ø§Ù„Ø¹Ø±Ø¨ÙŠØ© ä¸¬å›½ç®€åŒ– æ—¥æœ¬èªž í•œêµì–´ à¸ à¸²à¸©à¸²à¹„à¸—à¸¢ Filter Change your cookie settings 25 On Sun, Mar 16, 2025 at 1:26 PM tshingombe fiston wrote: re eaton warenty Inbox tshingombe fiston Wed, Mar 12, 1:51 PM (5 days ago) to me Self-service warranty portal Dealers can now submit outside of OEM warranty Direct Pay Claims online and run reports to track claim activity. Click here for help with the warranty portal Log in to the portal Follow this step-by-step process for accurate warranty claim submission. This easy to follow flowchart can help guide you through the warranty claim process. 1. Collect Information Document and verify driver complaint For automated transmissions, complete Driver Questionnaire Document the component model, serial number, VIN, mileage, and in-service data Automated transmission driver questionnaire (PDF 180 KB) RRCC0012 2. Determine Warranty Coverage Confirm OEM system coverage Beyond OEM coverage, determine if additional Eaton Standard or Extended coverage applies by using the "What's My Warranty" tool Refer to Eaton Warranty Guide (TCWY0900) for additional information. Document vehicle vocation Document if covered by extended protection plan 3. Pre-Repair Support Save time on overall repair by using an alternative to calling the Roadranger Call Center Review the Warranty Repair Guidelines and the Warranty Pre-Authorized Repair Guidelines (If failure meets criteria for preauthorized warranty repair, follow published repair guidelines. No further Eaton contact is required to file a claim or guarantee payment.) NOTE: Roadranger Automated Call Center is available to all dealers. Real-Time Warranty (RTW) for Manual Transmission and Clutch is restricted to authorized dealers only. RTW is an optional program and NOT required for any warranty claim. Reasons to call during pre-repair support Additional technical assistance is required. Unclear diagnostics and troubleshooting In either case above, the dealer must have the following key information available prior to calling. it will be requested by the Call Center or RTW agent. All Calls - Pre-Call Checklist which includes VIN, component serial number, mileage at the time of failure. Automated Transmission component - Automated component Driver Questionnaire plus Pre-Call Checklist. Automated transmission driver questionnaire (PDF 180 KB) RRCC0012 Pre-Call Checklists Clutch pre-call checklist (PDF 189 KB) RRCC-0013 Automated transmission pre-call checklist (PDF 1 MB) Mechanical transmission pre-call checklist (PDF 43 KB) RRCC0017 1. Troubleshoot Failure and Perform Diagnostics Review the available tools InfoRanger (Electronic Parts Catalog) Troubleshooting Manuals, Service Manuals, Service Bulletins can be found on the product page on Eaton.com or by using the search tool at the top of this page. Example: "manual transmission service manual" or "TRSM 0970". Roadranger Warranty Manual (TCWY0600) (see Important Sections: Replacement Guidelines, Limits and Exclusions, and Other Important Information) 2. Form Repair Plan Verify the complaint (may include visual inspection and/or performance verification) Review vehicle/component repair history in OEM system Identify the root cause of failure to determine the responsible party. (Note: Only defects in materials and workmanship are considered warrantable) Compare failure symptoms and description to select your Preauthorized Repair Guidelines. Establish estimate to assist in the determination of repair plan (component repair vs. replacement) Perform troubleshooting and diagnostics Review Roadranger Warranty Manual (TCWY0600) Component replacement guidelines Warranty limits and exclusions Other Important Information Confirm parts availability through ordering channel (OEM System) If parts are not available through your OEM's PDC network, please contact Roadranger Aftermarket Customer Support for availability at 1-800-826-4357, option 2 3. Complete the Repair 4. Technician to Document the following: Complaint, cause (findings), correction All inactive and active fault codes and diagnostic labor Diagnostic fault tree step leading to part replacement List reasons for labor above normal SRT times Location of failed parts 5. Repair Reasons for Claim Adjustment Excessive labor, time beyond SRT, with no technical documentation (example: requesting more labor hours than repair supports with no documentation.) Excessive parts, over-repair, worn parts (example: sliding clutches requested when only gear failure; basic rebuild kit requested for only bearing replacement required from failure) NOTE: Parts replaced not associated with failure must be approved and paid by customer. Failure, non-warrantable (example: failure caused by low lube, improper lube, no lube, shock load) 1. Closeout Repair Order If Automated Call Center or RTW is involved, dealer must close the claim with the Automated Call Center or RTW. Labor to be paid per OEM Chassis SRT's for a specific failure. Excessive labor to be justified in claim text (include fault codes) or have Eaton approval. See Eaton Warranty Manual (TCWY0600) Important Information Regarding Claim Approval 2. File Claim OEM Claim Follow OEM claim procedures All warranty claims for component that is within OEM warranty to be filed to truck nameplate OEM. Eaton supported, OEM certified dealers may be exempt from part return (OEM claims only). Eaton RTW Direct Pay Claim Follow RTW Direct Pay Claim filing procedures as trained by your Eaton representative. Roadranger Warranty Direct Pay Claims Use this program to file claims for Roadranger extended warranties where pre-approval has not been received from the Roadranger Call Center / RTW, or where a claim is not currently open. NOTE: For a claim submitted for a vehicle outside the OEM published warranty, a copy of the OEM warranty coverage for the vehicle must be included with the claim. Warranty claim requirements, limits, and exclusions Check Status Once claim is entered in the Roadranger warranty system, dealer can check the status by entering OEM Dealer Code and Repair Number 3. Return Warranty Parts OEM Claim Follow OEM part return direction Eaton supported, OEM certified dealers may be exempt from part return (OEM claims only). Eaton Direct Pay Claim Follow Eaton part return direction Part return requirements available in Eaton Warranty Manual (TCWY0600) Return address and shipping instructions available on Service Bulletin (TMIB0129) Please allow 10 days for claim processing (additional time for claim processing with part returns). See Direct Pay Claim Verification to view your claim online. 4. Check Claim Status OEM Claim Contact OEM Warranty Eaton Direct Pay Claim (not RTW) Direct Pay Claim Verification Eaton RTW Direct Pay Claim RTW Direct Pay Claim Verification 5. Core Credit Administration Core Credit is reimbursed through the OEM for: Transmission Transmission Electronics Core credit values are communicated in the Unit Exchange Program Guide (APSL0419) 6. Warranty Appeals OEM Claim Contact OEM for Warranty Appeals Eaton Direct Pay Claim Contact Roadranger Call Center 1-800-826-HELP (4357) Essential warranty documents Eaton warranty manual TCWY0600 (PDF 587 KB) This manual includes product warranty statements for eaton commercial vehicle products, warranty terminology, warranty programs, claim procedures and claim information, important information regarding claim approval, component repair or replacement guidelines, labor hour guidelines (SRTs), limits, exclusions, and requirements. Eaton warranty guide TCWY0900 (PDF 725 KB) TCWY0900 EN-US Eaton warranty repair guidelines TCWY1250 (PDF 7 MB) TCWY1250 EN-US Eaton transmission, hybrid components, and clutch warranty returns shipping instructions TMIB0129 (PDF 802 KB) TMIB-0129 Frequently asked questions: Expand all How do I file a Standard, Basic or OEM warranty claim? How do I file an Eaton Extended Warranty claim? After a failure, what parts need to be returned and why? Should the failed parts be identified? Where do I find Eaton SRT's? Where can I find a listing of what is not covered by Eaton Warranty? Direct pay claims Direct pay worksheets Warranty claim worksheet (English) Eaton warranty claim submission guidelines for OEM dealers CAT warranty claims Ford warranty claims Freightliner warranty claims GMC warranty claims Hino warranty claims International warranty claims Kenworth warranty claims Mack warranty claims Peterbilt warranty claims Sterling warranty claims Volvo warranty claims Western Star warranty claims Claim submission guidelines for Eaton Authorized Rebuilders Eaton authorized rebuilder warranty claims Roadranger call center 1-800-826-4357. Available 24/7 to assist you with technical or warranty claim support. Email us You can also email us. Find your rep Locate your local Roadranger representati tshingombe fiston Wed, Mar 12, 1:57 PM (5 days ago) to me Performance Automotive Pre-Call Checklist Page 1 of 2 Subject: Performance Automotive Pre-Call Checklist Original Date: May 18, 2021 Updated: May 18, 2021 Issue Description: This document will outline the necessary documentation and information required to request troubleshooting assistance and to start a warranty claim for Performance Automotive products Contact Information: Distributor: Name: Address: City: State: Zip Code: E-Mail: Phone Number: Product Information: Quantity Part Number Serial Number Description Required Documentation: ☐☐Pre-Call Checklist ☐☐Date of Purchase or Installation ☐☐Customer Sales Invoice ☐☐PO Between Eaton and the Distributor Technical Information: ☐☐Customer Complaint/Reason for Return: ☐☐Vehicle Year / Make / Model: ☐☐Application: ☐☐Engine Size and HP: ☐☐Front or Rear Axle: ☐☐Transmission Automatic or Manual: ☐☐Differential Lubricant Brand & Weight: ☐☐Brief Description of Differential Failure / History:Performance Automotive Pre-Call Checklist Revision 12/17/2020 Page 2 of 2 Warranty Information: ☐☐All Product Return Must be Accompanied by a Claim Authorization Number ☐☐Eaton RMA/Claim Number: ☐☐Return Tracking Number: ☐☐Return Carrier: ☐☐Scrap or Return if Part is Denied: Eaton Contact Information: • 1-800-328-3850 • AutomotiveSupport@Eaton.com 2 Attachments • Scanned by Gmail tshingombe fiston Wed, Mar 12, 2:31 PM (5 days ago) to me Company* Business Phone* Country* State / Province* Job Title* Zip or Postal Code* How can we help you?* Please select the offering(s) you are interested in from the following questions. Basic Studies: Power Quality Studies Power Quality Assessment Harmonic Analysis (IEEE-519) Arc Flash Analysis Short Circuit Analysis Coordination Analysis Advanced Studies: Protective Relay Settings Bus Bracing Analysis Load Flow/Motor Starting Studies Grounding/Lightning Protection Studies Switching Transient Analysis Microgrid/DER/EV Charging Feasibility Studies Power Factor Correction Studies Trainings: Arc Flash Training Electrical Worker Safety Training Utility Planning Studies & CYME Training Other (Please provide the details below) Please provide details about your request so we can better help you.* Design features that ease installation Installing and maintaining lighting in industrial facilities is often a complex and costly task, as the majority of the fixtures are in dangerous and difficult to reach locations. Elevated mounting heights, obstacles, and other challenges can drive up both the dangers and the costs associated with these tasks. Be sure to evaluate a luminaire's mounting and wiring features. A well-designed light can reduce installation effort and significantly lower labor costs. This is especially important with retrofit projects, where labor costs are a key factor. Key factors to consider Mounting styles | Simplified retrofits | Reduce installation effort | Eliminate dangers Contact us about a lighting project Crouse-Hinds series LED luminaires Designed with specific features to provide mounting flexibility and improve the speed and safety of the installation process Multiple mounting modules for ideal luminaire placement Fixture location placement and the proper mounting height are essential to designing a lighting installation that provides uniform illumination with minimal glare and light trespass. The numerous mounting styles available from Eaton's Crouse-Hinds Division offer unparalleled flexibility, ensuring that the fixtures are installed in the correct location to properly light your application. Backward compatibility for simplified retrofits Crouse-Hinds series LED luminaires utilize the same mounting modules as our legacy HID, fluorescent and incandescent products, simplifying installation and significantly reducing costs in retrofit projects. We also offer mounting adapters and kits for quick connection to other manufacturers' modules. Wiring features that reduce installation effort We engineer our LED luminaires to be as installation-friendly as possible. The features below help reduce installer effort, stress, and potential injury. Hinged support allows luminaire to hang from mounting module during wiring Lever lock connectors and terminal blocks for fast, plug and play wiring Quick clip accessory supports weight of the fixture during final tightening to the mounting module Quick-connect wire-free +ve/-ve connections between LED and mains (EVLL LED only). Poles that eliminate the dangers of working from heights For lights in elevated locations, OSHA/HSE regulations require fall prevention equipment any time a worker is exposed to a fall of six feet or greater. Since 2000, the #1 most frequently violated OSHA standard each year is General Requirements for Fall Protection. And while personal protection equipment will help protect workers from threat, there is still a risk of injury from a fall. Preventing the worker from being exposed to the threat altogether is the most effective risk-reduction measure. Safety lowering poles are an effective way to transition from protecting the worker to eliminating the risk. By enabling the luminaire to be lowered, the safely pole allows all installation or maintenance work to safely take place on the platform or walkway. This eliminates the timely and costly need for fall protection equipment and portable ladders or scaffolds. Safety lowering poles are a good option for industrial lighting applications in hard to reach areas, as well as for any luminaires installed on walkways, platforms, stairways and conveyors where OSHA/HSE regulations require fall prevention equipment. Make lighting installations safer, faster & easier with Crouse-Hinds series V-Spring telescoping light poles Our patent-pending V-Spring light poles increase safety and decrease labor costs associated with lighting installation and routine maintenance. Spring assistance allows the luminaire to be lowered safely and easily – eliminating the need for portable ladders and fall prevention equipment. When compared to 45 degree lowering systems, the V-Spring's spring assisted vertical movement requires 65% less force to raise or lower and removes mechanical stress on the handrail by over 300%. Easily extend to any height up to 9 feet – one product covers multiple mounting heights 360° pole rotation allows for effortless positioning of light Spring assist provides true controlled lowering and requires less force to raise or lower luminaire – no strain on worker Fixture housing will not fall from mounting module hinge hook during installation or maintenance No pinch points – protects hands and fingers 2" bottom pole for higher structural wind ratings Internal conduit protects wiring from spring assist mechanism Drain at bottom of pole assists in preventing moisture from entering conduit system Factory assembled wired and sealed for maximum environmental protection LED Lighting Design and Specification Guide This LED Lighting Design and Specification Guide details key factors to consider when selecting a manufacturer for industrial lighting, and demonstrates how Eaton's Crouse-Hinds series LED solutions are built to withstand the toughest conditions, deliver maximum lighting performance and safety, and reduce expensive maintenance costs. Download now More considerations Key factors to consider for lighting reliability in challenging harsh and hazardous area environments. Eaton receives dual honors for its commitment to inclusion and diversity Eaton receives dual honors for its commitment to inclusion and diversity Eaton earns perfect score on Human Rights Campaign Foundation's Corporate Equality Index for the eighth time and Equality 100 Award: Leader in LGBTQ+ Workplace Inclusion Eaton named one of America's Greatest Workplaces for Diversity in Newsweek for the second year in a row, earning five out of five stars DUBLIN – Intelligent power management company Eaton (NYSE:ETN) announced it was recently recognized by two prestigious organizations for its deep commitment to delivering an inclusive employee experience. First, Eaton achieved a 100% on the Human Rights Campaign Foundation's 2023-2024 Corporate Equality Index (CEI). Second, Newsweek once again named Eaton one of America's Greatest Workplaces for Diversity. Eaton believes inclusive behaviors drive innovation and growth, enable high-performing teams and deliver confidence to stakeholders that they are engaging with a sustainable, socially responsible company. The CEI, an annual benchmark for workplace equality, reflects how U.S.-based companies promote LGBTQ+-friendly workplace policies in the U.S. and abroad. It measures areas such as non-discrimination policies, equitable benefits, culture and corporate social responsibility. By satisfying all of the CEI's criteria this year, Eaton earned the Human Rights Campaign Foundation's Equality 100 Award: Leader in LGBTQ+ Workplace Inclusion. Scoring for America's Greatest Workplaces for Diversity is based on publicly available data, interviews with Human Resources professionals, press and anonymous online employee surveys at companies with more than 1,000 employees. Researchers also considered more than 21 Key Performance Indicators (KPIs) such as diversity ratio, diversity reviews and information from social media platforms. "These latest recognitions reflect our commitment to being a model for inclusion and diversity in our industry," said Cindy Fisher, vice president, Global Inclusion and Diversity, Eaton. "We are passionate about this important work because we know that it makes us stronger as individuals and as a company. We also know there is more work to do." The recognitions mark the latest in Eaton's inclusion and diversity journey. For the past three years, Eaton was named a Best Place to Work for Disability Inclusion, earning 100 out of 100 on the 2023 Disability Equality Index (DEI). In Mexico, Eaton was certified as a Best LGBTQ+ Place to Work and Age-Friendly Employer™ for 2024. To read more on Eaton's journey, visit the latest Global Inclusion and Diversity Transparency Report. A list of current job openings can be found here. Eaton is an intelligent power management company dedicated to improving the quality of life and protecting the environment for people everywhere. We are guided by our commitment to do business right, to operate sustainably and to help our customers manage power — today and well into the future. By capitalizing on the global growth trends of electrification and digitalization, we're accelerating the planet's transition to renewable energy, helping to solve the world's most urgent power management challenges, and doing what's best for our stakeholders and all of society. Eaton was founded in 1911 and has been listed on the New York Stock Exchange for more than a century. We reported revenues of $20.8 billion in 2022 and serve customers in more than 170 countries. For more information, visit www.eaton.com. Follow us on LinkedIn. Contact: Eaton recognized in three countries as a Best Place to Work for Disability Inclusion Eaton recognized in three countries as a Best Place to Work for Disability Inclusion For the fourth year in a row, Eaton scored 100 out of 100 on the Disability Equality Index® (DEI) in the United States For the first time, Eaton scored 100 out of 100 in India and 90 out of 100 in Brazil on the Disability Equality Index® (DEI) DUBLIN – Intelligent power management company Eaton (NYSE: ETN) today announced its commitment to inclusive strategies and programming for people with disabilities has earned high scores on three Disability Equality Indexes® (DEI), a benchmarking tool that measures workplace inclusion. "We are always looking at where we can expand inclusion," said Cindy Fisher, vice president, Global Inclusion and Diversity. "We've found new ways to encourage employees to share their needs and challenges with us anonymously through our global survey—and we're responding. We complete the DEI because we are committed to equity, inclusion and transparency and know there is more work to be done." The DEI was launched in 2015 by Disability:IN and The American Association of People with Disabilities (AAPD) to measure inclusive workplace policies. Companies that score 80 or higher are recognized as a Best Place to Work for Disability Inclusion. In 2024, the DEI expanded beyond the United States to include seven new countries, including India and Brazil. Eaton's recent achievements are the latest in its journey. Earlier this year, Eaton received dual honors for its commitment to inclusion and diversity, earning a perfect score on Human Rights Campaign Foundation's Corporate Equality Index (CEI) for the eighth time and the Equality 100 Award: Leader in LGBTQ+ Workplace Inclusion. Eaton was also named one of America's Greatest Workplaces for Diversity. To learn more about Eaton's I&D strategy, please review its recent Global Inclusion and Diversity Transparency Report. Eaton is an intelligent power management company dedicated to protecting the environment and improving the quality of life for people everywhere. We make products for the data center, utility, industrial, commercial, machine building, residential, aerospace and mobility markets. We are guided by our commitment to do business right, to operate sustainably and to help our customers manage power — today and well into the future. By capitalizing on the global growth trends of electrification and digitalization, we're accelerating the planet's transition to renewable energy sources, helping to solve the world's most urgent power management challenges, and building a more sustainable society for people today and generations to come. Eaton was founded in 1911 and has been listed on the New York Stock Exchange for more than a century. We reported revenues of $23.2 billion in 2023 and serve customers in more than 160 countries. For more information, visit www.eaton.com. Follow us on LinkedIn. ton engineers are at the forefront of emerging technologies, driving real and impactful change in the world. Our engineering team is a highly valued, global community of nearly 10,000 engineering professionals. We are doing our part to help protect the future of our planet through sustainable technology. Our engineers work in domains such as: power electronics, energy systems, material sciences, additive manufacturing, Industry 4.0, aerospace, eMobility, digital technologies, and cybersecurity. No matter what level you're at in your career, we have opportunities for you. Depending on your skills and experiences, you could contribute in the following areas as you progress in your engineering career: Product development Business advanced technology development Corporate research and technology Applications Software engineering Data science Power electronics Mechanical engineering Electrical engineering Build your career with our leadership development programmes We are looking for people who jump at the opportunity to grow. Our leadership development programmes offer an array of learning experiences. Our customised development curriculum includes leadership training, personal coaching, and networking with senior leaders. You will get to fast-track your development through rotational assignments in different locations, with exposure to multiple businesses. Here is your opportunity to make a difference at Eaton ton engineers are at the forefront of emerging technologies, driving real and impactful change in the world. Our engineering team is a highly valued, global community of nearly 10,000 engineering professionals. We are doing our part to help protect the future of our planet through sustainable technology. Our engineers work in domains such as: power electronics, energy systems, material sciences, additive manufacturing, Industry 4.0, aerospace, eMobility, digital technologies, and cybersecurity. No matter what level you're at in your career, we have opportunities for you. Depending on your skills and experiences, you could contribute in the following areas as you progress in your engineering career: Product development Business advanced technology development Corporate research and technology Applications Software engineering Data science Power electronics Mechanical engineering Electrical engineering Search Johannesburg, Gauteng, ZA × Advanced Options 1 open jobs in Johannesburg, Gauteng, ZA. Use your resume to get matched with the right job. Upload your resume Let your resume search for jobs Drag & drop file docx or pdf or When you upload your resume: • Jobs will be labeled when they're a good or great match • • Great matches will be shown first in search results • Relevant skills and experience will be listed so you know why those jobs are a match Selecting an option from the list below will update the main content Sales Engineer Johannesburg, Gauteng, ZAF, 1619 SLS No more matching jobs. Sales Engineer Johannesburg, Gauteng, ZAF, 1619 ____ Job Description Job Req ID 41328 Work Type Hybrid Department SLS ____ Eaton is a global power management company with a significant presence in Johannesburg, South Africa. We specialize in electrical systems for power quality, distribution, and control, as well as systems, and services for industrial and mobile equipment. Our team at Eaton's Johannesburg office is composed of skilled professionals dedicated to providing top-notch power management solutions and is known for its commitment to innovation and customer satisfaction. We are recruiting for a Sales Engineer. The Sales Engineer will be responsible for developing and maintaining a customer database, promoting Eaton products and services, and providing technical and commercial support to customers. This role involves identifying opportunities, resolving problems, and acting as a deputy to team leaders. What you'll do: Achieve sales targets while adhering to Eaton's market strategy; Stay informed about Eaton's products and market strategies; Manage and promote channel sales through a distribution model, which includes joint calls with our distribution channel partners to End users, IT resellers, value added resellers, panel builders, MOEM's and System Integrators; Prepare tenders and proposals using MS Office tools; Possess strong commercial knowledge; Create and deliver presentations on product offerings and technologies. Develop and maintain a customer base; Identify opportunities to offer Eaton products and services; Resolve problems using established policies and improvement techniques; Act as a deputy to team leaders, coordinating team activities and advising colleagues. Qualifications: A Commercial or Marketing Degree / Diploma; 3-5 years sales experience in Electrical products. Skills: Good understanding of IT channel or EWS route to Market; Ability to use the xEnergy Configurator, XSpider Software (Circuit breaker cascading and co-ordination tool); Good interpersonal, communication and presentation skills; Ability to operate in a fast-paced and changing market environment; Ability to coach and train people / customers. Why join us: Medical Aid - 50 % of the cost, depending on the option the employee chose; Pension / provident - Provident fund 10% of basic salary, employee contribution = 7.5%; Vehicle covered through Group Insurance. We are committed to ensuring equal employment opportunities for job applicants and employees. Our recruitment processes use balanced selection criteria and avoid unlawful discrimination against applicants on the basis of their age, colour, disability, marital status, national origin, gender, gender identity, genetic information, race or racial origin, religion, sexual orientation or any other status protected or required by law. #LI-AM7 Get Matched Upload your resume and see jobs that match your skills and experience Match Unknown Other Similar Jobs Area Sales Manager - Industrial Sales Nashville, Tennessee, USA, 37211 and 2 more SLS Business Development Manager, Life Safety (Emergency Lighting and Fire Detection), TR & CIS Istanbul, TUR, 34742 SLS Hybrid Area Sales Manager Wilsonville, Oregon, USA, 97070-8247 SLS Sales Engineer- Zhejiang Hangzhou, Zhejiang, CHN, 310000 SLS Product Line Sales Manager Leicestershire, GBR, LE12 5TH SLS OEM Area Sales Manager City Of Industry, California, USA, 91746 and 5 more SLS Hybrid Aftermarket Product Sales Manager Titchfield, GBR, PO14 4QA SLS Area Sales Manager Louisville, Kentucky, USA, 40213 SLS EOEM Sales Engineer, East Suzhou, Jiangsu, CHN, 215121 SLS Slide 1 of 3 Recommended Videos for you Life at Eaton We make what matters work.* Slide 1 of 2 Perks and Benefits Healthcare and retirement savings programs to support you now and as you plan for the future Wellness programs and resources to support the wellbeing of you and your family Flexible work options to help balance work/life demands Competitive compensation packages to reward skills and performance Ongoing learning and career development opportunities to help you grow About Us Eaton is an intelligent power management company dedicated to improving the quality of life and protecting the environment for people everywhere. We are guided by our commitment to do business right, to operate sustainably and to help our customers manage power — today and well into the future. By capitalizing on the global growth trends of electrification and digitalization, we're accelerating the planet's transition to renewable energy, helping to solve the world's most urgent power management challenges, and doing what's best for our stakeholders and all of society. Founded in 1911, Eaton is marking its 100th anniversary of being listed on the New York Stock Exchange. We reported revenues of $20.8 billion in 2022 and serve customers in more than 170 countries. Our commitment to Inclusion & Diversity and Sustainability We are powered by our vision, driven by strategy, guided by our aspirational goals and committed to doing business right. We believe diversity is our strength and diverse thinking powers innovation and growth. In our second annual Global Inclusion and Diversity Transparency Report, we look at the progress we've made in our journey and the work that's still left to do. Our latest sustainability report features our progress toward our 2030 Sustainability Goals, which include science-based greenhouse gas reduction targets and our commitment to become carbon neutral by 2030. Recent Awards: Honored to be recognized 2018-2022 World's Most Admired Companies, Fortune 2016-2022 Best Place to Work for LGBTQ Equality, HRC 2011-2022 World's Most Ethical Companies, Ethisphere 2007-2022 100 Best Corporate Citizens, 3BL Media 2022 Best Places to Work for Disability Inclusion, DEI Not ready to apply yet? Variable frequency drives Maximize your potential with VFD training Our training courses are designed to teach you how to safely commission, operate and troubleshoot Eaton's variable frequency drives. We offer self-guided eLearning and instructor-led training to achieve this goal. Course catalog How-to videos Register for in-person training What you will learn Introduction and intermediate courses are self-guided and can be accessed from our website. Commissioning and Service Certification courses are either in-person or accessed from Eaton Classroom, a password protected eLearning website. Self-guided online training Our eLearning courses cover a variety of topics, including product overviews, basic operations and troubleshooting. Course catalog How-to video series Our how-to videos provide step-by-step guidance on completing VFD tasks. Video library Commissioning and service certification courses Our structured approach teaches both theoretical concepts and practical skills in VFD technology and commissioning. VFD training courses cover a comprehensive range of topics essential for understanding and working with Eaton's variable frequency drives. Online basic startup training This program is for anyone who wants to start up their own VFD and utilize eLearning modules on installation, programming and commissioning of Eaton's DG1, SVX and H-Max VFD. Eaton Classroom In-person instructor-led training at an Eaton facility Commissioning training These courses are focused on the installation, programming and commissioning of Eaton's SVX, DG1, HMX and DH1 products. Upon completion, participants will earn commissioning certification and will be able to add an additional year to the of warranty coverage on their VFD drives. PowerXL DG1 and 9000SVX training Focused on the PowerXL DG1 and SVX products, this course includes installation procedures and programming. Attendees engage in hands-on programming exercises with the PowerXL DG1 and a demonstration of the Power Xpert inControl software. An overview and programming exercises for the SVX product are also included, as well as a demonstration of the 9000XDrive software. Upon completion of the Eaton Industrial VFD Commissioning course, attendees will earn commissioning certification and will be able to add an additional year to the standard 2-year warranty, resulting in a 3-year warranty for the SVX and DG1 products. Duration: One and a half days Cost: $675.00* PowerXL DH1 training This course is focused on the PowerXL DH1 product, covering installation and programming techniques. Much of the course if focused on practical programming exercises with the DH1 product. The session also includes the Power Xpert inControl software, which provides programming and monitoring capabilities. Upon completion of the Eaton PowerXL DH1 Commissioning course, attendees will earn commissioning certification and will be able to add an additional year to the standard 2-year warranty, resulting in a 3-year warranty for the PowerXL DH1 product. Duration: One day Cost: $675.00* *Note: The course fee includes all training materials. Travel and lodging expenses are the responsibility of the participant. Training schedule Training courses are held at Eaton regional offices across the U.S. Each site offers Industrial VFD Commissioning Training over the first two days, followed by PowerXL HD1 VFD Commissioning Training on the third day. This schedule allows attendees to complete both training courses in the span of three days. 2025 Training schedule and step-by-step registration instructions Date Eaton site Date Eaton site January 21-23 Deerfield Beach, FL July 15-17 Littleton, CO February 4-6 Chandler, AZ August 5-7 San Diego, CA March 18-20 Windsor, CT September 16-18 Glendale Heights, IL April 1-3 Boothwyn, PA October 14-15 Franklin, MA April 15-17 Pleasanton, CA November 18-20 Salt Lake City, UT May 20-22 Morrisville, NC December 2-4 Houston, TX June 17-19 Grapevine, TX 76051 Register for in-person training Custom on-site training Let us design a custom on-site training for you. Please complete our on-site training request form to get started. On-site training request Advanced Catalog Home / Installation and Commissioning Categories DG1 General HMX SVX Refine Search Terms Add and remove additional terms to your search. Newly-added content only Mobile-Friendly Courses Only Courses I haven't completed Free training only Rewards Offered Minimum Average Rating Subcategories Category DG1 Category General Category HMX Category SVX Courses View Course 2025 Industrial VFD Commissioning Training General Purpose/Industrial VFD Commissioning Certification of Eaton PowerXL DG1 (DG1) and 9000SVX (SVX). Training consists of VFD operation… Cost $675.00 Duration 12.00 Hours Course 2025 PowerXL DH1 Commissioning Training HVAC VFD Commissioning Certification of Eaton PowerXL DH1 (DH1). Training consists of VFD operation, description of DH1 features , an overview of… Cost $675.00 Duration 7.00 Hours Powered by BlueVolt ©2001-2025 Terms of Use Privacy Policy (0) Completion Time: 12 Hours Mobile Compatible: No SCHEDULED COURSE 2025 Industrial VFD Commissioning Training • VFD and 3 phase motor fundamentals, VFD operation •PowerXL DG1 and 9000SVX Overview • Installation requirements, including power and control wiring • Pre-power, power-on and operational checks and inspections • Advanc Read More » Categories: Installation and Commissioning, General Eaton Drives Commissioning Certification Training 2023 Industrial 1-1/2 Days (DG1/SVX) • Arrive/Introductions 3 Phase Motor and VFD Basics VFD fundamentals • PowerXL DG1 Product Overview • Installation • PowerXL DG1 Programming • Lunch • PowerXL DG1 Programming Exercises • Power Xpert inControl Software Demonstration • SVX Product Overview • SVX Programming •SVX Programming Exercises • 9000XDrive Software Demonstration • VFD Commissioning Process • Warranty Extension Process • Conclusion Cost USD $675.00 Course Schedules Tue, Mar 18 2025 8:00 am - Wed, Mar 19 2025 12:00 pm Time Zone: Eastern Daylight Time Location: Eaton Hartford CT, Conference Room Address: 40 International Dr. Windsor CT, 06095 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline In-person Cost: USD $675.00 Registration closed Tue, Apr 01 2025 8:00 am - Wed, Apr 02 2025 12:00 pm Time Zone: Eastern Daylight Time Location: Eaton - Philadelphia Sales Office, NAS Training Room Address: 7 Chelsea Pkwy Suite 700 Boothwyn PA, 19061 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline Tuesday, Mar 18 2025 11:00 PM In-person Cost: USD $675.00 Waitlist No. - 0 Schedule Full Tue, Apr 15 2025 8:00 am - Wed, Apr 16 2025 12:00 pm Time Zone: Pacific Daylight Time Location: Eaton , Training Room Address: 5735 W. Las Positas Pleasanton CA, 94588 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline Monday, Mar 31 2025 11:00 PM In-person Cost: USD $675.00 Tue, May 20 2025 8:00 am - Wed, May 21 2025 12:00 pm Time Zone: Eastern Daylight Time Location: Eaton Satellite Morrisville, Training Room Morrisville NC Address: 9400 Globe Center Dr Morrisville NC, 27560 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline Monday, May 05 2025 11:00 PM In-person Cost: USD $675.00 Tue, Jun 17 2025 8:00 am - Wed, Jun 18 2025 12:00 pm Time Zone: Central Daylight Time Location: Eaton - Grapevine, TX, Training Center Address: 637 Westport Pkwy Grapevine TX, 76051 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline Monday, Jun 02 2025 11:00 PM In-person Cost: USD $675.00 Tue, Jul 15 2025 8:00 am - Wed, Jul 16 2025 12:00 pm Time Zone: Mountain Daylight Time Location: Eaton - Littleton, CO, Training Room Address: 8022 Southpark Circle Suite 300 CO, 80120 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline Monday, Jun 30 2025 12:00 AM In-person Cost: USD $675.00 Tue, Aug 05 2025 8:00 am - Wed, Aug 06 2025 12:00 pm Time Zone: Pacific Daylight Time Location: Eaton San Diego, Training Room San Diego Address: 4863 Shawline Street San Diego CA, 92111 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline Monday, Jul 21 2025 11:00 AM In-person Cost: USD $675.00 Tue, Sep 16 2025 8:00 am - Wed, Sep 17 2025 12:00 pm Time Zone: Central Daylight Time Location: Eaton Glendale Heights, Training Room Address: 210 Windy Point Drive Glendale Hegiths IL, 60139 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline Monday, Sep 01 2025 11:00 PM In-person Cost: USD $675.00 Tue, Oct 14 2025 8:00 am - Wed, Oct 15 2025 12:00 pm Time Zone: Eastern Daylight Time Location: Eaton-Boston , Conference room Address: 165 Grove St. Suite 10 Franklin MA, 02038 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline Monday, Sep 29 2025 11:00 PM In-person Cost: USD $675.00 Tue, Nov 18 2025 8:00 am - Wed, Nov 19 2025 12:00 pm Time Zone: Mountain Standard Time Location: Eaton - Salt Lake City, Training Room Address: 4752B W. California Ave. Suite 100 Sal Lake City UT, 84104 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline Monday, Nov 03 2025 11:00 PM In-person Cost: USD $675.00 Tue, Dec 02 2025 8:00 am - Wed, Dec 03 2025 12:00 pm Time Zone: Central Standard Time Location: Eaton - Houston Experience Center , Training Center Address: 3413 N Sam Houston Pkwy W Houston TX, 77086 UNITED STATES Instructors: Bruce Gott Jr Registration Deadline Monday, Nov 17 2025 11:00 PM In-person Cost: USD $675.00 Course Outline 2025 Industrial VFD Commissioning Training SURVEY DG1 Application Manual DG1 Application and Programming Manual SVX Programming Manual DG1 Installation Manual SVX Installation Manual (0) Completion Time: 12 Hours Mobile Compatible: No SCHEDULED COURSE 2025 Industrial VFD Commissioning Training • VFD and 3 phase motor fundamentals, VFD operation •PowerXL DG1 and 9000SVX Overview • Installation requirements, including power and control wiring • Pre-power, power-on and operational checks and inspections • Advanced programming, including software navigation and customer interface • General Purpose / Industrial specific applications overview • Completion of startup reporting and handoff of equipment to the customer • Overview of online, warranty extension process. Completion of this training gives the trainees the capability to extend the 2 year warranty to a 3 year warranty for Eaton PowerXL DG1 and 9000SVX. « Read Less Categories: Installation and Commissioning, General Eaton Drives Commissioning Certification Training 2023 Industrial 1-1/2 Days (DG1/SVX) • Arrive/Introductions 3 Phase Motor and VFD Basics VFD fundamentals • PowerXL DG1 Product Overview • Installation • PowerXL DG1 Programming • Lunch • PowerXL DG1 Programming Exercises • Power Xpert inControl Software Demonstration • SVX Product Overview • SVX Programming •SVX Programming Exercises • 9000XDrive Software Demonstration • VFD Commissioning Process • Warranty Extension Process • Conclusion Cost USD $675.00 Course Schedules Advanced Estimated Duration: 5 h 36 m Training Track 301 DG1 Basic Start Up elearning Basic start up elearning training gives a user of the DG1 drives knowledge to perform basic commissioning as well as operation of the VFD. This course covers induction motor and variable frequency drive operation, installation of the VFD, programming of basic parameters, basic controls, common … Read More » Categories: DG1 Cost: USD $100.00 Courses Course 201 Induction Motor Basics Three-phase alternating current induction motor. A simple, efficient, reliable device for converting electrical power to motion. Duration 30 Minutes Course 201 Drive Basics This course focuses on how a drive converts line power into a variable voltage and frequency source that is used to control a motor's speed. Also… Duration 30 Minutes Course 101 Variable Frequency Drives Safety The purpose of this course is to prepare qualified electrical personnel with the specific safety considerations for variable frequency drives. Common… Duration 15 Minutes Course 101 Variable Frequency Drives Installation This presentation describes best practices, manufacturer requirements and recommendations in performing Mounting and Installation of Variable… Duration 1.00 Hours Course 101 DG1 Programming Keypad Navigation This Video Provides an overview of the layout and functions of the DG1 series Keypad. Duration 6 Minutes Course 101 DG1 Programming Basic Parameters This course will discuss choosing a software application, frequency scaling, acceleration and deceleration times, and motor settings for the PowerXL… Duration 1.00 Hours Course 101 DG1 Programming Controls Welcome to the course, DG1 Programming – Controls. This course will discuss control places, keypad reference, and basic functions for the PowerXL… Duration 1.00 Hours Course 301 Variable Frequency Drives Troubleshooting This Course covers basic faults seen during commissioning of a drive along with 10 common fault codes and how to troubleshoot those faults. Duration 30 Minutes Course 201 DG1 Maintenance This course provides an demonstration on scheduled maintenance on a DG1 series VFD, including checking connections, changing fans and cleaning heat… Duration 15 Minutes Course DG1 Basic Start Up Assessment This is the Final Assessment for the DG1 Basic Start up Course. Duration 30 Minutes Powered by BlueVolt ©2001-2025 Terms of Use Privacy Policy 200 Advanced Transcript for tshingombe tshitadi Summary Badges Earned 0 Year-To-Date Hours Completed 0 h 10 m Total Hours Completed 0 h 10 m Year-To-Date Courses Completed 1 Total Courses Completed 1 Filter My Transcript Date Range Date Range Status Status Eaton Classroom Within Selected Date Range: 0 h 10 m | 1 Courses Totals: 0 h 10 m | 1 Courses Courses ONLINE VFD Commissioning Pre-Test Status: On Schedule ONLINE Power Xpert C445 Online Demo Status: COMPLETE Download Certificate ONLINE H-Max Series Drive Online Demo Status: On Schedule Showing All Transcript Data Powered by BlueVolt ©2001-2025 Terms of Use Privacy Policy Info tshingombe tshitadi tshingombefiston@gmail.com 20 percy street rockview yeohvill street 20 percy street jhb , gauteng 1030 +270725298946 Company Name: engineering tshingombe Change Password Summary ____ ____ Demo Layout Review Let's review the drive control panel interface before we continue. The PowerXL DG1 series drives have: Eight digital inputs, which are assigned to the toggle switches Two Analog inputs which are assigned to the potentiometers Three relay outputs and one digital output, assigned to the LED lights Two analog outputs, assigned to Eaton Panel mate digital meters A Safe-Torque Off (STO) feature is also available, which is assigned to the red push button Interact with the orange, numbered circles on the left to reveal information about the elements of the demo layout. Eaton is a power management company with 2017 sales of $20.4 billion. We provide energy-efficient solutions that help our customers effectively manage electrical, hydraulic and mechanical power more efficiently, safely and sustainably. Eaton is dedicated to improving the quality of life and the environment through the use of power management technologies and services. Eaton has approximately 96,000 employees and sells products to customers in more than 175 countries. Company Policies and statements Responsible sourcing of conflict minerals Slavery and human trafficking statement Terms and conditions Popular links Careers Contact us Investor relations 201 Advanced Transcript for tshingombe tshitadi Summary Badges Earned 0 Year-To-Date Hours Completed 0 h 22 m Total Hours Completed 0 h 22 m Year-To-Date Courses Completed 2 Total Courses Completed 2 Filter My Transcript Date Range Date Range Status Status Eaton Classroom Within Selected Date Range: 0 h 22 m | 2 Courses Totals: 0 h 22 m | 2 Courses Courses ONLINE PowerXL DG1 Online Demo Status: On Schedule ONLINE PowerXL® DH1 Online Demo Status: COMPLETE Download Certificate ONLINE XV300 Series HMI and HMI-PLCs Online Demo Status: On Schedule ONLINE 101 DG1 Programming Keypad Navigation Status: On Schedule ONLINE VFD Commissioning Pre-Test Status: On Schedule ONLINE Power Xpert C445 Online Demo Status: COMPLETE Download Certificate ONLINE H-Max Series Drive Online Demo Status: On Schedule Powered by BlueVolt ©2001-2025 Terms of Use Privacy Policy 201 Advanced (0) Completion Time: 10 Minutes Mobile Compatible: No ONLINE XV300 Series HMI and HMI-PLCs Online Demo Welcome to the XV300 Series HMI and HMI-PLCs Online Demo. Eaton's XV300 HMI and HMI-PLC operator interfaces with capacitive multi-touch technology are redefining how man and machine interact. Deeply intuitive, this advanced HMI allows machine builders to offer next-generation performance and functions that will propel their equipment into the future. « Read Less Categories: Eaton Variable Frequency Drives Status: On Schedule 0% complete Course Outline XV300 Series HMI and HMI-PLCs Online Demo Interactive Demo Progress: In progress Powered by BlueVolt ©2001-2025 Terms of Use Privacy Policy (home) b Transcript for tshingombe tshitadi Summary BADGES EARNED YEAR-TO-DATE HOURS COMPLETED h m TOTAL HOURS COMPLETED h m YEAR-TO-DATE COURSES COMPLETED TOTAL COURSES COMPLETED Date Range Status Eaton Classroom https://go.bluevolt.com/Eatonclassroom/s/account/transcript 1 of 3 3/18/2025, 11:32

AMWithin Selected Date Range: h m | 2 Courses Totals: h m | 2 Courses Courses ONLINE PowerXL DG1 Online Demo (coursedetail/349915/powerxl-dg1-online-demo) Status: On Schedule Course Length - 0:12 Status: Active - Enrollment Date: 3/18/25 ONLINE PowerXL® DH1 Online Demo (coursedetail/351920/powerxl®-dh1-online-demo) Status: COMPLETE Download Certi�cate (https:// go.bluevolt.com/ Eatonclassroom/ CourseCerti�cate/23304216/351920/ Course Length - 0:12 Status: Enrollment Date: 3/18/25, COMPLETE 3/18/25 ONLINE XV300 Series HMI and HMI-PLCs Online Demo (coursedetail/351921/xv300-series-hmi-and-hmi-plcs-online-demo) Status: On Schedule Course Length - 0:10 Status: Active - Enrollment Date: 3/18/25 ONLINE 101 DG1 Programming Keypad Navigation (coursedetail/89933/101-dg1-programming-keypad-navigation) Status: On Schedule Course Length - 0:06 Status: Active - Enrollment Date: 3/18/25 ONLINE VFD Commissioning Pre-Test (coursedetail/93211/vfd-commissioning-pre-test) Status: On Schedule Course Length - 0:30 Status: Active - Enrollment Date: 3/18/25 Eaton Classroom https://go.bluevolt.com/Eatonclassroom/s/account/transcript 2 of 3 3/18/2025, 11:32 AMPowered by BlueVolt (http://www.bluevolt.com/) ©2001-2025 ONLINE Power Xpert C445 Online Demo (coursedetail/346461/power-xpert-c445-online-demo) Status: COMPLETE Download Certi�cate (https:// go.bluevolt.com/ Eatonclassroom/ CourseCerti�cate/23304201/346461/ Course Length - 0:10 Status: Enrollment Date: 3/18/25, COMPLETE 3/18/25 ONLINE H-Max Series Drive Online Demo (coursedetail/351922/h-max-series-drive-online-demo) Status: On Schedule Course Length - 0:12 Status: Active - Enrollment Date: 3/18/25 Eaton Classroom https://go.bluevolt.com/Eatonclassroom/s/account/transcript 3 of 3 3/18/2025, 11:32 AM Table of Contents 1.11. 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Influence on solution to drive. 853 o Understand the codes and ordinances local to the opportunity/project. 853 o Solutions Development: Provide appropriate design documents to support the proposal and allow the estimating team to assemble cost for the proposal. These design documents should identify at a minimum the following as applicable: 853 · Identification of major infrastructure equipment 853 · Bid specifications for the major/long lead equipments. 853 · Space, clearances and site layout. 854 · Systems diagrams, grounding, calculations, ventilation, gas exhaust, protection relays, others. 854 · Design Phase: 854 o Perform code analysis for the project. 854 o Take the lead for the basis of design for the project, including redundancy requirements, detailed design, detailed calculations, validate product selection, etc. 854 o Engineering support function, supporting requests from other engineering teams, factory, commisiong, sub-contractors, services, site support. 854 o Support on System sequence of operation (SOO) 854 o Contributes to team effort by accomplishing related results as needed. 854 · Construction Phase: 854 o Maintains professional and technical knowledge by attending educational workshops; reviewing professional publications; establishing personal networks; participating in professional societies. 855 o Attend new products trainings and events to improve knowledge and capabilities. 855 o Prepare and schedule trainings as a SME (Subject Matter Expert) to other engineers 855 o Social media, internal networking, ability to work in internations environment. Teamwork skills. 855 o Being familiar with a variety of the field´s concepts, practices and procedures. 855 o Travel to customer sites experiencing issues to support the technical resolution . 855 o Participate in Offer Safety related meetings. 855 o Good English speaking, written and verbal skills. 855 o Good Spanish speaking, written and verbal skills. 855 o Good Communication skills 855 o Good capability to work in a Multi Discipline Engineering team 855 o Good acknowledge on Schneider Medium Voltage portfolio. 856 o Good acknowledge on medium voltage products and safety standards. 856 o Good capability to work with Microsoft tools, REVIT & CAD. 856 o 5 years of experience in MV Power Systems Design. 856 o Data Center design experience. 856 o Experience on simulation tools such as ETAP or Caneco HT. 856 o MV/LV coordination, arc flash gassing simulation / study. 856 o Knowledge on Protective relays configuration. 856 o Background in LV power designs. 856 Qualifications 860 Primary Location 861 Other Locations 861 Profile 862 All Notifications 864 EcoStruxure™ Automation Expert 865 A new category of software-centric industrial automation system, which takes an event-driven, decentralized approach to automation engineering. 866 EcoStruxure Automation Expert 866 Upskilling pathways for Distributors 866 Our entire offer in one central eLearning hub — start your journey with Schneider Electric today. 866 Expand your presence in Residential market 867 Fine-tune your skills for the Residential market — join eLearnings today 867 Low Voltage solutions for Commercial and Industrial Buildings 867 Skill up with Schneider Electric today. 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experienced developers alike. Ever since its first release in 1991, Python has had a constant presence in the computer world and has become a go-to language thanks to its easy-to-understand code and versatility. Today, Python can boast a wide array of libraries and frameworks, and they are the cornerstone of fast and easy Python programming—the so-called Pythonic way of development. But like all programming languages, Python is not immune to security threats. Secure coding best practices must be adopted to avoid risks from attackers. In this webinar, we'll explore Python security best practices that should employed when building secure application. One-Stop DevOps: Simplifying Toolchains with GitLab and Google Cloud 2485 Seamless Edge Deployment and Management with Lenovo and Intel 2486 Senior Applied Scientist – Copilot Team 2486 Senior Applied AI Engineer – Microsoft Security AI Research team 2486 Data Scientist II – Microsoft Security 2487 Senior Applied Scientist – Power Apps 2487 Applied Scientist II – Power Apps 2487 Principal Applied Scientist – Advanced Autonomy and Applied Robotics 2488 Senior Applied Scientist – Advanced Autonomy and Applied Robotics 2488 Principal Researcher – Generative AI – Microsoft Research AI Frontiers 2488 Senior Applied Scientist 2488 Principal Data Scientist – Real-Time Intelligence team 2489 engineering 2489 tshingombe fiston 2489 CU03031227-0 2490 Stats 2490 Achievements 2490 Personal information 2491 Confirmation 2491 Registration details 2491 Compare Microsoft 365 with Office 2492 Microsoft 365 Family 2492 Microsoft 365 Personal 2492 Office Home 2024 2492 Office Home & Business 2024 2493 Frequently asked questions 2493 Microsoft Azure AI Fundamentals 2496 At a glance 2497 Overview 2497 Course Syllabus 2498 Search for a training provider 2500 Microsoft Azure AI Fundamentals 2500 At a glance 2500 Overview 2500 Course Syllabus 2501 Microsoft Azure AI Fundamentals 2503 At a glance 2503 Overview 2503 Course Syllabus 2504 Embrace responsible AI principles and practices 2506 Learning objectives 2506 Fundamentals of Generative AI 2507 Learning objectives 2507 Knowledge check 2507 All units complete: 2508 Craft effective prompts for Microsoft 365 Copilot 2509 At a glance 2509 Prerequisites 2510 Developer 2510 Business or technical leader 2510 Business user 2511 Data scientist 2511 IT professional 2512 Low-code developer 2512 ecurity professional 2512 Help secure your data in the age of AI 2512 Accelerate app development by using GitHub Copilot 2513 C++ Standard Library reference (STL) 2624 In this section 2624 Use the Microsoft C++ toolset from the command line 2625 In this 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Adults 2828 Caregiver Support Services Training - Preventing the Spread of Infection 2829 Fundamentals of Domestic Violence and Abuse 2829 Understanding Child Development and Disabilities 2829 Lifeguard Training Fundamentals 2830 Comprehensive Guide to Defensive Driving 2830 Hand Hygiene Steps, Practices and Strategies 2830 Fundamentals of RBT Certification Exam - Behavior & Crisis Management 2831 Autism Spectrum Disorder in Early Childhood 2831 Defensive Driving - Essential Principles & Practices 2831 Working with Students with Special Educational Needs 2832 Good Clinical Practice - ICH Guidelines E6 R2 2832 Childcare and EYFS 2832 Most Popular Teaching & Academics Courses 2832 Hydrogen Sulphide Safety Training 2833 Safe Practices for Working at Height 2833 OSHA Essentials - Forklifter Operations & Safety 2833 Anger Management: A Guide to Emotional Regulation and Conflict Resolution 2834 Environmental Management and Legal Compliance 2834 Childcare and Young People Development 2834 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Enjoy your time! 3026 Industrial Automation market solutions 3027 Find new business opportunities in Industrial Automation Market — skill up starting today 3027 Secure Power solutions for data centers, critical power infrastructure and small offices 3028 Gain new knowledge about Secure Power solutions 3028 Digital Power solutions to increase energy efficiency 3028 Basic Power Metering 3028 Gateways and Energy Servers 3028 Power Quality and Power Factor Correction 3029 Protection Relays 3029 Sustainability School 3029 Gain sustainability knowledge and skills 3029 Chapter 1: Gain knowledge 3029 Learner Home 3030 Your Subjects 3031 Your Playlists 3031 Continue Learning 3032 Schneider Home Certification 3032 Saved for Later 3033 Sustainability School for Partners Chapter 2 3033 Most Popular 3033 The Thermal Management Functions in Electrical Panels: Module 02 3034 EBO 2023: Engineering EasyLogic 3035 EBO 2023: Engineering Upgrade 3035 EcoXpert Smart Grid, Technical, Intermediate: Geographic Information Systems Path 3036 EcoStruxure Power Foundational 2.0 3036 Advanced Machines with PacDrive 3 [VILT] 3037 EcoStruxure Building: Graphics Editor Intermediate 3037 Fundamentals of Thermal Management in Electrical Panels: Module 01 3037 SP_MX_2021_Lanzamiento Square D Easy UPS 3S 10-40 kVA (208V) 3038 IT Solution Provider Certification Test - Select 3038 My Courses: Tshingombe fiston 3040 Search Results (134) 3041 Project-28 Untitled 3046 Project-27 Untitled 3050 Project-27 Untitled 3054 Project-26 Untitled 3055 Project-25 Untitled 3058 Project-24 Untitled 3061 Project-23 Untitled 3064 Project-22 Untitled 3068 Project-21 Untitled 3070 Project-20 Untitled 3073 Leaderboard 3079 Applying Safety Rules 3080 Course content 3081 Discover personal protective equipment 3082 We are happy to have you with us! 3082 Course Assessment - Results page 3091 Question 3092 Question 3092 Question 3092 Question 3092 Question 3093 Question 3093 Question 3093 Question 3093 Question 3094 Question 3094 Course Assessment - Test 3094 Course Assessment 3094 Signins / Completions 3121 re eaton warenty 3132 tshingombe fiston 3132 Self-service warranty portal 3133 Follow this step-by-step process for accurate warranty claim submission. 3133 Frequently asked questions: 3139 How do I file a Standard, Basic or OEM warranty claim? 3140 How do I file an Eaton Extended Warranty claim? 3140 After a failure, what parts need to be returned and why? 3140 Should the failed parts be identified? 3140 Where do I find Eaton SRT's? 3140 Where can I find a listing of what is not covered by Eaton Warranty? 3140 Direct pay claims 3140 Eaton warranty claim submission guidelines for OEM dealers 3140 tshingombe fiston 3141 tshingombe fiston 3142 Design features that ease installation 3144 Key factors to consider 3144 Multiple mounting modules for ideal luminaire placement 3144 Backward compatibility for simplified retrofits 3144 Wiring features that reduce installation effort 3145 Poles that eliminate the dangers of working from heights 3145 Make lighting installations safer, faster & easier with Crouse-Hinds series V-Spring telescoping light poles 3145 LED Lighting Design and Specification Guide 3146 More considerations 3146 Eaton receives dual honors for its commitment to inclusion and diversity 3147 ton engineers are at the forefront of emerging technologies, driving real and impactful change in the world. 3149 Build your career with our leadership development programmes 3150 ton engineers are at the forefront of emerging technologies, driving real and impactful change in the world. 3150 When you upload your resume: 3152 Sales Engineer 3152 Job Description 3152 What you'll do: 3153 Qualifications: 3153 Skills: 3153 Why join us: 3154 Get Matched 3154 Other Similar Jobs 3154 Recommended Videos for you 3156 Life at Eaton 3156 We make what matters work.* 3156 Perks and Benefits 3156 Healthcare and retirement savings programs 3156 Wellness programs and resources 3156 Flexible work options 3156 Competitive compensation packages 3156 Ongoing learning and career development opportunities 3156 About Us 3156 Our commitment to Inclusion & Diversity and Sustainability 3157 Recent Awards: Honored to be recognized 3157 Not ready to apply yet? 3157 What you will learn 3158 Self-guided online training 3158 How-to video series 3158 Commissioning and service certification courses 3158 Online basic startup training 3158 In-person instructor-led training at an Eaton facility 3158 PowerXL DG1 and 9000SVX training 3159 PowerXL DH1 training 3159 Training schedule 3159 Custom on-site training 3160 2025 Industrial VFD Commissioning Training 3164 Course Outline 3171 2025 Industrial VFD Commissioning Training 3171 301 DG1 Basic Start Up elearning 3173 Transcript for tshingombe tshitadi 3179 Eaton Classroom 3179 Demo Layout Review 3181 Transcript for tshingombe tshitadi 3182 Eaton Classroom 3183 XV300 Series HMI and HMI-PLCs Online Demo 3186 Course Outline 3186 tshingombe fiston ____ SQA MyAlerts Update ____ tshingombe fiston Tue, Mar 25, 2025 at 11:00 AM To: web.team@sqa.org.uk National 5 Skills for Work Energy Course Specification (C258 75) Valid from August 2013 This edition, August 2018, version 3.0 This specification may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. Additional copies of this course specification can be downloaded from SQA's website: www.sqa.org.uk. Please refer to the note of changes at the end of this course specification for details of changes from previous version (where applicable). © Scottish Qualifications Authority 2013, 2018October 2018, version 3.0 1 Course outline Course title: National 5 Skills for Work Energy SCQF credit points: (24 SCQF credit points) Course code: C258 75 This course has 3.5 units that are mandatory and a 0.5 unit which is taken from three 0.5 optional units. Mandatory units The course comprises the following mandatory units: J12W 75 Energy: An Introduction 6 SCQF credit points J12Y 75 Energy: Domestic Wind Turbine Systems 6 SCQF credit points J130 75 Energy: Domestic Solar Hot Water Systems 6 SCQF credit points J12X 75 Energy: Employability and Careers 3 SCQF credit points Optional units The course comprises the following optional units: A choice of one from the following options: J131 75 Energy and the Individual 3 SCQF credit points J133 75 Energy: Oil/Gas Extraction 3 SCQF credit points J132 75 Energy: Conventional Technologies and the Grid 3 SCQF credit points To achieve the course award, the learner must successfully achieve all the mandatory units and one of the optional units. Recommended entry Entry is at the discretion of the centre. Progression This course, or its units, may provide progression to: • National Progression Award • a National Certificate programme in Further Education • training/ employmentOctober 2018, version 3.0 2 Core Skills Achievement of this course gives automatic certification of the following Core Skills component: Complete Core Skill Working with Others at SCQF level 4 Core Skill component Critical Thinking at SCQF level 4 Planning and Organising at SCQF level 4 Working Co-operatively with Others at SCQF level 4 There are also opportunities to develop aspects of Core Skills which are highlighted in the support notes of the unit specifications. Links to National Occupational Standards National Occupational Standards (NOS) are developed by the key employment sectors of the United Kingdom. These standards set the competences required for job roles within a particular employment sector. The NOS for the energy sector (eg Occupational and Functional Map of the UK Renewable Energy Sector) reflect common requirements in the demonstration of competences across that sector. Some of these competences, which are identified in the current NOS, are reflected to varying degrees in this course. For example: • General engineering skills. • A combination of integrated electrical installation and plumbing skills. • Mechanical skills. Additionally, other generic skills included in the NOS are reflected throughout the course including: • Communication skills. • Using IT to exchange information. • Team working skills. • Ability to learn. • Ability to follow instructions. • Organising own learning and development. Further details are provided in the 'Rationale' section. Equality and inclusion This Course Arrangements Specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.October 2018, version 3.0 3 Common rationale for Skills for Work Courses Skills for Work Courses are designed to help learners to develop: • Skills and knowledge in a broad vocational area. • Skills for learning, skills for life and skills for work. • Core Skills. • An understanding of the workplace. • Positive attitudes to learning. • Skills and attitudes for employability. A key feature of these courses is the emphasis on experiential learning. This means learning through practical experience and learning by reflecting on experience. Learning through practical experience Teaching/learning programmes should include some or all of the following: • Learning in real or simulated workplace settings. • Learning through role play activities in vocational contexts. • Carrying out case study work. • Planning and carrying out practical tasks and assignments. Learning through reflecting at all stages of the experience Teaching/learning programmes should include some or all of the following: • Preparing and planning for the experience. • Taking stock throughout the experience, reviewing and adapting as necessary. • Reflecting after the activity has been completed, evaluating and identifying learning points. The Skills for Work courses are also designed to provide learners with opportunities for developing Core Skills, and Skills for Learning, Skills for Life and Skills for Work with a focus on enhancing skills and attitudes for employability.October 2018, version 3.0 4 Core Skills The five Core Skills are: • Communication • Numeracy • Information and Communication Technology (ICT) • Problem Solving • Working with Others Employability The skills and attitudes for employability, including self-employment, are outlined below: • Generic skills/attitudes valued by employers. • Understanding of the workplace and the employee's responsibilities, for example, timekeeping, appearance, customer care, etc. • Self-evaluation skills. • Positive attitude to learning. • Flexible approaches to solving problems. • Adaptability and positive attitude to change. • Confidence to set goals, reflect and learn from experience. • Specific vocational skills/knowledge. Course specifications highlight the links to NOS in the vocational area and identify progression opportunities. Opportunities for developing these skills and attitudes are highlighted in each of the course and unit specifications. These opportunities include giving young people direct access to workplace experiences or, through partnership arrangements, providing different learning environments and experiences which simulate aspects of the workplace. These experiences might include visits, visiting speakers, role play and other practical activities. A Curriculum for Excellence (Scottish Executive 2004) identifies aspirations for every young person. These are that they should become: • successful learners • confident individuals • responsible citizens • effective contributors The learning environments, the focus on experiential learning and the opportunities to develop employability, Skills for Learning, Skills for Life, Skills for Work and Core Skills in these courses contribute to meeting these aspirations.October 2018, version 3.0 5 Course rationale for National 5 Skills for Work Energy All new and revised National Courses reflect Curriculum for Excellence values, purposes and principles. They offer flexibility, provide more time for learning, more focus on skills and applying learning, and scope for personalisation and choice. In this course, and its component units, there will be an emphasis on skills development and the application of those skills. Assessment approaches will be proportionate, fit for purpose and will promote best practice, enabling learners to achieve the highest standards they can. This Skills for Work course is also designed to provide learners with opportunities for developing Core Skills and Skills for Learning, Skills for Life and Skills for Work, with a strong focus on enhancing skills and attitudes for employability. This course is intended to equip learners with the necessary knowledge and skills which will enhance their prospects for employment in the wide range of opportunities within energy sectors. The course will allow learners to develop a range of employability skills which are of particular relevance to energy industries. Core Skills of Information and Communication Technology and Problem Solving will also be developed throughout the course where opportunities arise. The course will offer a variety of approaches to learning and teaching and will include a strong element of experiential learning. It is intended that some of the course will be delivered and assessed in a different learning environment to that of the school through a partnership arrangement with a college, training provider, or employer. There are many technologies used in the production of energy and this course has been designed to contain both an electrical generation practical/skills element using wind turbines and a heat generation practical/skills element using solar panels. These elements were selected to ensure learners receive a range of skills using different technologies that are involved in the generation of energy. Other systems used to generate energy from both the traditional/conventional and renewable systems will be discussed and evaluated during the course. The general aims of the course are to: • Widen participation in vocationally-related learning for 14–16 year olds. • Allow learners to experience vocationally-related learning. • Provide learners with a broad introduction to the energy sector. • Allow learners the opportunity to develop skills relevant to the microgeneration energy sector. • Develop the learners' engineering skills. • Encourage learners to evaluate the impact of energy generation on the environment. • Encourage learners to foster a good work ethic, including timekeeping, a positive attitude and other relevant employability skills. • Provide opportunities to develop a range of core skills in a realistic context. • Encourage learners to take charge of their own learning and development. • Provide a range of teaching, learning, and assessment styles to motivate learners to achieve their full potential. • Facilitate progression to further education and/or training.October 2018, version 3.0 6 In particular, the aims of the course are to: • Encourage learners to consider a career in the energy sector. • Develop an awareness of the role of conventional and renewable energy systems in the UK. • Develop an awareness of what opportunities there may be within the sector in terms of the types and range of career options. • Provide learners with knowledge and skills which are directly relevant to employment within the energy sector, eg solar hot water and wind turbines. • Provide opportunities for the personal development of skills and attitudes that will improve the learners' employment potential within the energy sector. • Develop the learners' awareness of their individual strengths and weaknesses in relation to the requirements of the sector, and to reflect on how this affects their employability potential. • Raise awareness of the impact of the energy sector on the environment. • Raise awareness of the responsibilities of the energy industry with regard to the environment. Purposes and aims of the course The general aims of the course are to: • Widen participation in vocationally-related learning for 14–16 year olds. • Allow learners to experience vocationally-related learning. • Provide learners with a broad introduction to the energy sector. • Allow learners the opportunity to develop skills relevant to the microgeneration energy sector. • Develop the learners' engineering skills. • Encourage learners to evaluate the impact of energy generation on the environment. • Encourage learners to foster a good work ethic, including timekeeping, a positive attitude and other relevant employability skills. • Provide opportunities to develop a range of core skills in a realistic context. • Encourage learners to take charge of their own learning and development. • Provide a range of teaching, learning, and assessment styles to motivate learners to achieve their full potential. • Facilitate progression to further education and/or training.October 2018, version 3.0 7 In particular, the aims of the course are to: • Encourage learners to consider a career in the energy sector. • Develop an awareness of the role of conventional and renewable energy systems in the UK. • Develop an awareness of what opportunities there may be within the sector in terms of the types and range of career options. • Provide learners with knowledge and skills that are directly relevant to employment within the energy sector, eg solar hot water and wind turbines. • Provide opportunities for the personal development of skills and attitudes that will improve the learners' employment potential within the energy sector. • Develop the learners' awareness of their individual strengths and weaknesses in relation to the requirements of the sector, and to reflect on how this affects their employability potential. • Raise awareness of the impact of the energy sector on the environment. • Raise awareness of the responsibilities of the energy industry with regard to the environment. Information about typical learners who might do the course The primary target group for this course is school learners in S3 and S4. However, the course is also suitable for S5/S6 learners and adult learners who are seeking to enhance their employability and vocational skills in the energy sector.October 2018, version 3.0 8 Course structure and conditions of award Summary of course content Learners will explore a variety and range of industries and career opportunities which exist within the energy sector. Learners will become familiar with key words and terms used in the sector, and will develop an awareness of the impact of the energy sector on the environment and individual lives. Personal development of employability skills will be the main focus across the course with each unit aiming to enhance such skills. The development of teamwork and practical skills and carrying out test procedures are also given high profile. The mandatory units in this course introduce the various energy industries based in the UK, develop practical skills by building a small scale solar hot water system and wind turbine, and learners will also review their employability skills and evaluate their strengths and weaknesses. There is an opportunity to specialise in one subject area by selecting one of the three optional units, ie analyse their own carbon footprint or develop a deeper knowledge of oil and gas production in the North Sea or develop further knowledge on the conventional energy generation systems used in the UK. Summary of unit content Units are statements of standards for assessment and not programmes of learning and teaching. They can be delivered in a variety of ways; however Skills for Work units are designed to provide an experiential learning process. Energy: An Introduction (National 5) — Mandatory The aim of the unit is to provide learners with an overview of where we get our energy from, the engineering systems that convert it into a more convenient form, and the energy conversion processes that take place from fuel being input to energy being generated. It gives a broad overview of traditional and renewable energy systems, energy conservation and includes an evaluation of an industrial or domestic energy generation facility. Investigation and presentation skills are developed in this unit. Energy: Domestic Solar Hot Water Systems (National 5) — Mandatory The unit introduces a microgeneration system which generates heat from solar energy and transfers this heat energy to a heat exchanger and on to other appliances, eg hot water tank or under-floor heating system suitable for use in a domestic or small scale industrial building. This is a practical skills based unit which gives students the practical skills to manufacture some of the parts and assemble a small solar hot water panel through team working which is seen as an essential element in this unit. Energy: Domestic Wind Turbine Systems (National 5) — Mandatory This unit introduces residential or microgeneration wind turbine systems which generate electrical energy. This is a practical skills based unit which will give students the ability to wire up an electrical circuit, manufacture parts, assemble, and test a small scale wind turbine. The learners will use prepared components to build the turbine. Team working is seen as an essential element in this unit. Energy: Employability and Careers (National 5) — Mandatory Learners will review their performance in the employability skills undertaken in significant practical activities in the units throughout the course and evaluate their own strengths and weaknesses. It will also involve students investigating careers and job roles within the energy sector.October 2018, version 3.0 9 Energy and the Individual (National 5) — Optional Learners will investigate the energy they use over an average year. This will include producing their own carbon footprint. From the data gained, they will review and evaluate their lifestyles to try and reduce the energy they consume and thereby reduce the size of their carbon emissions/footprint. Presentation skills will also be developed in this unit. Energy: Oil/Gas Extraction (National 5) — Optional Learners will be introduced to the formation of oil and gas fields and the sustainability of these fields, and the type of platform construction used on offshore installations. The methods used to extract oil and gas including drilling, mud, and fluid control will also be investigated. Energy: Conventional Technologies and the Grid (National 5) — Optional Learners will investigate how conventional energy generation plants support the UK's total energy needs and review the effect each of them has on the environment. They will investigate systems used to generate electricity using coal, oil, gas, hydro, and nuclear energy as a power source. The national grid and the distribution of energy/power will be investigated from both present, and projected, future needs. Conditions of award To achieve the award of National 5 Skills for Work Energy, learners must achieve all the required units as outlined in the course outline. They will be assessed pass/fail within centres. Skills for Work Courses are not graded. October 2018, version 3.0 10 Assessment Assessment objectives The aim of the assessment in this course is to provide opportunities to gather evidence of development in: • practical skills • review and evaluation skills • investigation skills • knowledge and understanding Unit assessment The assessment of the units in this course will be as follows: Unit title Assessment Mandatory units Energy: An Introduction (National 5) outcome 1, outcome 2 and outcome 3 — investigation outcome 4 — group presentation Energy: Domestic Solar Hot Water Systems (National 5) outcome 1 individual practical exercises outcome 2 and outcome 3 — teamwork practical exercise outcome 4 — presentation Domestic Wind Turbine Systems (National 5) outcome 1 and outcome 2 — individual practical exercises outcome 3 and outcome 4 — teamwork practical exercise outcome 5 — presentation Energy: Employability and Careers (National 5) outcome 1 — review and evaluation outcome 2 — presentation Unit title Assessment Optional units Energy and the Individual (National 5) outcome 1 and outcome 2 — investigation outcome 3 — presentation Energy: Oil/Gas Extraction (National 5) outcome 1 and outcome 2 — investigation outcome 3 — presentation Energy: Conventional Production Technologies and the Grid (National 5) outcome 1 and outcome 2 — investigation outcome 3 — presentation It is the intention that the necessary skills and attitudes being developed in this course are assessed through the learners' involvement in a range of practical activities, however, there are also elements of knowledge and understanding which are important. An important element in the assessment process will be the ability of the learner to review progress and development throughout the course. Where possible, assessment should reflect current workplace practice, whether demonstrated through work placement, or simulated environments.October 2018, version 3.0 11 Unit assessment Further details about unit assessment for this course can be found in the unit specifications and the assessment support materials. Exemplification of possible assessment approaches for these units will be provided in the assessment support pack. Quality assurance All instruments of assessment used within this course should be internally verified, using the appropriate policy within the centre and the guidelines set by SQA. External verification will be carried out by SQA to ensure that internal assessment is within the national guidelines for these qualifications. Further information on internal and external verification can be found in SQA's Guide to Assessment (www.sqa.org.uk/GuideToAssessment).October 2018, version 3.0 12 Development of skills for learning, skills for life and skills for work It is expected that learners will develop broad, generic skills through this course. The skills that learners will be expected to improve on and develop through the course are based on SQA's Skills Framework: Skills for Learning, Skills for Life and Skills for Work and drawn from the main skills areas listed below. These must be built into the course where there are appropriate opportunities. 1 Literacy 1.1 Reading 1.2 Writing 1.3 Listening and talking 3 Health and Wellbeing 3.1 Personal learning 3.2 Emotional wellbeing 3.4 Planning for, and making, choices and changes 4 Employability, enterprise and citizenship 4.1 Employability 4.3 Working with others 4.4 Enterprise 5 Thinking Skills 5.1 Remembering 5.2 Understanding 5.3 Applying 5.4 Analysing and evaluating 5.5 Creating Amplification of these skills is given in SQA's Skills Framework: Skills for Learning, Skills for Life and Skills for Work. The level of these skills will be appropriate to the level of the course.October 2018, version 3.0 13 Employability skills profile In addition to the specific vocational skills developed and assessed in this course, employability skills are addressed as detailed in the table below. For the purposes of the table, the units are referred to as A, B, C and D as indicated. Energy: Introduction — mandatory = A Energy: Domestic Solar Hot Water Systems — mandatory = B Domestic Energy Systems: Wind Turbine Systems — mandatory = C Energy: Employability and Careers — mandatory = D Energy and the Individual — optional = E Energy: Oil/Gas Extraction — optional = F Energy: Conventional Production Technologies and the Grid — optional = G Employability skill/attitude Evidence • Maintaining good timekeeping and attendance A, B, C, D, E/F/G • Maintaining a tidy workplace B, C • Seeking feedback and advice A, B, C, D, E/F/G • Following instructions B, C • Working co-operatively with others A, B, C • Selecting and using tools correctly and for the purpose they were designed B, C • Using Personal Protective Equipment correctly and working safely A, B, C • Following basic drawings correctly B, C • Checking quality of work A, B, C, D, E/F/G • Working to agreed deadlines A, B, C, D, E/F/G • Organising work effectively A, B, C, D, E/F/G • Working confidently A, B, C, D, E/F/G • Willingness to learn new skills or techniques B, C • Working independently A, B, C, D, E/F/G • Reflecting on own performance B, C • Learning from past experiences B, C • Awareness of a range of careers and job roles D • Developing investigation skills A, D, E/F/G • Developing presentation skills A, B, C, D, E/F/G • Developing creativity skills A, B, C, D, E/F/G Assessment evidence in all units: Learner folio of performance and product evidence in response to a given brief, supported by assessor checklists.October 2018, version 3.0 14 Course support notes Course support notes are not mandatory; they provide advice and guidance on approaches to delivering and assessing the Skills for Work course. They are intended for teachers and lecturers who are delivering the course and its units. Guidance on approaches to delivery and assessment for this course Centres should ensure that an induction to the course is given which will enable learners to understand fully what is required and the approaches to be adopted. It is important that employability skills, both generic and specific to the energy industries, are stressed at this time. Sequencing/integration of units While the sequence of delivery of the units is for individual centres to decide, it is recommended that Energy: An Introduction (National 5) unit is offered first. This unit sets the scene for the other units to be delivered in the context of the energy sector and the energy people use. All teachers, lecturers and assessors involved in the delivery and assessment of this course should have an appreciation of the nature and content of the whole course. This is particularly important in the delivery of the Energy: Employability and Careers (National 5) unit. It is intended that the evidence requirements for this unit will be drawn from the other units in the course. Guidance on approaches to delivery The course has been designed to ensure that learners learn through practical experiences where possible. The main focus in each of the skills specific units is on practical work. General vocational skills, such as selecting and maintaining tools and equipment, are integrated with practical engineering activities within the units. Energy: An Introduction (National 5) includes practical lab work where learners will gain a greater understanding of the principles of energy conversion and how we can generate more useful forms of energy that can be used in a range of energy production processes. Learners should be encouraged to investigate energy related topics, including careers, within the energy sector, and the effect energy production has on the environment or climate change. Health and safety is integral to all practical tasks and should be emphasised at the start of, and throughout, each lesson. Brief lessons on workshop protocol should also be included at the start of the practical units and at appropriate points during these units. Teaching and learning approaches will include demonstrations of practical work by tutors. Short lessons on specific aspects of industrial practice and the correct use of tools will prove invaluable at intervals throughout the learning experience. These may be followed by brief practical sessions in which the learners practise the skill emphasised by the demonstration. Given the practical nature of teaching/learning and assessment, centres should ensure that teaching blocks are of sufficient time to allow a meaningful experience for learners. Reflecting on practical experiences and learning from them is an approach that is embedded in the course. Throughout the learning experiences, the emphasis should be on helping learners to develop an awareness of the employability skills and attitudes needed for the energy industry, for example, good timekeeping, co-operating with others, team working, October 2018, version 3.0 15 taking instructions, and a positive attitude to learning. Opportunities to develop these skills and attitudes arise naturally in the work during the course. Learners should be aware that these generic skills are just as important as the practical skills they are developing. For example, it is important for workshop activities to be carried out to effective schedules; learners will have opportunities to demonstrate good timekeeping in the context of these schedules. Learners will have to co-operate with others regarding shared workspace, tools and equipment. They will have to co-operate and communicate regarding the transfer of materials, tools, and equipment safely around and across the workshop. Learners will be encouraged to develop a positive attitude to reducing waste and reduce their impact on the environment with regard to the use of materials and the consumption of energy. Teaching and learning approaches should encourage learners to take responsibility for their own learning and development. In the practical units of the course, learners need to carry out quality checks on their own work. This provides a good opportunity to motivate learners to take pride in their work. The integration of employability skills, in particular self-evaluation skills, will allow learners to take responsibility for seeking feedback and identifying action points for improvement in their own performance. This should help to develop confidence in taking advice and in asking for direction and assistance where necessary. Investigations are used throughout this course and lecturing staff should encourage learners to use as many methods as possible to gain the information they need. Apart from the teaching notes provided, learners should make full use of the internet, journals (online and paper-based), books, national and local papers, friends or family who have knowledge or experience of the energy sector, site visits, practical demonstrations, and experimentation. Presentations are also frequently used in this course. Learners should be encouraged to use their creativity skills to develop a range of skills in presenting information, this could include a talk, flipcharts, whiteboard (electronic), computer software, practical demonstrations, digital pictures, video clips (using a mobile phone or camcorder). Teaching staff should emphasise the need for learners to try and develop their own ideas to solve problems or issues; these can then be used as points for discussion. Giving learners the solution should not be seen as the first option. Learners should be encouraged to play an active part in their own learning by discussing their views and thoughts on the technologies being used, the environment, careers and personal preferences with peers and teaching staff. Guidance on approaches to assessment Throughout the course, the need for correct preparation for practical activities should be stressed. However, such preparation should not take excessive time to complete. Teaching correct skills practice, effective and safe use of tools and equipment, and a positive view of health and safety should help to ensure that preparation for practical work is comprehensive. Learners will require supervision during practical work — both on a skills level and for health and safety reasons. The learning environment should be designed to minimise risks and provide a safe context for carrying out tasks. For example, when undertaking the task of soldering, learners should be made aware of the risk from heat and fumes to themselves and others. It is recommended that each practical session be preceded by a 'tool box' talk on an aspect of health and safety relevant to the work in hand. It is recommended that learners be given regular but short practice sessions in the correct and safe working principles of the materials to be used in each session, as well as coaching in the correct use of associated tools and equipment.October 2018, version 3.0 16 Centres are encouraged to establish links with local industry. Local engineering companies, trades associations, Sector Skills Councils (SSCs) and Engineering or Energy Institutes may be prepared to offer support, for example, in the form of visits from representatives of their organisations. Visitors from the energy industry will be able to give learners a realistic view of jobs and conditions within the energy sector. Centres should try and arrange a visit to an energy generation facility as part of the learners' learning experience and assessment. Visits to local sites are often particularly useful to give learners a feel for the environment, equipment, and staff working and using energy generation systems. Site visits should be carefully arranged, organised and authorised. Due regard should be placed on insurance arrangements, necessary when taking students on these visits, particularly when going on to industrial sites. Teaching and learning approaches should impart enthusiasm and help to inform learners of realistic prospects in the energy industries. They should become aware of steps to employment or further training. Through their experiences of the various practical skills and knowledge of various energy systems in the course, they should become better equipped to make valid personal choices regarding careers and further study. A holistic approach to the course delivery and assessment should be adopted. The types of energy generation methods and plant/systems contained within the Energy: An Introduction (National 5) unit should form the basis of the practical units Energy: Domestic Wind Turbine Systems (National 5) and Energy: Domestic Solar Hot Water Systems (National 5). Energy: Employability and Careers (National 5) unit should be central to the whole course and delivered alongside the other units. Opportunities for e-assessment E-assessment may be appropriate for some assessments in this course. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the evidence requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment. Opportunities for developing Core Skills Learners will be encouraged to learn through practical activity with workshop skills, and practical lab work, forming a main type of delivery. The development of Core Skills and employability skills should be uppermost in the minds of those considering how to plan lessons. Learners should be encouraged to accept responsibility for learning and ownership of the review and self-evaluation process. The Energy: Employability and Careers (National 5) unit, in particular, will actively encourage learners to analyse their strengths and weaknesses with regard to the employability skills identified within the course units and review their own performance through self-reflection and self-evaluation. Tasks involving investigations into energy systems and the effects these energy systems have on individuals or the environment should be incorporated throughout the course. This approach will encourage development in the use of information technology as a tool for information gathering and analysis, independent working, and investigation skills.October 2018, version 3.0 17 Opportunities to develop aspects of Core Skills should be used where they arise naturally. For example, in order to carry out activities in a workshop environment, learners will develop aspects of numeracy when making calculations and taking measurements. They will also have to communicate simple science/engineering/construction terms with tutors and fellow learners regarding skills practices, materials and tools, health and safety, and working together in the workplace. They will have to work in a team during the practical units; it is important that they realise what the positive attitudes are to ensure good team working dynamics. Aspects of Problem Solving will arise through their participation in practical work. This course gives automatic certification of Working with Others at SCQF level 4, Critical Thinking at SCQF level 4, and Planning and Organising at SCQF level 4.October 2018, version 3.0 18 General information for learners The National 5 Skills for Work Energy course is an introduction to the various energy industries based in the UK. You will also develop practical skills by building a small scale solar hot water system and wind turbine, review your employability skills and evaluate your own strengths and weaknesses. There is an opportunity to specialise in one subject area by selecting one of the three specialist areas to study: • analyse your own carbon footprint • develop a deeper knowledge of oil and gas production in the North Sea • develop further knowledge on the conventional energy generation systems used in the UK The primary target group for this course is school learners in S3 and S4. However, it is also suitable if you are an S5/S6 learner, or an adult learner wanting to increase employability and vocational skills in the energy sector. Once you have finished this course, you may progress to: • a National Progression Award • a National Certificate programme in Further Education • training/employmentOctober 2018, version 3.0 19 Administrative information Published: October 2018 (version 3.0) History of changes to national course specification Version Description of change Date 2.0 2013 — course re-coded as part of CfE development programme but no change to course and unit content. August 2013 3.0 Course specification moved to a new template. No change to content. Units re-coded to align with corresponding course 2 code. October 2018 This specification may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. Additional copies of this course specification can be downloaded from SQA's website at www.sqa.org.uk. Note: You are advised to check SQA's website (www.sqa.org.uk) to ensure you are using the most up-to-date version of the course specification. © Scottish Qualifications Authority 2013, 2018 1 National Qualifications 2019 Qualification Verification Summary Report Skills for Work: Energy The purpose of this report is to provide feedback to centres on verification in National Qualifications in this subject.Skills for Work Courses Skills for Work: Energy (National 5) General comments This session saw an increase in the number of centres offering this award. All the newly-approved centres were schools and it appears that the 're-branding' of the award as 'National 5 Energy' was a significant factor in the increase. Course arrangements, unit specifications, instruments of assessment and exemplification materials The majority of the assessments used were from the assessment support packs, or localised adaptations of these. In all cases where adaptions had been made, these were appropriate and assessments remained valid. Evidence requirements At each of the four centres visited, candidate evidence that was reviewed met the requirements of the unit specifications. Evidence was presented in the form of physical artefacts, paper documents and electronic submissions. Administration of assessments Assessments had been administered correctly and all assessment and internal verification judgements were valid for the samples reviewed. Centres have been utilising appropriate practices and documentation to administer and record their internal verification activity. Areas of good practice • Internal verification processes supported by course documents including a course verification plan with a checklist of required actions and associated comments. • Innovation in the use of resources required to deliver the award successfully — for example, the use of component kits to facilitate efficient assembly work by candidates. • Up-cycling of discarded materials for the construction element of the Domestic Wind Turbine module. • The use of an online calculator to assist candidates evaluate their own carbon footprint helps reinforce the significance of the environmental impact of individuals. 2 National 4 Skills for Work Engineering Skills Course Specification (C243 74) Valid from August 2013 This edition, October 2018, version 3.0 This specification may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. Additional copies of this course specification can be downloaded from SQA's website: www.sqa.org.uk. Please refer to the note of changes at the end of this course specification for details of changes from previous version (where applicable). © Scottish Qualifications Authority 2013, 2018October 2018, version 3.0 1 Course outline Course title: National 4 Skills for Work Engineering Skills SCQF credit points: (24 SCQF credit points) Course code: C243 74 Mandatory units The course comprises the following mandatory units: J16F 74 Engineering Skills: Mechanical 6 SCQF credit points J16G 74 Engineering Skills: Electrical/Electronic 6 SCQF credit points J145 74 Engineering Skills: Fabrication 6 SCQF credit points J144 74 Engineering Skills: Manufacture and Assembly 6 SCQF credit points Recommended entry Entry to this course is at the discretion of the centre. However, learners would normally be expected to have attained the skills, knowledge and understanding required by the following or equivalent qualifications and/or experience: • an interest in engineering • an ability to work in numeracy and literacy at SCQF level 3 • some aptitude for graphical forms of communication In terms of prior learning and experience, relevant experiences and outcomes may also provide an appropriate basis for doing this course. Progression This course or its components may provide progression to: • Scottish Progression Award in Engineering (National 5) • SVQs and Modern Apprenticeships in Engineering areas • further study, employment and/or trainingOctober 2018, version 3.0 2 Core Skills Achievement of this course gives automatic certification of the following Core Skills component: Core Skill component Critical Thinking at SCQF level 4 There are also opportunities to develop aspects of Core Skills which are highlighted in the support notes of this unit specification. Links to National Occupational Standards National Occupational Standards (NOS) are developed by the key employment sectors of the United Kingdom. These standards set the competences required for job roles within a particular employment sector. The National 4 Skills for Work Engineering Skills course has been designed to link broadly to NOS, but the standards required of first-year apprentices in the engineering industry are significantly more onerous than those in this course. Compared to NOS, this course requires either reduced scale and complexity, or more achievable tolerances, and therefore provides a useful preparation for employment or further training in the engineering industry. The general tolerance required for the practical activities in this course should be ±3mm. The specific tolerances required for practical unit assessments are specified in the assessment support packs (ASPs). Further details are provided in the 'Rationale' section. Equality and inclusion This Course Arrangements Specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.October 2018, version 3.0 3 Common rationale for Skills for Work Courses Skills for Work Courses are designed to help learners to develop: • skills and knowledge in a broad vocational area • skills for learning, skills for life and skills for work • Core Skills • an understanding of the workplace • positive attitudes to learning • skills and attitudes for employability A key feature of these courses is the emphasis on experiential learning. This means learning through practical experience and learning by reflecting on experience. Learning through practical experience Teaching/learning programmes should include some or all of the following: • learning in real or simulated workplace settings • learning through role play activities in vocational contexts • carrying out case study work • planning and carrying out practical tasks and assignments Learning through reflecting at all stages of the experience Teaching/learning programmes should include some or all of the following: • preparing and planning for the experience • taking stock throughout the experience, reviewing and adapting as necessary • reflecting after the activity has been completed, evaluating and identifying learning points The Skills for Work Courses are also designed to provide learners with opportunities for developing Core Skills, and Skills for Learning, Skills for Life and Skills for Work with a focus on enhancing skills and attitudes for employability.October 2018, version 3.0 4 Core Skills The five Core Skills are: • Communication • Numeracy • Information and Communication Technology (ICT) • Problem Solving • Working with Others Employability The skills and attitudes for employability, including self-employment, are outlined below: • generic skills/attitudes valued by employers • understanding of the workplace and the employee's responsibilities, for example, time keeping, appearance, customer care, etc • self-evaluation skills • positive attitude to learning • flexible approaches to solving problems • adaptability and positive attitude to change • confidence to set goals, reflect and learn from experience • specific vocational skills/knowledge Course specifications highlight the links to NOS in the vocational area and identify progression opportunities. Opportunities for developing these skills and attitudes are highlighted in each of the course and unit specifications. These opportunities include giving young people direct access to workplace experiences or, through partnership arrangements, providing different learning environments and experiences which simulate aspects of the workplace. These experiences might include visits, visiting speakers, role play and other practical activities. A Curriculum for Excellence (Scottish Executive 2004) identifies aspirations for every young person. These are that they should become: • successful learners • confident individuals • responsible citizens • effective contributors The learning environments, the focus on experiential learning and the opportunities to develop employability, Skills for Learning, Skills for Life, Skills for Work and Core Skills in these courses contribute to meeting these aspirations.October 2018, version 3.0 5 Course rationale for National 4 Skills for Work Engineering Skills All new and revised National Courses reflect Curriculum for Excellence values, purposes and principles. They offer flexibility, provide more time for learning, more focus on skills and applying learning, and scope for personalisation and choice. In this course, and its component units, there will be an emphasis on skills development and the application of those skills. Assessment approaches will be proportionate, fit for purpose and will promote best practice, enabling learners to achieve the highest standards they can. This Skills for Work course is also designed to provide learners with opportunities for developing Core Skills and Skills for Learning, Skills for Life and Skills for Work, with a strong focus on enhancing skills and attitudes for employability. The National 4 Skills for Work Engineering Skills course has been designed to provide a basis for progression into further education or for moving directly into training in employment within an engineering sector. The overall purpose of the course is to ensure that learners start to develop the generic and practical skills, knowledge and understanding and employability skills needed within an engineering sector. The engineering sector includes the following: Mechanical Manufacture Maintenance Fabrication Welding Electrical Electronic Foundry Automotive Servicing Transport Aeronautical Communications Space Energy generation Conservation Marine Water Salination Oil/Gas Petroleum This course focuses on the four broad areas of mechanical, electrical/electronic, fabrication and manufacture. This will allow the learners to gain basic transferable skills which can be applied to any of the above engineering areas. Purposes and aims of the course The general aims of this course are to: • Widen participation in vocationally-related learning for school learners from S3 upwards. • Allow learners to experience vocationally-related learning. • Provide learners with a broad introduction to the engineering vocational sector. • Encourage learners to foster a good work ethic, including time-keeping, a positive attitude and other relevant employability skills. • Provide opportunities to develop a range of Core Skills in a vocational context. • Encourage learners to take charge of their own learning and development. • Provide a range of teaching, learning and assessment styles to motivate learners to achieve their full potential. • Facilitate progression to further education and/or training. • Encourage learners to plan their work and review their progress. • Encourage learners to develop a positive attitude to waste minimisation and environmental issues.October 2018, version 3.0 6 In particular, the aims of the National 4 Skills for Work Engineering Skills course are to: • Encourage learners to consider a career in the engineering industry. • Develop an awareness of the opportunities there may be within engineering in terms of the types and range of career options. • Enable learners to develop and apply practical, technical and communication skills as a foundation for future learning and progression. • Develop the learners' awareness of their individual strengths and weaknesses in relation to the requirements of engineering, and to reflect on how this affects their employability potential. • Give learners the technical knowledge, skills and understanding associated with a range of skills in engineering at this level. • Encourage learners to apply their knowledge and understanding of engineering by using skills of evaluation and problem solving in a vocational context. • Develop an awareness that health and safety issues are integral to the world of work generally and engineering in particular. • Prepare learners for further learning opportunities, study and training for employment in engineering and related occupations. Information about typical learners who might do the course The primary target group for this course is school learners in S3 and above. This course is designed at a level and scope such that it can be delivered in schools, if the school has suitable facilities and teaching expertise. Due to the specialist expertise and facilities available in further education colleges and with training providers, it is anticipated that the course will rely on, and build on, existing partnerships between schools, further education colleges, training providers and employers, A partnership approach will enable the course to be delivered in a variety of appropriate learning environments enhancing the learning experience. The course is also suitable for adult learners who are seeking to enhance their employability and develop introductory vocational skills in an engineering sector.October 2018, version 3.0 7 Course structure and conditions of award Summary of course content This course comprises four 40-hour units. The content of the course focuses on the development of basic hand skills across the disciplines of mechanical, electrical/electronic, fabrication and manufacture and assembly. Central to the content are the generic employability skills valued by employers in an engineering sector. These skills are developed in each of the four units and are assessed at least twice during the course. These add value to the development of the specific vocational skills. All the engineering skills units, while focusing on specific skill areas, also address generic skills related to: • engineering communications • engineering materials • measurement and marking • working to tolerances • Core Skills The engineering skills units also include employability skills outlined below: • time-keeping and attendance • positive attitudes to learning • responding positively to advice and feedback • following instructions • working co-operatively with others • health and safety awareness • necessary preparation planning • checking own work • problem solving Summary of unit content Units are statements of standards for assessment and not programmes of learning and teaching. They can be delivered in a variety of ways; however Skills for Work units are designed to provide an experiential learning process. Engineering Skills: Mechanical (National 4) This unit is designed to be the first attempted on the course. Learners are required to select the correct tools and materials required to safely manufacture an artefact. During the manufacture, learners will read simple engineering drawings, measure and mark, select appropriate materials and work to specified tolerances. Embedded into the practical activities of this unit are the employability skills that employers value. Although it is envisaged that all employability skills will be developed in this unit, not all will be assessed. Engineering Skills: Electrical/Electronic (National 4) In this unit learners will select the correct tools and components required to construct a basic functional extra low voltage electrical/electronic circuit from a given diagram and specification. Embedded into the practical activities of this unit are the employability skills that employers value. 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In particular, assessment will focus on: • practical vocational skills • skills for employment in an engineering context Unit assessment In all of the units that focus on the development of specific engineering skills, assessment follows a similar pattern involving a range of practical activities which will produce evidence for all the outcomes. The evidence will be confirmed by the use of an assessor checklist, which will cover: • interpretation of a drawing or specification • the appropriate use of tools, materials and equipment • successful involvement in the completion of a task, product or assembly • quality checking of their work by the learner • attention to health and safety aspects of working in a workshop type of environment The assessment of employability skills is integrated in all of the units and is based on assessor checklists and the completion of a learner review sheet on four different occasions throughout the course. 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They are intended for teachers and lecturers who are delivering the course and its units. Guidance on approaches to delivery and assessment for this course The course has been designed to ensure that learners learn through practical experiences. The main focus in each of the skills specific units is on practical work. General vocational skills, such as selecting and maintaining tools and equipment, are integrated with practical engineering activities within the units. Health and safety is integral to all practical tasks and should be emphasised at the start of and throughout each lesson. Brief lessons on workshop protocol should also be included. Teaching and learning approaches will include demonstrations of practical work by tutors. Short lessons on specific aspects of industrial practice and the correct use of tools will prove invaluable at intervals throughout the learning experience. 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For example, it is important for workshop activities to be carried out to effective schedules; learners will have opportunities to demonstrate good time-keeping in the context of these schedules. Learners will have to co-operate with others regarding shared workspace, tools and equipment. They will have to co-operate and communicate regarding the transfer of materials, tools and equipment safely around and across the workshop. Learners will be encouraged to develop a positive attitude to waste minimisation and environmental issues regarding the use of materials. The work of the course will increase awareness that health and safety issues are important in the world of work generally and in engineering in particular. In carrying out engineering activities, learners will learn that there are correct and incorrect ways to use tools and equipment. Tutors will have ample opportunity to demonstrate good practice and correct procedures to learners, who will learn the importance to self and others of following instructions. Such positive experiences will foster a positive attitude to learning.October 2018, version 3.0 13 Teaching and learning approaches should impart enthusiasm and help to inform learners of realistic prospects in the engineering sector or in industry generally. They should become aware of steps to employment or further training. Through their experiences of the various practical skills in the course, they should become better equipped to make valid personal choices regarding careers and further study. Sequencing/integration of units The course has four mandatory units which offer a broad range of different engineering experiences. It is recommended that the unit Engineering Skills: Mechanical (National 4) is attempted and completed initially as some aspects of the content of this unit are incorporated in all of the other course units. The Engineering Skills: Manufacture and Assembly (National 4) unit should only be attempted after successful completion of the other three units. It is important that a well-planned induction to the course is delivered, emphasising its integrated nature and stressing the importance of generic employability skills throughout. Employability skills should span the course, allowing learners ample opportunity to develop and review employability skills and attitudes over a range of engineering skills and over a reasonable period of time. Guidance on approaches to delivery Throughout the course, the need for correct preparation for practical activities should be stressed. However, such preparation should not take excessive time to complete. Teaching correct skills practice, effective use of tools and equipment and a positive view of health and safety should help to ensure that preparation for practical work is comprehensive. Learners will require supervision during practical work — both on a skills level and for health and safety reasons. The learning environment should be designed to minimise risks and provide a safe context for carrying out tasks. For example, when undertaking the task of Metal Active Gas (MAG) welding learners should be made aware of the risk from fire, fumes and harmful rays to themselves and others. It is recommended that each practical session be preceded by a 'tool box' talk on an aspect of health and safety relevant to the work in hand. It is recommended that learners be given regular but short practice sessions in the correct use of the materials to be used in each session as well as coaching in the correct use of associated tools and equipment. Centres are encouraged to establish links with local industry. Local engineering companies, trades associations, Sector Skills Councils (SSCs), Institutes and Chambers of Commerce may be prepared to offer support, for example, in the form of visits from representatives of their organisations. Visitors from industry will be able to give learners a realistic view of jobs and conditions in the engineering industry. It may be possible for centres to arrange visits to engineering works as part of the learners' learning experience. Visits to local industry are often particularly useful because work in progress will be at different stages and learners can see various different trades working at the same time. Industrial visits should be carefully arranged, organised and authorised. It would be preferable for those responsible for such visits to have prior knowledge of the industry in question.October 2018, version 3.0 14 Guidance on approaches to assessment Approaches to assessment that promote the efficient and effective gathering of evidence are to be encouraged. The development and assessment of generic employability skills is a key feature of this course and is integrated with the skills specific units. Learners can readily gather evidence for assessment during their work in these practical skills units. Reviewing progress with engineering employability skills and attitudes will take place in the practical context of work in the different activities. Learners will complete a minimum of four review sheets in the different trade activities. Assessment of interpreting drawings and specifications and materials should also take place during the work in skills specific practical units. An employability skills profile for the course is included and this gives a clear indication of where assessment evidence is gathered for generic employability skills. Within the skills specific practical units, the learner will produce evidence as a natural part of the learning and teaching process. Learners will first learn and practise the correct techniques and methods for each of the skills they undertake. Assessment of the various practical tasks will take place at appropriate points throughout the course, allowing time for learners to make quality checks of their finished products against the prescribed tolerances, before being submitted for assessment. In the Engineering Skills: Manufacture and Assembly (National 4) unit learners can if appropriate work in teams of no more than three to manufacture and assemble an artefact. It is expected that the artefact produced by such a team will be of sufficient complexity and scope to allow all members of the team to make a contribution equal to the manufacture and assembly of an artefact by an individual learner. The artefact manufactured by a team can be, for example, a community-based project for the school, college or a youth group. Where this occurs, each learner must identify their contribution to the completion of the task and present evidence to satisfy the assessor that all outcomes and performance criteria have been met. Opportunities for e-assessment E-assessment may be appropriate for some assessments in this course. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the evidence requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment. Opportunities for developing Core Skills Opportunities to develop aspects of Core Skills should be used where they arise naturally. For example, in order to carry out engineering activities in a workshop environment, learners will develop aspects of Numeracy when making engineering calculations and taking measurements. They will also have to communicate simple engineering terms with tutors and fellow learners regarding skills practices, materials and tools, health and safety and working together in the workplace. Aspects of Problem Solving will arise through their participation in practical work.October 2018, version 3.0 15 Teaching and learning approaches should encourage learners to take responsibility for their own learning and development. In the practical units of the course, learners need to carry out quality checks on their own work. This provides a good opportunity to motivate learners to take pride in their work. The integration of employability skills, in particular self-evaluation skills, will allow learners to take responsibility for seeking feedback and identifying action points for improvement in their own performance. This should help to develop confidence in taking advice and in asking for direction and assistance where necessary. This course gives automatic certification of the Core Skill component Critical Thinking at SCQF level 4. October 2018, version 3.0 16 General information for learners The National 4 Skills for Work Engineering Skills course focuses on four broad areas of engineering — mechanical, electrical/electronic, fabrication and manufacture. You will learn the basic skills across these areas by the: • Interpretation of a drawing or specification. • Appropriate use of tools, materials and equipment. • Successful involvement in the completion of a task, product or assembly. • Quality checking of your own work. • Attention to health and safety aspects of working in a workshop type of environment. Integrated throughout the course is the development of generic employability skills valued by employers in an engineering sector. Your assessor will use checklists and you will complete a learner review sheet on four different occasions throughout the course. The National 4 Skills for Work Engineering Skills course provides a basis for progression into further education or for moving directly into training in employment within an engineering sector. October 2018, version 3.0 17 Administrative information Published: October 2018 (version 3.0) History of changes to national course specification Version Description of change Date 2.0 2013 — course re-coded as part of CfE development programme but no change to course and unit content. August 2013 3.0 Course specification moved to a new template. No change to content. Units re-coded to align with corresponding course 2 code. October 2018 This specification may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. Additional copies of this course specification can be downloaded from SQA's website at www.sqa.org.uk. Note: You are advised to check SQA's website (www.sqa.org.uk) to ensure you are using the most up-to-date version of the course specification. © Scottish Qualifications Authority 2013, 2018 National 4 Skills for Work Engineering Skills Course Specification (C243 74) Valid from August 2013 This edition, October 2018, version 3.0 This specification may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. Additional copies of this course specification can be downloaded from SQA's website: www.sqa.org.uk. Please refer to the note of changes at the end of this course specification for details of changes from previous version (where applicable). © Scottish Qualifications Authority 2013, 2018October 2018, version 3.0 1 Course outline Course title: National 4 Skills for Work Engineering Skills SCQF credit points: (24 SCQF credit points) Course code: C243 74 Mandatory units The course comprises the following mandatory units: J16F 74 Engineering Skills: Mechanical 6 SCQF credit points J16G 74 Engineering Skills: Electrical/Electronic 6 SCQF credit points J145 74 Engineering Skills: Fabrication 6 SCQF credit points J144 74 Engineering Skills: Manufacture and Assembly 6 SCQF credit points Recommended entry Entry to this course is at the discretion of the centre. However, learners would normally be expected to have attained the skills, knowledge and understanding required by the following or equivalent qualifications and/or experience: • an interest in engineering • an ability to work in numeracy and literacy at SCQF level 3 • some aptitude for graphical forms of communication In terms of prior learning and experience, relevant experiences and outcomes may also provide an appropriate basis for doing this course. Progression This course or its components may provide progression to: • Scottish Progression Award in Engineering (National 5) • SVQs and Modern Apprenticeships in Engineering areas • further study, employment and/or trainingOctober 2018, version 3.0 2 Core Skills Achievement of this course gives automatic certification of the following Core Skills component: Core Skill component Critical Thinking at SCQF level 4 There are also opportunities to develop aspects of Core Skills which are highlighted in the support notes of this unit specification. Links to National Occupational Standards National Occupational Standards (NOS) are developed by the key employment sectors of the United Kingdom. These standards set the competences required for job roles within a particular employment sector. The National 4 Skills for Work Engineering Skills course has been designed to link broadly to NOS, but the standards required of first-year apprentices in the engineering industry are significantly more onerous than those in this course. Compared to NOS, this course requires either reduced scale and complexity, or more achievable tolerances, and therefore provides a useful preparation for employment or further training in the engineering industry. The general tolerance required for the practical activities in this course should be ±3mm. The specific tolerances required for practical unit assessments are specified in the assessment support packs (ASPs). Further details are provided in the 'Rationale' section. Equality and inclusion This Course Arrangements Specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.October 2018, version 3.0 3 Common rationale for Skills for Work Courses Skills for Work Courses are designed to help learners to develop: • skills and knowledge in a broad vocational area • skills for learning, skills for life and skills for work • Core Skills • an understanding of the workplace • positive attitudes to learning • skills and attitudes for employability A key feature of these courses is the emphasis on experiential learning. This means learning through practical experience and learning by reflecting on experience. Learning through practical experience Teaching/learning programmes should include some or all of the following: • learning in real or simulated workplace settings • learning through role play activities in vocational contexts • carrying out case study work • planning and carrying out practical tasks and assignments Learning through reflecting at all stages of the experience Teaching/learning programmes should include some or all of the following: • preparing and planning for the experience • taking stock throughout the experience, reviewing and adapting as necessary • reflecting after the activity has been completed, evaluating and identifying learning points The Skills for Work Courses are also designed to provide learners with opportunities for developing Core Skills, and Skills for Learning, Skills for Life and Skills for Work with a focus on enhancing skills and attitudes for employability.October 2018, version 3.0 4 Core Skills The five Core Skills are: • Communication • Numeracy • Information and Communication Technology (ICT) • Problem Solving • Working with Others Employability The skills and attitudes for employability, including self-employment, are outlined below: • generic skills/attitudes valued by employers • understanding of the workplace and the employee's responsibilities, for example, time keeping, appearance, customer care, etc • self-evaluation skills • positive attitude to learning • flexible approaches to solving problems • adaptability and positive attitude to change • confidence to set goals, reflect and learn from experience • specific vocational skills/knowledge Course specifications highlight the links to NOS in the vocational area and identify progression opportunities. Opportunities for developing these skills and attitudes are highlighted in each of the course and unit specifications. These opportunities include giving young people direct access to workplace experiences or, through partnership arrangements, providing different learning environments and experiences which simulate aspects of the workplace. These experiences might include visits, visiting speakers, role play and other practical activities. A Curriculum for Excellence (Scottish Executive 2004) identifies aspirations for every young person. These are that they should become: • successful learners • confident individuals • responsible citizens • effective contributors The learning environments, the focus on experiential learning and the opportunities to develop employability, Skills for Learning, Skills for Life, Skills for Work and Core Skills in these courses contribute to meeting these aspirations.October 2018, version 3.0 5 Course rationale for National 4 Skills for Work Engineering Skills All new and revised National Courses reflect Curriculum for Excellence values, purposes and principles. They offer flexibility, provide more time for learning, more focus on skills and applying learning, and scope for personalisation and choice. In this course, and its component units, there will be an emphasis on skills development and the application of those skills. Assessment approaches will be proportionate, fit for purpose and will promote best practice, enabling learners to achieve the highest standards they can. This Skills for Work course is also designed to provide learners with opportunities for developing Core Skills and Skills for Learning, Skills for Life and Skills for Work, with a strong focus on enhancing skills and attitudes for employability. The National 4 Skills for Work Engineering Skills course has been designed to provide a basis for progression into further education or for moving directly into training in employment within an engineering sector. The overall purpose of the course is to ensure that learners start to develop the generic and practical skills, knowledge and understanding and employability skills needed within an engineering sector. The engineering sector includes the following: Mechanical Manufacture Maintenance Fabrication Welding Electrical Electronic Foundry Automotive Servicing Transport Aeronautical Communications Space Energy generation Conservation Marine Water Salination Oil/Gas Petroleum This course focuses on the four broad areas of mechanical, electrical/electronic, fabrication and manufacture. This will allow the learners to gain basic transferable skills which can be applied to any of the above engineering areas. Purposes and aims of the course The general aims of this course are to: •Widen participation in vocationally-related learning for school learners from S3 upwards. •Allow learners to experience vocationally-related learning. •Provide learners with a broad introduction to the engineering vocational sector. •Encourage learners to foster a good work ethic, including time-keeping, a positive attitude and other relevant employability skills. •Provide opportunities to develop a range of Core Skills in a vocational context. •Encourage learners to take charge of their own learning and development. •Provide a range of teaching, learning and assessment styles to motivate learners to achieve their full potential. •Facilitate progression to further education and/or training. •Encourage learners to plan their work and review their progress. •Encourage learners to develop a positive attitude to waste minimisation and environmental issues.October 2018, version 3.0 6 In particular, the aims of the National 4 Skills for Work Engineering Skills course are to: •Encourage learners to consider a career in the engineering industry. •Develop an awareness of the opportunities there may be within engineering in terms of the types and range of career options. •Enable learners to develop and apply practical, technical and communication skills as a foundation for future learning and progression. •Develop the learners' awareness of their individual strengths and weaknesses in relation to the requirements of engineering, and to reflect on how this affects their employability potential. •Give learners the technical knowledge, skills and understanding associated with a range of skills in engineering at this level. •Encourage learners to apply their knowledge and understanding of engineering by using skills of evaluation and problem solving in a vocational context. •Develop an awareness that health and safety issues are integral to the world of work generally and engineering in particular. •Prepare learners for further learning opportunities, study and training for employment in engineering and related occupations. 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They are intended for teachers and lecturers who are delivering the course and its units. Guidance on approaches to delivery and assessment for this course The course has been designed to ensure that learners learn through practical experiences. The main focus in each of the skills specific units is on practical work. General vocational skills, such as selecting and maintaining tools and equipment, are integrated with practical engineering activities within the units. Health and safety is integral to all practical tasks and should be emphasised at the start of and throughout each lesson. Brief lessons on workshop protocol should also be included. Teaching and learning approaches will include demonstrations of practical work by tutors. Short lessons on specific aspects of industrial practice and the correct use of tools will prove invaluable at intervals throughout the learning experience. These may be followed by brief practical sessions in which the learners practise the skill emphasised by the demonstration. Given the practical nature of teaching/learning and assessment, centres should ensure that teaching blocks are of sufficient time to allow a meaningful experience for learners. Reflecting on practical experiences and learning from them is an approach that is embedded in the course. Throughout the learning experiences, the emphasis should be on helping learners to develop an awareness of the employability skills and attitudes needed for the engineering industry, for example, good time-keeping, co-operating with others, taking instructions, and a positive attitude to learning. Opportunities to develop these skills and attitudes arise naturally in the work of the course. Learners should be aware that these generic skills are just as important as the practical engineering skills they are developing. For example, it is important for workshop activities to be carried out to effective schedules; learners will have opportunities to demonstrate good time-keeping in the context of these schedules. Learners will have to co-operate with others regarding shared workspace, tools and equipment. They will have to co-operate and communicate regarding the transfer of materials, tools and equipment safely around and across the workshop. Learners will be encouraged to develop a positive attitude to waste minimisation and environmental issues regarding the use of materials. The work of the course will increase awareness that health and safety issues are important in the world of work generally and in engineering in particular. In carrying out engineering activities, learners will learn that there are correct and incorrect ways to use tools and equipment. Tutors will have ample opportunity to demonstrate good practice and correct procedures to learners, who will learn the importance to self and others of following instructions. Such positive experiences will foster a positive attitude to learning.October 2018, version 3.0 13 Teaching and learning approaches should impart enthusiasm and help to inform learners of realistic prospects in the engineering sector or in industry generally. They should become aware of steps to employment or further training. Through their experiences of the various practical skills in the course, they should become better equipped to make valid personal choices regarding careers and further study. Sequencing/integration of units The course has four mandatory units which offer a broad range of different engineering experiences. It is recommended that the unit Engineering Skills: Mechanical (National 4) is attempted and completed initially as some aspects of the content of this unit are incorporated in all of the other course units. The Engineering Skills: Manufacture and Assembly (National 4) unit should only be attempted after successful completion of the other three units. It is important that a well-planned induction to the course is delivered, emphasising its integrated nature and stressing the importance of generic employability skills throughout. Employability skills should span the course, allowing learners ample opportunity to develop and review employability skills and attitudes over a range of engineering skills and over a reasonable period of time. Guidance on approaches to delivery Throughout the course, the need for correct preparation for practical activities should be stressed. However, such preparation should not take excessive time to complete. Teaching correct skills practice, effective use of tools and equipment and a positive view of health and safety should help to ensure that preparation for practical work is comprehensive. Learners will require supervision during practical work — both on a skills level and for health and safety reasons. The learning environment should be designed to minimise risks and provide a safe context for carrying out tasks. For example, when undertaking the task of Metal Active Gas (MAG) welding learners should be made aware of the risk from fire, fumes and harmful rays to themselves and others. It is recommended that each practical session be preceded by a 'tool box' talk on an aspect of health and safety relevant to the work in hand. It is recommended that learners be given regular but short practice sessions in the correct use of the materials to be used in each session as well as coaching in the correct use of associated tools and equipment. Centres are encouraged to establish links with local industry. Local engineering companies, trades associations, Sector Skills Councils (SSCs), Institutes and Chambers of Commerce may be prepared to offer support, for example, in the form of visits from representatives of their organisations. Visitors from industry will be able to give learners a realistic view of jobs and conditions in the engineering industry. It may be possible for centres to arrange visits to engineering works as part of the learners' learning experience. Visits to local industry are often particularly useful because work in progress will be at different stages and learners can see various different trades working at the same time. Industrial visits should be carefully arranged, organised and authorised. It would be preferable for those responsible for such visits to have prior knowledge of the industry in question.October 2018, version 3.0 14 Guidance on approaches to assessment Approaches to assessment that promote the efficient and effective gathering of evidence are to be encouraged. The development and assessment of generic employability skills is a key feature of this course and is integrated with the skills specific units. Learners can readily gather evidence for assessment during their work in these practical skills units. Reviewing progress with engineering employability skills and attitudes will take place in the practical context of work in the different activities. Learners will complete a minimum of four review sheets in the different trade activities. Assessment of interpreting drawings and specifications and materials should also take place during the work in skills specific practical units. An employability skills profile for the course is included and this gives a clear indication of where assessment evidence is gathered for generic employability skills. Within the skills specific practical units, the learner will produce evidence as a natural part of the learning and teaching process. Learners will first learn and practise the correct techniques and methods for each of the skills they undertake. Assessment of the various practical tasks will take place at appropriate points throughout the course, allowing time for learners to make quality checks of their finished products against the prescribed tolerances, before being submitted for assessment. In the Engineering Skills: Manufacture and Assembly (National 4) unit learners can if appropriate work in teams of no more than three to manufacture and assemble an artefact. It is expected that the artefact produced by such a team will be of sufficient complexity and scope to allow all members of the team to make a contribution equal to the manufacture and assembly of an artefact by an individual learner. The artefact manufactured by a team can be, for example, a community-based project for the school, college or a youth group. Where this occurs, each learner must identify their contribution to the completion of the task and present evidence to satisfy the assessor that all outcomes and performance criteria have been met. Opportunities for e-assessment E-assessment may be appropriate for some assessments in this course. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the evidence requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment. Opportunities for developing Core Skills Opportunities to develop aspects of Core Skills should be used where they arise naturally. For example, in order to carry out engineering activities in a workshop environment, learners will develop aspects of Numeracy when making engineering calculations and taking measurements. They will also have to communicate simple engineering terms with tutors and fellow learners regarding skills practices, materials and tools, health and safety and working together in the workplace. Aspects of Problem Solving will arise through their participation in practical work.October 2018, version 3.0 15 Teaching and learning approaches should encourage learners to take responsibility for their own learning and development. In the practical units of the course, learners need to carry out quality checks on their own work. This provides a good opportunity to motivate learners to take pride in their work. The integration of employability skills, in particular self-evaluation skills, will allow learners to take responsibility for seeking feedback and identifying action points for improvement in their own performance. This should help to develop confidence in taking advice and in asking for direction and assistance where necessary. This course gives automatic certification of the Core Skill component Critical Thinking at SCQF level 4. October 2018, version 3.0 16 General information for learners The National 4 Skills for Work Engineering Skills course focuses on four broad areas of engineering — mechanical, electrical/electronic, fabrication and manufacture. You will learn the basic skills across these areas by the: •Interpretation of a drawing or specification. •Appropriate use of tools, materials and equipment. •Successful involvement in the completion of a task, product or assembly. •Quality checking of your own work. •Attention to health and safety aspects of working in a workshop type of environment. Integrated throughout the course is the development of generic employability skills valued by employers in an engineering sector. Your assessor will use checklists and you will complete a learner review sheet on four different occasions throughout the course. The National 4 Skills for Work Engineering Skills course provides a basis for progression into further education or for moving directly into training in employment within an engineering sector. October 2018, version 3.0 17 Administrative information Published: October 2018 (version 3.0) History of changes to national course specification Version Description of change Date 2.0 2013 — course re-coded as part of CfE development programme but no change to course and unit content. August 2013 3.0 Course specification moved to a new template. No change to content. Units re-coded to align with corresponding course 2 code. October 2018 This specification may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. Additional copies of this course specification can be downloaded from SQA's website at www.sqa.org.uk. Note: You are advised to check SQA's website (www.sqa.org.uk) to ensure you are using the most up-to-date version of the course specification. © Scottish Qualifications Authority 2013, 2018 Introduction to Digital Question Papers for Centres Publication date: November 2021 Publication code: FA4378b Published by the Scottish Qualifications Authority The Optima Building, 58 Robertson Street, Glasgow G2 8DQ Lowden, 24 Wester Shawfair, Dalkeith, EH22 1FD www.sqa.org.uk The information in this publication may be reproduced in support of SQA qualifications. If it is reproduced, SQA should be clearly acknowledged as the source. If it is to be used for any other purpose, written permission must be obtained from SQA. It must not be reproduced for trade or commercial purposes. © Scottish Qualifications AuthorityThis document can be produced, on request, in alternative formats, including large type, Braille and numerous community languages. For further details telephone SQA's Customer Contact Centre on 0845 279 1000. SQA is committed to using plain English. We will try to make our publications as easy and straightforward to understand as we can, and will try to avoid all unnecessary jargon. If there's any language in this document that you feel is hard to understand, or could be improved, please write to Editor, Editorial Team, at the Glasgow address or email: editor@sqa.org.uk.Contents What is a digital question paper? 1 Who can use a digital question paper? 2 What hardware and software do my centre need to use digital question papers? 3 How does my centre request digital question papers? 4 How does SQA create digital question papers? 4 How can candidates practise using digital question papers? 5 Where can I get further information on digital question papers? 6What is a digital question paper? A digital question paper is a digitised version of the question paper that can be completed electronically using a PC, laptop, or tablet. Digital question papers are produced in Portable Document Format (PDF), an open standard file format compatible with many software applications, operating systems, and hardware platforms. Like physical question papers, digital question papers are either in the combined question and answer format or the question only format. The combined question and answer format digital question papers have answer spaces enabled within the file for completion. The question only format digital question papers have an associated digital answer booklet. Digital answer booklets are produced in PDF format and Microsoft Word format. Both formats have answer spaces enabled within the file for completion. Combined question and answer format digital question paper 1Digital answer booklet in PDF format Who can use a digital question paper? Digital question papers can only be used by disabled candidates and those identified as having additional support needs who have an approved assessment arrangement. Digital question papers may be suitable for candidates who have difficulty reading the physical question paper or who have difficulty writing their responses on the physical question paper or answer booklet. Candidates use a PC, laptop, or tablet to access digital question papers. This enables them to adjust the colour of the paper and the text, and, to read and respond to questions, in conjunction with a range of other assistive technologies. Any candidates using information and communication technology (ICT) to complete their question papers can use a digital answer booklet. Digital answer booklets are available on our digital question papers website. Further information on assessment arrangements can be found on our assessment arrangements website. 23 What hardware and software do my centre need to use digital question papers? Hardware To use digital question papers your centre will require a PC or laptop or tablet. We recommend that PCs and laptops are running Windows. We recommend that tablets are iPads. Digital question papers must be printed at the end of the exam, so your centre will also require a printer. Chromebooks We asked CALL Scotland to investigate the use of Chromebooks for assessment arrangements, including digital question papers. CALL Scotland's report, published in 2020, is available on the Chromebook section of the CALL Scotland website. The report highlights that currently, there is no satisfactory solution for accessing and using our digital question papers on a Chromebook. We are actively investigating this issue, but until we have a satisfactory solution, we do not advocate the use of Chromebooks to access and use our digital question papers for the 2022 exam diet. Software To use digital question papers your centre will require an application that can read PDFs. The most widely used free application is Adobe Acrobat Reader, but many other free and paid-for applications are available. To use the Microsoft Word digital answer booklets your centre will require Microsoft Word or another application that can read Microsoft Word documents. Many assistive technology applications are available. Depending on the needs of your candidates, you may need to investigate which assistive technology applications you require. More detailed advice and guidance on hardware, software, and assistive technology can be found on the setting up and using digital exams section of the CALL Scotland website.4 How does my centre request digital question papers? Digital question papers must be requested using the Assessment Arrangements Request (AAR) system. We issue access details and instructions for using the AAR system to your centre's SQA Co-ordinator each year. Requests for digital question papers must be submitted by the date specified in our Delivering National Qualifications Key Dates document. This enables us to produce, collate, and distribute all digital question papers to all centres in time for the exam diet. How does SQA create digital question papers? We can only begin creating a digital question paper once the physical question paper has been through all its quality assurance stages and has been signed off as approved for the exam. Our skilled staff use specialist software to convert the physical question paper file into a digital question paper, adding bookmarks for sections, parts, and questions. For combined question and answer format digital question papers, they also create answer boxes and spaces where answer lines or spaces appear in the physical question paper. Our staff then check the digital question paper against the physical question paper and check that bookmarks are correct, and that answer boxes and spaces have been added correctly. We create two versions of question-and-answer format digital question papers. One has spell checking enabled and one has spell checking disabled. A similar process is used to create digital answer booklets. We create two versions of PDF digital answer booklets. One has spell checking enabled and one has spell checking disabled. We also create a Word digital answer booklet. We duplicate digital question paper files and associated digital answer booklet files on CD. We gather all the requests for digital question papers from all centres and collate, package, and distribute the digital question paper CDs to centres in advance of the exam diet.5 How can candidates practise using digital question papers? Your candidates must •Practise using digital question papers, including under exam conditions, before they sit an exam during the exam diet using a digital question paper. •Be familiar with the PC, laptop or tablet they are using to access a digital question paper. •Be familiar with the software they are using to access a digital question paper, and any functionality within the software they are using. •Be familiar with any assistive technologies they are using with digital question papers. We make all our digital question papers available on our website after the exam diet. As with physical past question papers, these are available for five years. Our digital answer booklets are available on our website. As these contain no confidential question content, they are available permanently, although they may, on occasion, be updated. You can access past digital question papers and digital answer booklets on our digital question papers website. We recommend that your candidates practise using past digital question papers and digital answer booklets. You may wish to create your own digital question papers. Advice and guidance on this can be found on the making digital prelim papers section of the CALL Scotland website.Where can I get further information on digital question papers? SQA An Introduction to Digital Question Papers for Candidates and a Digital Question Papers Exam Guide for Centres are available. Our digital question papers website contains these guides, past digital question papers, digital answer booklets and other resources. Our Assessment Arrangements team manages the assessment arrangements request system and provides advice and guidance on assessment arrangements, including digital question papers. Phone: 0345 213 6890 Email: aarequests@sqa.org.uk Web: http://www.sqa.org.uk/assessmentarrangements Our NQ Assessment team produces and distributes digital question papers. Phone: 0345 213 6807 E-mail: question.papers@sqa.org.uk CALL Scotland We work in partnership with CALL Scotland (Communication, Access, Literacy and Learning) on developing and supporting digital question papers. CALL have a website dedicated to digital question papers, providing a wealth of advice and guidance to support you and your candidates in using digital question papers. CALL Scotland University of Edinburgh Moray House Paterson's Land Holyrood Road Edinburgh EH8 8AQ Phone: 0131 651 6235 Email: webmaster@callscotland.org.uk Web: https://www.adapteddigitalexams.org.uk/home/ 67 Assessment Arrangements Learner Agreement Form Details Learner's name: Learner's SCN: Subject(s): Requested assessment arrangements: As part of the process of requesting your assessment arrangements, we need to share the following information about you with SQA: •your name, SCN, date of birth, and the name of this centre (usually a school or college) •an indication of your disability or identified difficulty •details of the assessment arrangement(s) you need SQA will only use this information to process your request for assessment arrangements. This information is not shared with anyone outside of SQA, and is only kept for as long as it is needed to support your request. Learner's agreement I confirm that I have been involved in discussions about and agree to the assessment arrangements being requested. Print name: Signature: Date: Parent or carer confirmation (if applicable) I confirm that I have been involved in discussions about the assessment arrangements requested for my child. Print name: Signature: Date: There's more information about how SQA uses your information in their Privacy Statement https://www.sqa.org.uk/sqa/45397.html Unit assessment: class checklist xxxx xx name of Unit Class Group Candidate Surname Candidate Forename Candidate ID Outcomes Overall Achievement* 1 2 3 4 1 P F 2 P F 3 P F 4 P F 5 P F 6 P F 7 P F 8 P F 9 P F 10 P F 11 P F 12 P F 13 P F 14 P F 15 P F 16 P F 17 P F 18 P F 19 P F 20 P F 21 P F 22 P F 23 P F 24 P F 25 P F * Mark as appropriate Assessment Exemplar for Higher National Units Guidance note: Introduction and How to Generate Evidence 1 st edition: September 2008 2 nd edition: January 2010 Publication code: xxxx Published by the Scottish Qualifications Authority, The Optima Building, 58 Robertson Street, Glasgow, G2 8DQ, and Ironmills Road, Dalkeith, Midlothian, EH22 1LE © Scottish Qualifications Authority 2008, 2010Guidance note: Introduction and How to Generate Evidence Scottish Qualifications Authority Assessment Exemplars for Higher National Units 1 1 Introduction This pack must be used in conjunction with a copy of the Unit specification which details the standard of performance expected of the candidate. A copy of the Unit specification can be obtained from SQA. This pack supplements the assessment guidelines and support notes of the Unit specification. It aims to provide an example of assessment that is valid, reliable and practicable. The assessment task(s) detailed in this pack correspond to the assessment guidelines outlined in the Unit specification. Whilst the example provided is intended for guidance, it may also be used as an assessment instrument, as long as the centre ensures the integrity and confidentiality of the assessment in the first and subsequent years of use and between centres. It may be used in a variety of ways including, for example: as an assessment instrument, in whole or in part to exemplify the standard of performance expected of candidates achieving the Unit, ie as a benchmark to help you develop your own assessment for the Unit to help you develop valid and practicable assessments for other Units within the subject area of the Group Award to which it contributes to give you new ideas as a staff development tool It is important that you make sure that the assessment exemplar is used in a context appropriate to the delivery of the Unit and to the Group Award of which it forms a part. Although the content of this exemplar has been prior verified as a suitable instrument of assessment, you should note that using this assessment exemplar does not automatically guarantee successful external verification. It is still your responsibility to make sure that all the appropriate internal quality assurance procedures are satisfactorily completed. For example, a valid, effective and approved internal verification system must be in use at your centre. Recommended reading Before using this material you might find it useful to look at some of our other publications, in particular: Guide to Assessment Introduction to Assessment Arrangements for Schools and Colleges SQA's Quality Framework: a guide for centresGuidance note: Introduction and How to Generate Evidence Scottish Qualifications Authority Assessment Exemplars for Higher National Units 2 Details of these and other SQA publications are available on our website. Most publications can be downloaded free of charge from our website at: www.sqa.org.uk on the 'Publications, Sales and Downloads' section. If you require a publication to be sent to you, please telephone our Business Development and Customer Support Team on 0303 333 0330 quoting the product code and, where a charge is applicable, have a purchase order number or credit card details available. Details of all HN assessment exemplars published after April 2004 are listed on our website on the HN subject-specific pages. Your centre's SQA or HN Co-ordinator will have access to these HN assessment exemplars on SQA's secure website. Please approach them for copies. However, if you require a paper copy you can obtain one from SQA's Business Development and Customer Support Team, Scottish Qualifications Authority, The Optima Building, 58 Robertson Street, Glasgow, G2 8DQ (telephone: 0303 333 0330 or fax: 0845 213 5000).Guidance note: Introduction and How to Generate Evidence Scottish Qualifications Authority Assessment Exemplars for Higher National Units 3 2 How to generate evidence Introduction The Scottish Qualifications Authority's system of assessment measures the evidence of a candidate's attainment of knowledge, understanding and skills against defined criteria. The assessment process must allow for evidence of each candidate's performance to be generated and collected. This evidence must then be judged against the standards set out in the Unit specification. To achieve the Unit the candidate must successfully meet the standards and there must be evidence to prove this. The Unit specification defines the criteria you need to use to judge whether or not the candidate has met the standards. All Units have the following: Outcomes These tell you what the candidate actually has to do. Knowledge and/or skills This section details the essential knowledge and skills which the candidate must attain in order to achieve each Outcome, combination of Outcomes or for the Unit as a whole. Evidence Requirements Evidence Requirements can be written for each Outcome, for a combination of Outcomes, or for the Unit as a whole. There is no standard format for writing Evidence Requirements. Provided that they state clearly and unambiguously the type, standard and amount of evidence which candidates have to produce in order to be judged competent, the Evidence Requirements can be written in the format which will be most easily understood by users of the Unit. Note: The national standard of achievement expected, which was previously specified as Performance Criteria, is now stated in the Evidence Requirements. Where it is not possible to cover all the items listed under knowledge and/or skills through holistic assessment, sampling can be used as a method of gaining additional evidence. Sampling may also sometimes be an appropriate method of assessing very knowledge-based Units. This type of assessment must always be carried out in supervised conditions. Where sampling is used, the Evidence Requirements must clearly state: The standard of evidence required for each knowledge and/ or skills item so that satisfactory performance can be judged whichever items are sampled on any one occasion. The proportion of knowledge and/or skills which can be sampled.Guidance note: Introduction and How to Generate Evidence Scottish Qualifications Authority Assessment Exemplars for Higher National Units 4 Whether any item(s) must be included in each assessment, ie if it is crucial to the achievement of the Outcome(s) or to an embedded Core Skill. The fact that a different sample should be chosen on each assessment occasion to prevent candidates being able to foresee what they will be asked. The conditions of assessment. Assessment guidelines This section should give guidance on how best to conduct the assessment to generate the evidence required, eg recommending the use of a particular assessment instrument. It should include guidance on how to integrate the assessment of the whole Outcome or, if appropriate, how to link assessment holistically with other Outcomes in the Unit. Like Evidence Requirements, assessment guidelines can be written for each Outcome, a combination of Outcomes, or for the Unit as a whole. It is important to realise that it is up to the assessor to judge when and if the candidate has satisfactorily met the standards. This decision should be based on the quality and correct quantity of evidence collected, set against the standards in the Unit. The assessment instrument in this pack should not create any unnecessary barriers to achievement for open/distance learning delivery and the additional support needs of individual candidates should be taken into account. You may need to adapt it so that you can assess candidates with additional support needs or candidates who are undertaking the Unit on an open/distance learning basis. However, whilst taking into account the needs of the candidate concerned, the methods of assessment you choose must still be valid, reliable and practicable. If you have any questions or problems, or if you are in any doubt as to whether or not the alternative assessment you have chosen is still valid, please telephone the Business Development and Customer Support Team at the Scottish Qualifications Authority on: 0303 333 0330. Core Skills The Unit specification will detail the Core Skills covered within the Unit. Where Core Skills have been embedded in a Unit specification and an assessor wishes to use an alternative method of assessment, she/he must ensure that the assessment generates the Evidence Requirements specified in the Unit specification. It is recommended that the centre seek prior verification for t Invigilator Report Form National Qualifications 2025 All fields are mandatory and must be completed according to section 9 of the Handbook for Invigilators. You must ensure that details reported are factual and do not express any personal opinion. Centre name Centre code Full name of candidate involved (Use Appx 1 where you have multiple candidates) SCN of candidate involved Click on the grey box to populate an (x) next to the relevant field(s). Prohibited item (please state) _______________________ ☐ Please select Yes or No for the question below Yes ☐ Other possible malpractice ☐ Was the reminder given to the candidate(s) to undertake a final check to ensure they were not in possession of any prohibited items before the start of the exam? No ☐ Date of exam Start time Subject name Level Paper Subject code Issue with the content of the exam material ☐ Disruption ☐ Centre/Invigilator Oversight ☐ ICT/Technical Issue ☐ Invigilator Misconduct ☐ All other incidents or interruptions ☐ Start time of incident or interruption: End time of incident or interruption:What actions were taken? Was this an AA candidate? Yes ☐ No ☐ Were the correct Assessment Arrangements provided Yes ☐ No ☐ N/A ☐ Was the candidate provided with the full exam time entitlement? Yes ☐ No ☐ Full details of incident or interruption:I confirm that the above information is factually accurate and that a copy of the report has been passed to the head of centre or their delegate. Invigilator signature Chief Invigilator signature Date submitted to SQA Reports must be submitted by email within two days of the exam to invigilator.enquiries@sqa.org.uk A typed name is acceptable in place of a written signature. Reports must not be enclosed in the script return envelopes or poly-envelope. Where reports refer to any physical evidence - faulty QPs / faulty CDs / contaminated scripts - then please use the return envelope marked Faulty Question Papers/CDs/Contaminated Scripts and return with the completed report to SQA. For SQA use only Date Received Actioned By Date Added to Database Additional comments: Appendix 1 - Additional Candidates Full name of candidate SCN of candidate involved he Attendance Register Supplement (Visiting Examining Additional Candidates) This form is to be completed and given to the Visiting Assessor for those candidates whose names are not included on the appropriate pre-printed Ex6 Attendance Register and have been assessed for a practical component. An Attendance Register Supplement is to be completed for each course/level, up to a maximum of ten candidates per form. Centre making submission: Centre No Centre Name Presenting Centre if different from above: Centre No Centre Name Course Name eg Drama Higher Course Code (eg X821) National Course Level National 5 Higher Advanced Higher Circle as appropriate 75 76 77 Candidate Name Date of Birth Scottish Candidate Number Mark Mark 1 2 3 4 5 6 7 8 9 10 1 Please ensure that this form is enclosed with the other candidates already on the Ex6 Attendance Register Form. 2 Ensure the SQA Co-Ordinator has submitted the new entry or change of level to the SQA. Signature Designation Date For SQA use only Entry checked Processed Verified Date Date Date *VEARS01* Allocation of Invigilation Duties – National Qualifications 2025 Invigilator Chief Invigilator Contact number Contact number E-mail address E-mail address Please indicate dates you are unable to invigilate in the table below and submit the completed form to your Chief Invigilator. This form will be returned to you with your confirmed allocations. Actual Day and Day Number Date Dates Not Available Extra Time Allocation (Chief Invigilator use only) AM PM AM PM Training day Day 1 Friday 25 April Day 2 Monday 28 April Day 3 Tuesday 29 April Day 4 Wednesay 30 April Day 5 Thursday 01 May Day 6 Friday 02 May No Exams Bank Holiday Day 7 Tuesday 06 May Day 8 Wednesday 07 May Day 9 Thursday 08 May Day 10 Friday 09 May Day 11 Monday 12 May Day 12 Tuesday 13 May Day 13 Wednesday 14 May Day 14 Thursday 15 May Day 15 Friday 16 May Day 16 Monday 19 May Day 17 Tuesday 20 May Day 18 Wednesday 21 May Day 19 Thursday 22 May Day 20 Friday 23 May Day 21 Monday 26 May Day 22 Tuesday 27 May Day 23 Wednesday 28 May Day 24 Thursday 29 May Day 25 Friday 30 May No Exams Contingency Day 1 National Qualifications 2025 Modern Languages National 5, Higher and Advanced Higher Gàidhlig National 5 and Higher English for Speakers of Other Languages National 5 and Higher Listening exam Instructions to person nominated to operate sound equipment This guidance relates to carrying out a check of the CD. If your centre has opted to receive electronic audio files you must refer to the guidance on Downloading and Securely Storing Electronic Files which will have been issued to the nominated people in your centre. 1 Arrangements for the exam a) Recordings will be supplied on CD or electronically via SQA's secure site. b) You should check the room(s) to be used for the examination and the sound equipment before the day of the examination. The room(s) used for the examination should be sufficiently isolated from any other room in which an examination is being held so that other candidates will not be disturbed by the sound of the recording. The sound equipment should be in satisfactory working order. The sound equipment should be suited to the size of the room(s) used and/or to the number of candidates in a group. The optimum number of candidates in each group, and the best position for the sound equipment so that all candidates can hear clearly, should be determined by practical experiment. c) You are required to conduct a check of the CD prior to the examination. You will be admitted to the examination room 30 minutes before the start of the exam. d) When you receive the CD from the invigilator, check to ensure that it states the correct subject, level, date and time of the exam. e) You should play a short section of the recording to check for any faults and to adjust volume and tone as necessary. f) No candidate is to be present or within earshot during the recording check or admitted to the room until the check has been completed. g) On completion of the check, inform the invigilator that the CD is working correctly and is ready to play. Remain in the examination room to operate the equipment for the examination. While you are in the examination room you must not communicate with the candidates.2 2 Emergency procedure If there is an issue playing the CD, it must first be tried on another machine. If the CD proves faulty and unusable, you must tell the invigilator who will inform the SQA co-ordinator who will contact SQA. Follow any further instructions from the invigilator. 3 Conduct of the exam a) Start playing the CD when the invigilator asks. b) The CD must be left to play through without interruption*. No part of the CD may be repeated, unless specifically authorised by the invigilator. c) In the event of an interruption which might seriously affect the candidates' hearing of the recording the invigilator may ask you to pause the CD until the interruption has passed. The invigilator may ask you to take the recording back a few seconds or to the start of a section. Please note that if the CD is stopped, it will return to the first track. Therefore, it should be paused. d) When the CD has been played through, you should pass the CD to the invigilator and leave the room. *If candidates have been given an allowance of extra time, there may be a requirement to pause the CD. Please refer to the Sound Equipment Extra Time Operator's Instructions for the relevant subject/level. alternative method to ensure that the Core Skill is still covered. On Tue, Mar 25, 2025 at 10:49 AM tshingombe fiston wrote: y Profile Hi fiston. Using the navigational panel on the left hand side, you can set up, review and update the information and preferences stored in our system. We would encourage you to regularly visit your candidate account to ensure that we have the most up to date information about you as we may contact you direct when vacancies that suit your skills and experience arise. For your own privacy, when you have finished please ensure that you log off. Overview of applications Job Title Reference Stage Product Maintenance Manager (M365) 6163 Application Started My Inbox Your inbox is empty Contact Information • General Enquiries • 0345 279 1000 Vacancies • My profile • Access details • Personal details • Manage job alerts • History • Current vacancies • Withdraw application • Logoff o Home o Vacancies > From shared.service@sqa.org.uk To tshingombefiston@gmail.com Subject SQA Registration Confirmation Hi, Thank you taking the time to look around the Jobs at SQA website and registering with us. To check the status of your applications, update your contact details, register for job alerts and withdraw or amend completed applications please do this by logging into the site. - https://jobs.sqa.org.uk/home.html - https://appointeeopportunities.sqa.org.uk/home.html Don't worry if you forget your password: just follow the links on the website to request a password reset. If you need any more help, please do not hesitate to contact us. Kind regards, Scottish Qualifications Authority On Tue, Mar 25, 2025 at 10:41 AM tshingombe fiston wrote: The heart of Scotland's world-renowned education system. Offering globally recognised qualifications and services to realise your potential. • Past papers • Timetable • Your exams • Find NQ subjects • Skills for Work • HNCs and HNDs • SVQs • Lost your certificate? Enter Qualification... Search Read our Prospectus for change Become a marker Latest research News View all SQA rebalancing assessment for practical qualifications SQA appoints headteacher as Senior Advisor to strengthen support for Scotland's schools SQA websites • Connect • Appointees • Secure • SOLAR • Academy Modified past papers Some of the 2022 and 2023 past papers are labelled 'modified'. This means SQA made changes to the question paper in response to the disruption caused by the Covid-19 pandemic, as part of our modifications to assessment in National Courses. For example, a modified past paper may be shorter, have fewer marks or contain fewer topics than past papers from previous years. Specimen question papers Specimen question papers are available for National 5, Higher and Advanced Higher qualifications. These show what a question paper looks like - how it is structured and the types of questions it contains. They also include marking instructions. Find them under 'Past Papers and Marking Instructions' on our NQ subject pages. Digital question papers Braille question papers Conditions of use The information in a past paper may be reproduced in support of SQA qualifications only on a non-commercial basis. If it is reproduced, SQA must be clearly acknowledged as the source. 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Timetable changes If you have any queries about the exam timetable, please speak to your school, college or training provider in the first instance. Personal timetable builder Create your own timetable using our online version. Build your own online timetable Exam apps Our MyExams app has been updated with the timetable changes made on Monday 3 February. Important for learners whose exams have changed • MyStudyPlan users: If you imported exams before the update, remove them in the Subjects window (tap the edit icon in the top right, then the red icon next to each exam). After that, re-import from MyExams to get the new dates. • Calendar users: If you exported exams to your calendar before the MyExams update, delete those entries and repeat the export again to ensure your dates are correct. • If you are still seeing old exam dates on the MyExams app, check the app troubleshooting section below. MyExams • Download MyExams from the App Store. • Download MyExams for Android. 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What you need to know about exams in 2025 • Exams start on Friday 25 April and end on Monday 2 June. • Your school provides an estimated grade for each course before the exams start. • An Examination Exceptional Circumstances Consideration Service is available if you cannot attend your exam, or your performance in the exam is disrupted. • Results day is Tuesday 5 August. • There is an appeals service that you can access directly or through your school. Download Your Exams 2025 Your Exams - college edition (5.20 MB) Na Deuchainnean Agad (5.07 MB) Use the tabs below to open each section individually. Alternatively you can show all the sections. Before your exams Timetable • Download the exam timetable. • Double-check the times of your exams as schools can change the start times. • Make sure you know what exams you're taking, when they are, and where they are. • Ask your school which teacher will be in charge of SQA exams on the day. You need to know so you can report to them if you are late. Past papers • Practice with previous exam papers. • Use the marking instructions to check your answers. SQA Apps • MyExams app - create a personal timetable, add notes, and add to other calendars. • MyStudyPlan app - organise your revision by creating a personal study plan. • Create your own personal exam timetable using the online Timetable Builder. Info and download links Your Scottish Candidate number Your Scottish Candidate Number (SCN) is your personal identification number. • You need to write it on your exam answer booklets. • Your school can tell you what your SCN is. Your teacher will give you an SCN card to write your name, school name, date of birth and SCN on. You can take this card into the exam room as long as you don't write anything else on it. Check your school has the right name and address Has your address changed? If any of your personal details change, or are going to change over the summer, you must tell your school before you finish for the summer holidays. You can check the personal details we hold for you by logging in to MySQA. On exam day Arriving for your exam • Make sure you know when and where your exam is taking place • Give yourself plenty of time to get there • Have your SCN with you • Be outside the exam room 10 minutes before the exam starts If you're late, the teacher in charge will tell you if you can sit the exam. How to find your Scottish Candidate Number (SCN) Speak to your school, call us on 0345 279 1000, or complete our Candidate Enquiry Form. Supplies Make sure you have the necessary exam supplies, such as pens. In the exam room Desks If your school allocates a specific desk for exams, make sure you know what desk number is yours for each exam. Prohibited items You must not take any prohibited item to your seat. You're not allowed (unless an approved assessment arrangement is in place): • Mobile phones (even if it's switched off) • Electronic devices such as tablets, earbuds, smartwatches or any other device that stores information or can connect to the internet • Books, sketches or paper, and anything written on your clothes or body • Pencil cases or calculator cases • Calculators (except when allowed) • Dictionaries (except when allowed) • Notes Check your bags and pockets to make sure you do not have any of these things with you - plan ahead and leave them in a safe place. When specific items are allowed in an exam, you must make sure they meet SQA regulations. You are not allowed to share any equipment during an exam. Invigilators Invigilators supervise the exam and make sure the rules are followed. Follow any instructions given by the invigilator and ask them for help if you feel unwell or upset. Leaving the exam room If you finish early or have done as much of the exam as you can, and you want to leave the exam room, raise your hand and ask the invigilator for permission to leave. If the exam is longer than one hour, the invigilator may allow you to leave after 30 minutes. If the exam is less than one hour, you must stay in the exam room until the end of the exam. Before you leave, you must give the invigilator all your exam papers, including any answer booklets, extra sheets, question papers and data booklets. You could lose all marks for the paper concerned if you don't give your exam papers to the invigilator before leaving the exam room. Question papers and answer booklets 1. Read the instructions on the front of your question paper 2. Check the subject and level are correct 3. Fill in your details on the front page - including your name, school name and SCN You will get either a : • combined question paper and answer booklet or • separate question paper and answer booklet Work through the question paper until you see the statement END OF QUESTION PAPER. In a question paper, pages that don't have any questions or instructions will say BLANK PAGE on them. No page is completely blank. If you find a completely blank page before the END OF QUESTION PAPER statement, tell the invigilator. Extra paper If you need extra paper, raise your hand and ask the invigilator. If you use extra paper, you must write your name, SCN and school name on each sheet and put these inside your answer booklet. In some subjects, you will find extra pages or graph paper at the end of the answer booklet. Writing your answers You must use a pen with black or blue ink. Do not use gel pens or pencils as these can fade. It is important the markers can read your writing. They might not be able to award marks if your writing is difficult to read. When writing on unlined pages, try to leave a space of about one centimetre between lines. In some subjects, poor spelling and punctuation could also result in marks not being awarded. If you have any concerns about this, or about your handwriting, speak to your teacher. Cross out any rough work, or any unwanted answers if you make more than one attempt at a question. You are not allowed to use correction pens, tape or fluid in any exam. Remember • Take your time. • Read the question carefully. • Answer the question being asked. • Double check your answers if you finish early. • Stay calm and do your best. Using calculators and dictionaries You can only use calculators and dictionaries in specific subjects and levels. When can you use a calculator? You can use a calculator in the subjects listed below: Subject Level Notes Accounting All Applications of Mathematics* National 5 Paper 2 only Applications of Mathematics* Higher Gnìomhachas Matamataigs* Nàiseanta 5 Pàipear 2 only Gnìomhachas Matamataigs* Àrd-Ìre Biology All Business Management All Chemistry All Computing Science All Economics All Engineering Science All Environmental Science National 5 and Higher Geography Advanced Higher Cruinn-eòlas Àrd-Ìre Adhartach Graphic Communication All Human Biology Higher Mathematics* All Paper 2 only Matamataig* All Pàipear 2 only Mathematics of Mechanics Advanced Higher Physics All Practical Cookery National 5 Practical Electronics National 5 Practical Metalworking National 5 Practical

Woodworking National 5 Statistics Advanced Higher Download Some learners may be allowed to use a calculator in the non-calculator papers for Mathematics or Applications of Mathematics, or for Gaelic Medium Matamataig or Gnìomhachas Matamataigs as part of an assessment arrangement. The calculator must be a basic calculator and not a scientific calculator. A basic calculator should perform the four basic arithmetic operations only and should not have the function to calculate the square root of a number. Please note that calculators containing the following keys are allowed: %, +/-, M-, M+, and MRC. Please speak to your teacher or lecturer if you have any questions about the type of calculator allowed. When can you use a dictionary? You can use a dictionary in the subjects and levels listed below: Subject Level Notes Cantonese National 5 Reading and Writing Cantonese Higher Reading and Directed Writing Cantonese Advanced Higher Reading and Translation Cantonese Advanced Higher Listening and Discursive Writing French National 5 Reading and Writing French Higher Reading and Directed Writing French Advanced Higher Reading and Translation French Advanced Higher Listening and Discursive Writing Gaelic (learners) National 5 Reading and Writing Gaelic (learners) Higher Reading and Directed Writing Gaelic (learners) Advanced Higher Reading and Translation Gaelic (learners) Advanced Higher Listening and Discursive Writing German National 5 Reading and Writing German Higher Reading and Directed Writing German Advanced Higher Reading and Translation German Advanced Higher Listening and Discursive Writing Italian National 5 Reading and Writing Italian Higher Reading and Directed Writing Italian Advanced Higher Reading and Translation Italian Advanced Higher Listening and Discursive Writing Mandarin Simplified National 5 Reading and Writing Mandarin Simplified Higher Reading and Directed Writing Mandarin Simplified Advanced Higher Reading and Translation Mandarin Simplified Advanced Higher Listening and Discursive Writing Mandarin Traditional National 5 Reading and Writing Mandarin Traditional Higher Reading and Directed Writing Mandarin Traditional Advanced Higher Reading and Translation Mandarin Traditional Advanced Higher Listening and Discursive Writing Spanish National 5 Reading and Writing Spanish Higher Reading and Directed Writing Spanish Advanced Higher Reading and Translation Spanish Advanced Higher Listening and Discursive Writing Urdu National 5 Reading and Writing Urdu Higher Reading and Directed Writing Download Conduct Everyone should have a fair chance to do their best during exams. Cheating and causing a disturbance during an exam are unfair to other candidates. Examples of cheating and unfair behaviour include: • Having prohibited items with you • Pretending to be someone else or getting someone else to take an exam for you. • Disruptive behaviour in the exam room. • Using rude, abusive, offensive or discriminatory language or images in your answers. • Copying from another person. • Collusion - working with other candidates on an individual task that must be your own work. • Plagiarism - failing to reference sources properly or presenting someone else's work as your own, which includes using artificial intelligence programmes such as ChatGPT to create responses. Any cheating or unfair behaviour can have serious consequences for your results. This could include losing marks, getting a lower grade or having your qualification cancelled. Your school can explain more about this. Exam day checklist Do • Do arrive in good time - at least 10 minutes before the exam starts. • Do bring the right equipment - including black or blue ink pens. • Do check that you don't have any prohibited items with you at your seat. • Do check you have been given the correct exam paper. • Do put your name, SCN and the name of your school on every piece of work you hand in (including separate answer booklets and answer sheets). • Do write legibly so markers can read your answers. • Do read instructions and listen carefully for any announcements from the invigilator. • Do cross out any rough work that is not part of your answer. • Do stay in the room until the exam is finished. You can only leave early with permission from the invigilator. • Do give the invigilator all your exam papers, including any answer booklets, extra sheets, question papers and data booklets, before you leave the exam room. Don't • Don't get someone else to sit your exam for you or pretend to be someone else. • Don't take any prohibited items to your seat. • Don't behave in a disruptive way or cause a disturbance. • Don't copy from anyone else. • Don't share your work with anyone else. • Don't share equipment with anyone else. • Don't use any rude, abusive, offensive or discriminatory language or images in your answers. • Don't use correction pens, tape or fluid. After your exam What if I couldn't sit the exam? You or your parent or carer should contact your school as soon as possible, explaining what has happened. They will be able to discuss your options and whether or not you would be entitled to use the Examination Exceptional Circumstances Consideration Service. If you are eligible for the service, your school would need to contact us. Exam Exceptional Circumstances Consideration Service This Service will support you if: • you have been unable to attend the exam, or prevented from completing the exam, due to a personal circumstance beyond your control (such as a medical issue) • you have been affected during the exam by a disruption, or other exam circumstance, reported by the chief invigilator • your performance in the exam was affected by a personal circumstance, or an unplanned incident on the day, which was beyond your control. Exam nerves, distraction or loss of concentration during an exam are not valid reasons to use this service. Your school must request the service for you within 10 days after the exam, so it's important that you speak to them as soon as possible after the exam, giving them the information about what happened. You must give your school permission to request the service. Your school will then need to provide alternative evidence based on the assessments you completed throughout the year. This could be prelims, class tests, class work, records of performances (in some subjects). SQA examiners will review this, and any exam materials that you completed, to decide your grade. If you use the EECCS, the grade you are awarded may be different from the estimated grade provided by your school. You will not be able to appeal against your grade through the appeals service. More on the exceptional circumstances service. Results You get your results by post on Tuesday 5 August. You can also get your results by text, email or both if you sign up to MySQA Your school will also receive your results. If you have applied to a university or college through UCAS, they will also receive your results. If you don't receive your certificate on results day, contact your school immediately. They can tell you your results and will work with us to find out what has happened to your certificate. If you think there's a mistake on your certificate, or something looks wrong, contact your school. MySQA - results by text/email MySQA is where you can: • see your qualifications • check the personal details we hold for you • get your results sent by text, email or both You'll need to sign up at MySQA by 5pm on Wednesday 16 July (you need an email address and your SCN). You will still receive your certificate by post. Remember, if you change your mobile number or email after signing up, you'll need to update your details to receive your text message or email. On results day, if you cannot find yo Download Your National Qualifications College edition Your National Qualifications (4.62 MB) Gaelic edition Your National Qualifications Gaelic (2.07 MB) Completing your coursework There are rules you must follow when you are completing your coursework. Use the tabs below to open each section individually. Alternatively you can show all the sections. What types of coursework are there? The type of coursework you will do depends on what subject you are studying. These can be; • A portfolio • Practical activities • Performances • Assignments • Projects Only hand in your own work You must only submit your own work. Passing off other people's work and ideas as your own is called 'plagiarism' and it's cheating. It's not your own work if: • all or some of it has been done, or worked on, by someone else • it has been done by someone who has produced similar work in the past (such as an older student) • you use work that your teacher has prepared as an example • you've copied it from a source, such as a book, website or an essay bank, without trying to put it in your own words or referencing it • you've copied text, images or any other material produced by an AI tool. Working with others Unless you are working as part of a group (for example, on a group project), you must work alone to complete your coursework. If someone asks you for help, you should tell them to ask a teacher instead. If you are finding any part of your course difficult, ask your teacher for advice. No other person can be involved, at any stage, in discussing or reviewing your coursework. How to use sources You may be able to use lots of different sources (including books, the internet and TV programmes) in your work, but it's important that you reference them correctly. When using sources, the general rules are; • Use 'quotation marks' around any text that has come from other sources and clearly say where that text is from. • Provide a reference for any diagrams or illustrations you've used from other sources. • Create a bibliography (a list of sources you have used). This will go at the end of your work. Your teacher will be able to help if you get stuck. Can I use Artificial Intelligence (AI)? No. You might have heard about or used artificial intelligence (AI) tools such as ChatGPT or Google Bard. Many of these AI tools have age restrictions, which means they are not suitable for everyone. The text they produce can be incorrect or contain biased information. As the information is not reliable, you must not use or reference AI tools as sources for your work. Find out more about our policy on AI in assessments. What if I break the rules? If an investigation finds you've broken any rules, there may be a penalty, which could include the following. • Your marks can be reduced, or you can be awarded zero marks. • Your qualification for that subject can be cancelled. • All of your qualifications for the e o Home o National Qualifications > Learner support > Private candidates Information for private candidates (home-schooled) Private candidates include home-schooled learners ¬who are taught by a parent, carer, or tutor. If you are a private candidate and you wish to take SQA qualifications, you need to be entered for the qualifications by an SQA approved centre (such as a school, college, or training provider) that will act as your presenting centre. What does a presenting centre do? Your presenting centre will register you for your chosen qualifications and arrange for you to complete the required assessments, including any exams or coursework. They are also responsible for making sure that you complete your assessments under the conditions required by SQA – for example, under direct supervision or completing the assessment within a time limit. How do I find a presenting centre? You can contact your local schools, colleges and training providers and ask if they can act as your presenting centre. You can also approach your local authority education department. We strongly advise doing this as early as possible before the start of the academic year. When you contact a centre, make sure you provide them with details of the qualifications you are looking to be entered for, including your chosen subjects. The centre will advise if they are able to enter you for those qualifications. The centre may also arrange a discussion with you to find out more and to explain what's involved. Is there anything I need to discuss with the centre? At an early stage, you should ask the centre about the assessments you will need to complete for your chosen qualifications. They will advise you what coursework and/or exams you will need to do and when these will take place. If you are disabled and/or have additional support needs, you should also discuss these with the centre as soon as possible, so that they can agree appropriate assessment arrangements with you and ensure they are put in place. If they agree to act as my presenting centre, what happens next? Once a centre has agreed to present you as a private candidate, they will ensure that you are registered with SQA and have a Scottish Candidate Number (SCN). The centre will enter you for your chosen qualifications and provide you with all the information you need to know about your assessments – including coursework, any tests or internal assessments that take place throughout the year, and details of any exams you will be sitting. They will also explain the rules and essential information you need to know about your coursework and assessments. It is important that you understand ntire year can be cancelled. • Home • National Qualifications > NQ teaching support > Teaching support Teaching resources Support and resources for delivery of National Qualifications including internal assessment materials, exam support and contact details. Internal Assessment Support Materials Download Internal Assessment Support Materials. 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Details of updates to Unit assessment support packs and other documents can be found in our Notification of Changes spreadsheets. • Unit Assessment Support Publication List currently being revised - to be added here soon HN — ASP February 2025 monthly update The following Assessment Exemplar/Assessment Support Pack materials have been added, replaced or revised in February 2025. To access these materials via our secure website, please speak to the SQA co-ordinator in your centre. Social Sciences Level Title Publication Code New/Revised 6 Social Anthropology: Who does it and how to do it HG55 33/ASP001 New Download Travel and Tourism Level Title Publication Code New/Revised 7 Working as Senior Air Cabin Crew J7LJ 34/ASP001 New Download HN ASP full list NQ — NAB/ASP February 2025 monthly update The following Assessment Exemplar/Assessment Support Pack materials have been added, replaced or revised in February 2025. 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To access these materials via our secure website, please speak to the SQA co-ordinator in your centre. • Centre Devised PV Publication List (119 KB) SVQ — Assessor's Guidelines/Portfolio February 2025 monthly update There were no SVQ - Assessor's Guidelines/Portfolio materials added, replaced or revised in February 2025. SVQ support materials full list Training and Assessment Packs February 2025 monthly update There were no Training and Assessment Packs Assessor's Guidelines/Portfolio materials added, replaced or revised in February 2025. TAPS support materials full list Digital Assessment Support Materials SOLAR Assessments A list of subjects with Digital Assessment Support Materials provided by SOLAR. HN Guidance Notes and Blank Checklists These documents should be used in conjunction with Assessment Exemplars downloaded from the secure website. • Guidance Note: Introduction and How to Generate Evidence (70 KB) • Blank Class Checklist: Four Outcomes (57 KB) • Blank Class Checklist: Three Outcomes (54 KB) • Blank Class Checklist: Two Outcomes (54 KB) o Home o National Qualifications > NQ teaching support > Exam support and forms > Exam support Exam support and forms Forms and materials support during the exams: Accommodation arrangements o Accommodation arrangements (124 KB) Allocation of duties o Allocation of duties (355 KB) Attendance register o VE Attendance register supplement (additional candidates) (51 KB) o Attendance register supplement (notes) (49 KB) Flyleafs o 2025 Exam Flyleafs Invigilator o Invigilator Report Form (266 KB) Sound equipment - music and languages o Languages Sound Equipment Operator's Instructions (131 KB) o Music and Music Technology Sound Equipment Operator's Instructions (129 KB) Scaling calculator The scaling calculator can be used as an aid to calculate the total mark for National 5, Higher or Advanced Higher courses that have scaled components. o Scaling calculator 2025 (110 KB) Estimates Guidance for practitioners explaining what estimates are, with examples of assessment evidence needed. 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Pre-application stage We'll meet with you to discuss becoming an SQA Centre, including if it's right for your organisation. If you would still like to apply after that, we'll then send further information and carry out due diligence, including a soft finance check. Application stage Next, we send you the relevant documents and forms to apply for the two parts of approval: 1. Systems approval – this confirms that your centre has management and systems needed to deliver, assess and internally verify SQA qualifications. 2. Qualification approval – this confirms that your centre has the materials and resources to deliver, assess and internally verify SQA qualifications. Application review stage We'll review your application. This includes: • a centre approval meeting by a Quality Enhancement Manager and • a subject approval meeting by a subject expert External verifier. After review, the Quality Enhancement Manager and External Verifier will submit a report and communicate any feedback and recommendations to you. Outcome - centre approval There are two possible outcomes: 'approved' or 'not yet approved'. • Approved - We'll provide a centre operating agreement (COA), which you must sign and return to SQA. We then issue your centre number, and you can start registering candidates. • Not yet approved - We'll offer to help you re-apply. o Home o Past Papers Past papers and marking instructions Find past papers and marking instructions for your revision. You can search by topic and or refine by subject and level. To add the matching marking instructions simply tick the box. We provide up to five years of past papers. Subject: Search: Level: Include Marking Instructions Modified past papers Some of the 2022 and 2023 past papers are labelled 'modified'. This means SQA made changes to the question paper in response to the disruption caused by the Covid-19 pandemic, as part of our modifications to assessment in National Courses. For example, a modified past paper may be shorter, have fewer marks or contain fewer topics than past papers from previous years. Specimen question papers Specimen question papers are available for National 5, Higher and Advanced Higher qualifications. These show what a question paper looks like - how it is structured and the types of questions it contains. They also include marking instructions. Find them under 'Past Papers and Marking Instructions' on our NQ subject pages. 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We have a variety of roles in the business that support this activity. We look for talented individuals who share our values: • Trusted • Progressive • Enabling Vacancies Find out what opportunities are available for working at SQA. Appointee opportunities Provide vital support for SQA by joining us as an appointee. View the opportunities available. Benefits Annual leave, financial and pensions benefits. Working for us We promote and support equalities, staff development and support our community. The information that you have provided to SQA will be used to process your application as well as for monitoring and statistical purposes. If you are appointed this information will form part of your employee/appointee/consultant record. Further information about how SQA uses your information can be found in SQA's Privacy Statement. 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The Award is made up of two units: 1. Money Management 2. Personal Finance in Action To gain the Award learners must achieve both units. Once learners have studied the content of the units, they will sit their final assessments via SQA's on screen assessment system (SOLAR). This pack is intended to help learners become familiar with the terms used in financial products and services and understand more about how they work and what they are used for before they sit their final assessment. Questions included in the final assessment will draw from the content of units one and two. Learners can use the explanations and descriptions given within this pack as a starting point for further investigation into the various topics covered, or they can use it as a reminder of the various topics covered. PLEASE NOTE Where terms are defined in this document by giving examples of specific values that might apply, the values given are usually based on 2021-22 rates. For example: VAT; Income Tax Bands; Land and Buildings Transaction Tax rates; ISA savings limit; Capital Gains Tax threshold; etc. Learners must be aware that the government has the authority to increase or decrease tax and threshold rates each year depending on inflation and other economic, societal or political factors. • Unit 1: Money Management SCORM packages: 5 • Unit 2: Personal Finance in Action SCORM packages: 5 • Feedback o Feedback URL SQA Staff Induction Dashboard This sections contains links to all modules which are required to be completed by staff as part of their induction. Understanding SQA This sections contains links to all modules which are required to be completed by staff as part of their induction. Last updated 16 August 2023. Health & Safety Dignity at Work This course is for SQA staff, the aim of this course is to identify the definition of Dignity at Work and explain how our values, culture and policies help us all to take responsibility to create and support a respectful, equal, and fair working environment. Autism Awareness Our Culture Anti-Bribery & Corruption This Anti-Bribery Training module has been designed to be used by anyone who could be exposed to bribery and/or corruption. It explains what bribery is and helps to increase understanding of situations where gifts and hospitality shouldn't be offered or accepted. Protecting Information 1. Courses 2. SQA Staff 3. Develop yourself Develop yourself • Category • More Course categories Search courses Develop yourself Courses for staff looking to develop their knowledge and skills. Recruitment Essentials ISO and our Management Systems Going Digital Scotland's Languages This course is for SQA Staff. If your a member of staff and cannot access the course, please contact das.helpdesk@sqa.org.uk Your Development, Your Choice A guide to owning your development in the workplace Complaints Handling SQA staff guide to handling complaints. My Carbon Impact This course is for all SQA staff and aims to raise your awareness of the environmental impact of everyday activities and the ability to reduce emissions, on an individual and organisational basis. The course will also develop your understanding of the wider challenges facing Scotland, the UK and the world as a result of the climate emergency. A Guide to Remote Working SQA Staff guide to Remote Working Change Management This course is for SQA staff. Please contact the OD and Change Practitioners if you have any questions. Clear and Confident Writing Here you'll find modules to help you write more effectively for your audience. Managing Stressful Situations at Work This course is designed to support SQA colleagues when managing stressful situations at work. Mental Health Matters This course is designed to support SQA colleagues understand Mental Health and provide guidance on when and how to seek support, if needed. My Review Audience: SQA Staff Course owner: Organisational Development Contact: odchange.team@sqa.org.uk Resilience This course is designed to support SQA colleagues understand the definition of Resilience and how to put it into practice. Virtual Meeting Facilitation We've gathered the following tips and best practices to support all staff members who are hosting and facilitating virtual meetings for colleagues, and stakeholders, inside and outside of SQA. 1. Courses 2. SQA Staff 3. Equalities Equalities • Category • More Course categories Search courses Equalities Welcome to the Equalities section. Equality, Diversity & Inclusion Training This training aims to provide an overview of the Equality Act 2010, its impact for SQA and your responsibilities. Introduction to WCAG (Web Content Accessibility Guidelines) This short course will develop your understanding of Web Content Accessibility Guidelines (WCAG) and how you can apply them in your work. Designing Inclusive Assessment Designing Inclusive assessment Equality Impact Assessment This SQA course explains how Equality Impact Assessments are a valuable tool in creating and developing policies and practices which consider how what we do impacts on people, and specifically people with Protected Characteristics. Equality Impact Assessments allow us to create policies and practices which are inclusive and provide us with the opportunity to embed equalities into wider decision making. Digital Accessibility Training This course is aimed at SQA staff Upon completion of this course, users should be able to: • Name relevant legislation underpinning accessibility measures. • Demonstrate familiarity with two key acronyms: UDL (Universal Design for Learning) and WCAG (Web Content Accessibility Guidelines). • Demonstrate knowledge of how to make documents and slideshows more accessible. • Identify and use free software or software features to check and enhance the accessibility of documents and slideshows. • Audit their everyday practice for accessibility and embed appropriate accessibility techniques. • Identify individuals within the organisation who would benefit from sharing good accessibility practice. Care Experience and Corporate Parenting This is an introductory course to help learners understand more about care experience and their responsibilities as Corporate Parents. All images featured are the copyright of Who Cares? Scotland unless stated otherwise. 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Data Governance Training Programme Business Continuity Procurement C.S.M. training About This course is about Procurement Contract and Supplier management. Audience This course is aimed at the Procurement team, however all SQA staff are able to access the training. Workplace Investigations This course is mandatory training for colleagues who are going to be conducting a workplace investigation at SQA. This course must be completed prior to conducting any workplace investigation. This training book can also be used as a reference guide for investigators once they have completed the training. Risk Management 1. urses 2. SQA Staff 3. Qualifications Development Qualifications Development • Category • More Course categories Search courses Qualifications Development We have training for tasks completed by the Qualifications Development directorate. Please select a course below. Finalisation 1. Courses 2. SQA Staff 3. DAS Staff Training DAS Staff Training • Category • More Course categories Search courses DAS Staff Training Welcome to the DAS staff training section. SQA Academy staff training This course contains training and guidance for SQA Academy team members. Helpdesk Training This course has been designed as a resource to support DAS Helpdesk staff to resolve enquiries relating to the SQA Academy. Marker Check 1. Courses 2. SQA Staff 3. NQ Assessment and Data Services NQ Assessment and Data Services • Category • More Course categories Search courses NQ Assessment and Data Services Courses for NQ Assessment and Data Services E-Marking Helpdesk Training Supervisor Training Podcasts • Category • More Course categories Search courses Podcasts Tune into a podcast and learn something new while you work Academy Podcast Learn while you work with Academy Podcasts. Each month we'll discuss all the things digital with guests from across the organisation. Podcast guidance Welcome. Here you will find learning and materials relating to Contract Ops. Protecting Information (Contract Ops) 2024 SQA Academy Course categories Search courses Expand all Assessment Development Fundamentals for Vocational Qualifications External Agencies International Joint SQA/External Agencies NextGen: HN Open courses - available to everyone SQA Appointees SQA Centres SQA Staff Skip to main content SQA Academy • Home • Dashboard • My courses • Course categories • Get help • Contact form Collapse • Welcome • Developing Vocational Assessments • Selecting Valid Assessment Methods for Vocational Qualifications • Developing Multiple Choice Assessments for HN/VQ • Feedback Assessment Development Fundamentals for Vocational Qualifications • Course • Competencies • More You are enrolled in the course. Topic outline • o Welcome to Assessment Development Fundamentals for Vocational Qualifications, fiston Please select one of the modules below to get started. o Developing Vocational Assessments SCORM package • o o Feedback URL • • Selecting Valid Assessment Methods for Vocational Qualifications SCORM package • • Developing Multiple Choice Assessments for HN/VQ SCORM package Standards and Testing Agency (STA) This module is designed to support SQA staff and Qualification Development Specialists (QDS) in developing assessments for our vocational and externally regulated qualifications, however it provides content applicable across our portfolio. By completing this module, you will: • become familiar with the basics of assessment theory • become familiar and compliant with SQA HN/VQ assessment development processes • be given some practical assessment development advice Throughout the module there will be some reflection points and an end of course test to consolidate your knowledge and understanding, to prepare you for developing your own assessments. This module should be used in conjunction with 'SQA's Code of Practice, Assessment: A Guide for Regulated Qualifications' and the HNVQ Assessment Development Process dependent on whether this a paper based or online assessment. The full process for our paper based and online assessments is available on request from the Assessment Materials and SOLAR teams. On Mon, Mar 24, 2025 at 11:47 AM wrote: MyAlerts ____ Dear Tshingombe , There have been no recent updates to the content you have subscribed to on the SQA website. To change your page selection / frequency, or to unsubscribe, log in to your MyAlerts account. You receive this update because you are subscribed to MyAlerts. This email is intended for the addressee only. Unsubscribe Privacy and Cookies | About Us | Terms and Conditions | Visit our main website | Contact us ____ SQA, Optima Building, 58 Robertson Street, Glasgow, G2 8DQ, UK | Tel: 0303 333 0330 © 2021 All rights reserved QA Advanced Unit Specification General information Unit title: Energy Technologies Unit code: HT1L 48 Superclass: QB Publication date: August 2017 Source: Scottish Qualifications Authority Version: 01 Unit purpose The Unit is designed to enable learners to develop knowledge and understanding in a range of technologies related to energy production on an industrial scale. Traditional, renewable and emerging and/or less common technologies will be considered in relation to key components, principles of operation, operational aspects and environmental and sustainability factors as appropriate. The Unit is optional for learners in Engineering-related SQA Advanced Awards. It could also be used as a stand-alone Unit where appropriate. Outcomes On successful completion of the Unit the learner will be able to: 1 Analyse the technologies and factors associated with traditional methods of energy production. 2 Analyse the technologies and factors associated with renewable methods of energy production. 3 Describe the technologies and factors associated with emerging and/or less common sustainable methods of energy production. Credit points and level 1 SQA Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8). SQA Advanced Unit Specification HT1L 48, Energy Technologies (SCQF level 8) 2 Recommended entry to the Unit While entry is at the discretion of the centre, learners would normally be expected to have attained the entry requirements specific to the SQA Advanced Certificate/Diploma award. Core Skills Opportunities to develop aspects of Core Skills are highlighted in the Support Notes for this Unit specification. There is no automatic certification of Core Skills or Core Skill components in this Unit. Context for delivery If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes. Equality and inclusion This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements. SQA Advanced Unit Specification HT1L 48, Energy Technologies (SCQF level 8) 3 SQA Advanced Unit Specification: Statement of standards Unit title: Energy Technologies Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA. Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion. Outcome 1 Analyse the technologies and factors associated with traditional methods of energy production. Knowledge and/or Skills ¨ Components, principles of operation, operational aspects, energy produced and environmental and sustainability factors associated with: — coal based technologies — gas based technologies — oil based technologies — nuclear based technologies Outcome 2 Analyse the technologies and factors associated with renewable methods of energy production. Knowledge and/or Skills ¨ Components, principles of operation, operational aspects, energy produced and environmental and sustainability factors associated with: — onshore wind turbines — offshore wind turbines — catchment based hydroelectric schemes — pumped storage based hydroelectric schemes — solar photovoltaic based technologies — solar thermal based technologies — biomass based technologies SQA Advanced Unit Specification HT1L 48, Energy Technologies (SCQF level 8) 4 Outcome 3 Describe the technologies and factors associated with emerging and/or less common sustainable methods of energy production. Knowledge and/or Skills ¨ Components, principles of operation, operational aspects and environmental and sustainability factors associated with: — tidal based schemes — wave based schemes — geothermal based schemes — waste based technologies Evidence Requirements for this Unit Outcome 1 Evidence for the Knowledge and/or Skills in this Outcome will be generated through sampling. Each learner will need to provide evidence to demonstrate they can analyse two of the four technologies and factors associated with traditional methods of energy production. The evidence should be responses to specific questions. To ensure that learners will not be able to foresee all the items they will be questioned about, a different sample should be used on successive assessment occasions. The new sample may contain a maximum of one of the Knowledge and/or Skills used in the previous assessment occasion. A learner's response can be judged to be satisfactory where the evidence shows that the learner can: ¨ Describe the key components of the chosen technology. ¨ Explain the principles of operation of the chosen technology. ¨ Explain the operational aspects of the chosen technology. ¨ Describe the environmental and sustainability factors of the chosen technology. ¨ Determine the energy produced using supplied data for the chosen technology. Evidence should be generated through a closed-book assessment under supervised conditions. Outcome 2 Evidence for the Knowledge and/or Skills in this Outcome will be generated through sampling. Each learner will need to provide evidence to demonstrate they can analyse three of the seven technologies and factors associated with renewable methods of energy production. Each sample should consist of one wind and one hydro technology plus one from either solar or biomass. The evidence should be responses to specific questions. To ensure that learners will not be able to foresee all the items they will be questioned about, successive assessment occasions should contain a different sample. As before, the requirement for one wind and one hydro to be included is valid although the choice of which wind (onshore or offshore) and which hydro (catchment or pumped storage) may be changed. The same solar technology cannot be used on the next assessment occasion. If SQA Advanced Unit Specification HT1L 48, Energy Technologies (SCQF level 8) 5 biomass technology was used in the assessment occasion then one of the solar technologies must be used on the next assessment occasion A learner's response can be judged to be satisfactory where the evidence shows that the learner can: ¨ Describe the key components of the chosen technology. ¨ Explain the principles of operation of the chosen technology. ¨ Explain the operational aspects of the chosen technology. ¨ Describe the environmental and sustainability factors of the chosen technology. ¨ Determine the energy produced using supplied data for the chosen technology. Evidence should be generated through a closed-book assessment under supervised conditions. Outcome 3 Evidence for the Knowledge and/or Skills in this Outcome will be generated through sampling. Each learner will need to provide evidence to demonstrate they can describe two of the four technologies and factors associated with emerging and/or less common sustainable methods of energy production. The evidence should be responses to specific questions. To ensure that learners will not be able to foresee all the items they will be questioned about, a different sample of technologies should be used on successive assessment occasions. The new sample may contain a maximum of one of the technologies used in the previous assessment occasion. A learner's response can be judged to be satisfactory where the evidence shows that the learner can: ¨ Describe the key components of the chosen technology. ¨ Explain the principles of operation of the chosen technology. ¨ Explain the operational aspects of the chosen technology. ¨ Describe the environmental and sustainability factors of the chosen technology. Evidence should be generated through a closed-book assessment under supervised conditions. SQA Advanced Unit Specification HT1L 48, Energy Technologies (SCQF level 8) 6 SQA Advanced Unit Specification:Support notes Unit title: Energy Technologies Unit Support Notes are offered as guidance and are not mandatory. While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours. Guidance on the content and context for this Unit This Unit is designed to introduce some of the current and emerging or less common technologies used in energy production. Traditional methods (coal, oil, gas and nuclear) and renewable methods (wind, solar, hydro and biomass) will be described in terms of principle of operation, system components, operational aspects and environmental and sustainability factors. Emerging and less common technologies (tidal, wave, geothermal and waste) will be described in terms of principle of operation, system components, operational aspects and environmental and sustainability factors. Outcome 1 It is suggested that the following technologies be used in the delivery of this Outcome: Coal: Pulverised coal combustion (PCC) Gas: Combined cycle gas turbine (CCGT) Oil: Crude oil combined cycle Nuclear: Pressurised water reactors (PWR) For each of the four technologies, diagrams should be used showing the key components in the energy conversion process from input through to output. Each stage in the process should be explained in terms of its function/operation. Operational aspects should include typical overall plant efficiencies, start-up time, utilisation for base or peak loads, reliability of supply and CO2 emissions per Unit of energy generated (gCO2/kWh). Environmental and sustainability factors and the significance of each will vary depending on the technology but would typically include several of the following: ¨ Use of finite fossil fuels ¨ CO2 released into atmosphere ¨ Visual amenity and noise impacts ¨ Air, land and water pollution ¨ Impact on wildlife and ecological systems ¨ Health and safety ¨ Waste products SQA Advanced Unit Specification HT1L 48, Energy Technologies (SCQF level 8) 7 Outcome 2 For each of the technologies, diagrams should be used showing the key components in the energy conversion process from input through to output. Each stage in the process should be explained in terms of its function/operation. Operational aspects should include typical overall plant (or Unit) efficiency, weather constraints, logistics (for offshore wind), reliability of supply and CO2 emissions per Unit of energy generated (gCO2/kWh). Environmental and sustainability factors and the significance of each will vary depending on the technology but would typically include several of the following: ¨ Use of renewable resources ¨ CO2 released into atmosphere ¨ Visual amenity and noise impacts ¨ Air, land and water pollution ¨ Land-loss (large hydro schemes in particular) ¨ Impact on wildlife, marine life and ecological systems ¨ Waste products Outcome 3 Marine (wave and tidal) technologies are expected to contribute to the future energy 'mix'. At present, worldwide there are only a few operational marine power plants. Technologies to harness energy from the tide include tidal barrage and tidal stream. The European Marine Energy Centre (EMEC) in Orkney is one of the world's leading marine technology research and testing centres and a useful source of information. Currently, there are several types of wave energy technologies at various stages of development. In the UK, examples include the 'Pelamis' attenuator system, the 'Limpet' oscillating water column system and the 'Oyster' oscillating wave surge convertor system. Energy production from geothermal sources utilises three main technologies and currently the US is the largest producer of geothermal energy. Historically, energy from waste has been via incineration however more recent technologies such as gasification and pyrolysis are now being commissioned. It is suggested that the following technologies be used in the delivery of this Outcome: Tidal: Tidal barrage and Tidal stream Wave: Attenuator systems, Oscillating water column systems and Oscillating wave surge convertor systems Geothermal: Dry steam, Flash steam and Binary cycle Waste: Incineration and Advanced Thermal Treatments (Gasification and Pyrolysis) SQA Advanced Unit Specification HT1L 48, Energy Technologies (SCQF level 8) 8 For each of the technologies, diagrams should be used showing the key components in the energy conversion process from input through to output. Each stage in the process should be explained in terms of its function/operation. Operational aspects should include typical overall plant (or Unit) efficiency (where data is available), logistics (for waste), reliability of supply and CO2 emissions per Unit of energy generated (gCO2/kWh). Environmental and sustainability factors and the significance of each will vary depending on the technology but would typically include several of the following: ¨ Use of renewable/sustainable resources ¨ CO2 released into atmosphere ¨ Visual amenity and noise impacts ¨ Air, land and water pollution ¨ Impact on wildlife, marine life and ecological systems (tidal barrage in particular) ¨ Waste products Guidance on approaches to delivery of this Unit This Unit should be delivered in year 2 of an SQA Advanced Diploma programme. It would be beneficial if learners had previously completed the level 7 Unit Energy Overview. It is unlikely that it could be delivered through integration with other Units. It would be beneficial if learners had classroom internet access. It is suggested that an equal amount of time be allocated to each Outcome. Guidance on approaches to assessment of this Unit Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners. All Outcomes should be assessed on a sample basis. Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education. The Unit may be assessed on an Outcome by Outcome basis or through a combination of Outcomes. Outcome 1 This Outcome may be assessed individually or in combination with Outcomes 2 and/or 3. Evidence should be generated through a closed-book assessment under supervised conditions. Outcome 2 This Outcome may be assessed individually or in combination with Outcomes 1 and/or 3. Evidence should be generated through a closed-book assessment under supervised conditions. SQA Advanced Unit Specification HT1L 48, Energy Technologies (SCQF level 8) 9 Outcome 3 This Outcome may be assessed individually or in combination with Outcomes 1 and/or 2. Evidence should be generated through a closed-book assessment under supervised conditions. Opportunities for e-assessment E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment. Opportunities for developing Core and other essential skills Some Core Skills may be developed through the delivery of this Unit. Information and Communications Technology (ICT) may be developed in all Unit Outcomes and in particular, the use of the internet to search for flowcharts, block diagrams and animations associated with each of the technologies. Numeracy may be developed in Outcomes 1 and 2 in relation to the determination of energy output. SQA Advanced Unit Specification HT1L 48, Energy Technologies (SCQF level 8) 10 History of changes to Unit Version Description of change Date © Scottish Qualifications Authority 2013, 2017 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification HT1L 48, Energy Technologies (SCQF level 8) 11 General information for learners Unit title: Energy Technologies This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment. The Unit is designed to introduce a range of technologies associated with energy production. The technologies will be classified as traditional, renewable, and emerging and less common sustainable methods, for the purposes of this Unit. Traditional (existing) methods are based upon fossil fuel technologies and nuclear. Renewable methods are based upon the utilisation of non-fossil fuel based technologies. Emerging and less common sustainable methods are based upon technologies that are currently at various stages of development, implementation or operation together with technologies that are operational but are, overall, small energy producers relative to traditional and renewable methods. The Unit is optional for learners on related SQA Advanced Engineering Awards. It could also be used as a stand-alone Unit where appropriate. No prior knowledge is required although it would be beneficial if learners have previously completed the level 7 Unit Energy Overview and were familiar with using the internet for research purposes. Outcome 1 has been designed to introduce traditional methods of energy production using coal, gas, oil and nuclear fuel sources. Typical power plant operation and processes will be explained detailing energy input through to energy output. Operational aspects, environmental and sustainability issues and numerical calculations pertaining to each technology will also be considered. Outcome 2 has been designed to introduce renewable methods of energy production using wind, hydro, solar and biomass technologies. Typical power plant or device operation and processes will be explained detailing energy input through to energy output. Operational aspects, environmental and sustainability issues and numerical calculations pertaining to each technology will also be considered. Outcome 3 has been designed to introduce emerging and/or less common sustainable methods of energy production. Tidal, wave, geothermal and waste technologies will be considered. Typical power plant or device operation and processes will be explained detailing energy input through to energy output. Operational aspects and environmental and sustainability issues pertaining to each technology will also be considered. In order to achieve this Unit, all Outcomes must be achieved. This Unit will be assessed by responses to structured questions under closed-book conditions. There is no automatic certification of Core Skills or Core Skill components in this Unit. The Unit has been designed to support articulation routes to degree programmes and also to support employment opportunities in the energy sector.SQA Advanced Unit Specification General information for centres Unit title: Engineering Mathematics 1 (SCQF level 6) Unit code: HP48 46 Superclass: RB Publication date: August 2017 Source: Scottish Qualifications Authority Version: 01 Unit purpose This Unit is designed to develop or consolidate a basic level of mathematical skills required of learners across a range of Engineering disciplines. The Unit provides learners with opportunities to develop knowledge, understanding and skills to solve mathematical problems including polynomial, trigonometric, exponential and logarithmic functions. Learners will also be introduced to 3-dimensional vectors and complex numbers. Outcomes On successful completion of the Unit the learner will be able to: 1 Solve problems involving functions and trigonometric equations. 2 Solve problems involving exponential and logarithmic equations. 3 Apply mathematical techniques involving vectors and complex numbers. Credit points and level 1 SQA Credit at SCQF level 6: (8 SCQF credit points at SCQF level 6) Recommended entry to the Unit Entry requirements are at the discretion of the centre. However, it would be advantageous if learners had good algebraic skills together with an ability to transpose engineering formulae and solve simple trigonometric equations. This knowledge and understanding may be SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 2 evidenced by possession of the NQ Unit Mathematics: Technician 1 or a pass at National 5 in Mathematics. Core Skills Achievement OF this Unit gives automatic certification of the following Core Skills component: Complete Core Skill None Core Skill component Using Number at SCQF level 6 There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes for this Unit specification. Context for delivery If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes. The Assessment Support Pack (ASP) for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website (http://www.sqa.org.uk/sqa/46233.2769.html). Equality and inclusion This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements. SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 3 Unit specification: statement of standards Unit title: Engineering Mathematics 1 (SCQF level 6) Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA. Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion. Outcome 1 Solve problems involving functions and trigonometric equations. Knowledge and/or Skills ¨ Properties of functions ¨ Inverse functions ¨ Composite Functions ¨ Trigonometric equations Outcome 2 Solve problems involving exponential and logarithmic equations. Knowledge and/or Skills ¨ Evaluation of logarithmic and exponential expressions ¨ Transposition from logarithmic to exponential form and vice versa ¨ Laws of logarithms ¨ Graphics of logarithmic and exponential functions Outcome 3 Apply mathematical techniques involving vectors and complex numbers. Knowledge and/or Skills ¨ Collinearity ¨ Addition, subtraction and scalar multiplication of vectors ¨ Scalar product ¨ Conversion of complex numbers between rectangular and polar form ¨ Addition and subtraction of complex numbers ¨ Multiplication and division of complex numbers ¨ Representation of complex numbers on an Argand Diagram SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 4 Evidence Requirements for this Unit A sampling approach will be used in the assessment of the Knowledge and/or Skills in this Unit. Learners will need to provide written and/or recorded oral evidence to demonstrate their Knowledge and/or Skills across all Outcomes by showing they can: Outcome 1 Provide evidence of the following Knowledge and/or Skills each time this Outcome is assessed: ¨ Solve two problems (one in degrees and one in radians) involving expressions of the formsin( )A nx a b± = orcos( )A nx a b± = Provide evidence of two out of three Knowledge and/ or Skills remaining in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled: ¨ Identify the domain, range and asymptotes of a given function ¨ Solve one problem involving an inverse function ¨ Solve one problem involving a composite function Outcome 2 Provide evidence of the following Knowledge and/or Skills each time this Outcome is assessed. Solve three problems to cover the Knowledge and/or Skills as follows, combining them where appropriate: ¨ Evaluate formulae; one must include exponentials and one must include logarithms ¨ Transpose expressions from exponential form to logarithmic form and vice versa ¨ Use two out of the three laws of logarithms: —log log logx y xy+ = —log log log x x y y - = —log log p p x x= ¨ Sketch or identify a graph of either a logarithmic function (of the formy A In x= or10logy A x=) or an exponential function (of the formx Ae or.10x A) Fractional and negative coefficients and indices should be included. Outcome 3 Provide evidence of five out of seven Knowledge and/or Skills in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled: ¨ Verify that three, 3-dimensional coordinates (A,B,C) are collinear and determine the ratio of AB to BC ¨ Solve two vector problems involving a combination of at least two of the following: addition of vectors; subtraction of vectors and multiplication of a vector by a scalar SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 5 ¨ Calculate the angle between two 3-dimensional vectors using the scalar product ¨ Convert one vector (2-dimensional cases) or complex number in Cartesian form to polar form and one vector or complex number in polar form to Cartesian form showing clearly all working ¨ Solve one problem involving the addition and subtract of complex numbers (in rectangular form) ¨ Solve one problem involving the multiplication of two complex numbers (in rectangular form) and one problem involving the division of two complex numbers (in polar form) ¨ Represent accurately complex numbers in all four quadrants of an Argand Diagram It is recommended that the assessment for all three Outcomes takes places at a single end of Unit assessment event. Outcomes may also be assessed individually. All re-assessments should be based on a different assessment instrument. This should re-assess all three Outcomes or a full individual Outcome reflecting the format of the original assessment. All re-assessments should be based on a different sample of Knowledge and/or Skills. All assessments should be unseen, closed-book and carried out under supervised, controlled conditions. Computer algebra must not be used in the assessment of this Unit. SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 6 Unit specification: support notes Unit title: Engineering Mathematics 1 (SCQF level 6) Unit Support Notes are offered as guidance and are not mandatory. While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours. Guidance on the content and context for this Unit This Unit is one of a suite of five Units in Mathematics developed for SQA Advanced Qualifications across a range of engineering disciplines. The five Units are: Engineering Mathematics 1 Engineering Mathematics 2 Engineering Mathematics 3 Engineering Mathematics 4 Engineering Mathematics 5 In the development of this Unit a list of topics expected to be covered by lecturers has been identified. Recommendations have also been made on how much time lecturers should spend on each Outcome. The use of this list of topics is strongly recommended to ensure continuity of teaching and learning and adequate preparation for the assessment of the Unit. Consideration of this list of topics alongside the Assessment Support Pack developed for this Unit will provide clear indication of the standard expected in this Unit. Outcome 1 (10 hours) Solve problems involving functions and trigonometric equations ¨ Introduce the concept of the function (this may be done in terms of set theory and, in particular, a function or mapping as a rule which relates each element in one set to one and only one element in another set) ¨ List typical functions that occur in Engineering ¨ Introduce typical mathematical notation used with functions (eg( )f x ,ex R , (or, , ,N W Z Q etc.) ¨ Explain what is meant by an independent and dependent variable ¨ Define the terms domain and range of a function ¨ Introduce the concept of a pole (s) in a function and explain the impact of a pole (s) on the domain of a function which has one or more poles ¨ Demonstrate the way in which to determine the range and domains of functions ¨ Define the term asymptotes ¨ Demonstrate the way in which to determine the asymptotes to functions ¨ Introduce the idea of an inverse function1 ( )f x ¨ Determine the inverse functions of a range of functions ¨ Graph functions and their inverse functions ¨ Introduce composite functions (again this may be done in terms of set theory) ¨ Derive and evaluate a number of composite functions SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 7 ¨ Introduce the concept of the radian Convert degrees to radians and vice versa (egrad π 180 q = ′) ¨ Determine the solutions of equations of the formsin( )A nx B a+ = ± orcos( )A nx B a+ = ± Outcome 2 (8 hours) Transpose and solve exponential and logarithmic equations ¨ Introduce the exponential functionx y a= ¨ Plot graphs of this function for different values ofa ¨ Plot a graph ofx y a- = to demonstrate that this produces the image ofx y a= ¨ Explain thatlogax = y is the inverse function ofx y a= ¨ Examine10x y = and10logx y= as an important example of exponential and logarithmic functions ¨ Plot10x y = and10logx y= for a specified domain ¨ Examinex y e= andlogex y= as a further important example of exponential and logarithmic functions especially in the context of Engineering ¨ Plotx y e= andlogex y= for a specified domain ¨ Evaluate expressions that include1010 ,log ,x x y e and10log y ¨ Introduce the three laws of logarithms ¨ Solve problems involving the three laws of logarithms ¨ Transpose and evaluate expressions from Engineering which include the termkt Ae orkt Ae- ¨ Solve exponential equations3 5 (5 95, 0 1)x x × = = × ¨ Solve logarithmic equations (eg10 10log (2) log (4) 0 5x x+ + + = × ;log (3) log (3) log 6e e et t- - + =) Outcome 3 (14 hours) Apply mathematical techniques to vectors and complex numbers 2-d and 3-d Vectors ¨ Introduce the concept of a vector and scalar and give examples of each form from Engineering ¨ Outline notation commonly used with vectors ¨ Demonstrate the way in which to add and subtract 2-dimensional vectors graphically ¨ Introduce 2-dimensional vectors in component form ¨ Add and subtract vectors using their component form ¨ Multiply 2-dimensional vectors by a scalar ¨ Calculate the magnitude of 2-dimensional vectors using the equation2 12 2 12)()(yyxxd -+-= SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 8 ¨ Introduce 3-dimension coordinates and the representation of 3-dimensional vectors in component form ¨ Calculate the magnitude of 3-dimensional vectors using the equation2 12 2 12 2 12)()()(zzyyxxd -+-+-= ¨ Apply the concept of collinearity to 2- and 3- dimensional vectors ¨ Introduce the scalar product for 2-d and 3-d vectors ¨ Identify the properties of the scalar product (eg. .a b b a= ,.( ) . .a b c a b a c+ = + etc) ¨ Demonstrate the way in which the scalar product can be used to find the angle between two vectors Complex Numbers ¨ Introduce complex numbers (different approaches may be taken to this, for example what happens when the determinant2 4 0b ac- < , or1i = - etc.) ¨ Identify normal notation used with complex numbers (engineers tend to usej while mathematicians usei) ¨ Introduce the Argand Diagram ¨ Demonstrate the representation of complex numbers in Cartesian and polar form (noting the domain of principal argument,arg( )z) ¨ Demonstrate the way in which to convert between Cartesian and polar form and vice versa ¨ Add and subtract complex numbers ¨ Multiply complex numbers in both Cartesian and polar form ¨ Introduce the complex conjugate ¨ Divide complex numbers in both Cartesian and polar form ¨ Represent complex numbers in all four quadrants of an Argand Diagram Guidance on approaches to delivery of this Unit This Unit provides core mathematical principles and processes which underpin much of the studies undertaken in a number of SQA Advanced Qualifications across a range of engineering disciplines. It is recommended that the Unit be delivered towards the beginning of these awards. Centres may deliver the Outcomes in any order they wish, it is recommended that Outcome 1 is delivered first followed by Outcomes 2 and then Outcome 3. It is recommended that Unit delivery is principally undertaken using a didactic approach. All teaching input should be supplemented by a significant level of formative assessment in which learners are provided with opportunities to develop their knowledge, understanding and skills of the mathematical topics covered in the Unit. Computer software and computer algebra may be used to support learning (eg to confirm the solutions of mathematical problems), but it is strongly recommended that such learning resources are only used in a supportive capacity and not as the principal means of delivering Unit content. Guidance on approaches to assessment of this Unit Evidence can be generated using different types of assessment. SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 9 A recommended approach is the use of an examination question paper. The question paper should be composed of an appropriate balance of short answer, restricted response and structured questions. All assessment papers should be unseen by learners prior to the assessment event and at all times, the security, integrity and confidentiality of assessment papers must be ensured. Assessment should be conducted under closed-book, controlled and invigilated conditions. The questions in the examination should not be grouped by Outcome or be labelled in terms of the Outcomes they relate to when a single end-of-Unit examination is used. The summative assessment of all three Outcomes — whether individually or at a single assessment event — should not exceed two hours. When assessing a learner's responses to summative assessment lecturers should concentrate principally on the candidate's ability to apply the correct mathematical technique and processes when solving problems. Candidates should not be penalised for making simple numerical errors. An appropriate threshold score may be set for the assessment of this Unit. A threshold score should be used for each assessment if Outcome level assessment is used. Learners should be provided with a formulae sheet appropriate to the content of this Unit when undertaking their assessment. Computer algebra should not be used in the assessment of this Unit. It is the learner's responsibility to ensure that any calculator they use during assessment are not designed or adapted to offer any of the following facilities: ¨ language translators ¨ symbolic algebra manipulation ¨ complex number manipulation ¨ communication with other machines or the internet. In addition, any calculator used by learners should have no retrievable information stored in them. This includes: ¨ data banks ¨ dictionaries ¨ mathematical formulae Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education. Opportunities for e-assessment E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e- assessment. SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 10 Opportunities for developing Core and other essential skills This Unit has the Using Number component of Numeracy embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show that they have achieved Using Number at SCQF level 6. SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 11 Administrative information Version Description of change Date © Scottish Qualifications Authority 2014, 2017 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification HP48 46 Engineering Mathematics 1 (SCQF level 6) 12 General information for candidates Unit title: Engineering Mathematics 1 (SCQF level 6) This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment. The Engineering Mathematics 1 Unit is one of a suite of five Units in Mathematics developed for SQA Advanced Certificates and Diplomas across a range of Engineering disciplines. The five Units help develop the mathematical skills required for workplace roles and for more advanced studies in Engineering, for example, articulation to degree study at university. The Unit is mandatory in a number of SQA Advanced Certificates in Engineering. This Unit is designed to develop or consolidate a basic level of mathematical skills required of learners across a range of Engineering disciplines. You will learn about the properties of some mathematical functions commonly used in Engineering including linear, trigonometrical, exponential and logarithmic functions. You will also learn how to solve trigonometric, exponential and logarithmic equations. You will also study 2 and 3- dimensional vectors and complex numbers which are widely used in mechanical and electrical Engineering. It is likely that Unit delivery will comprise of a significant teaching input from your lecturer. This will be supplemented by tutorial exercises which will allow you to develop the knowledge, understanding and skills to apSQA Advanced Unit Specification General information for centres Unit title: Engineering Mathematics 2 (SCQF level 7) Unit code: HP49 47 Superclass: RB Publication date: August 2017 Source: Scottish Qualifications Authority Version: 01 Unit purpose This Unit is designed to develop the necessary mathematical skills required of learners seeking to use an SQA Advanced Diploma in Engineering as an exit qualification for an Engineering workplace role or as a pathway to further studies in mathematics at an advanced level. The Unit provides learners with opportunities to develop knowledge, understanding and skills to solve problems involving trigonometric and hyperbolic functions and identities; to differentiate and integrate a wide range of functions and use differentiation and integration techniques to solve Engineering problems. Outcomes On successful completion of the Unit the learner will be able to: 1 Solve trigonometric and hyperbolic function problems. 2 Use differentiation techniques to solve Engineering problems. 3 Use integration techniques to solve Engineering problems. Credit points and level 1 SQA Unit credit at SCQF level 7: (8 SCQF credit points at SCQF level 7) Recommended entry to the Unit Entry requirements are at the discretion of the centre. However, it would be advantageous if learners had a knowledge and understanding of functions including trigonometrical, log and SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 2 exponential functions together with sound algebraic skills. This knowledge and understanding may be evidenced by possession of the SQA Advanced Unit Engineering Mathematics 1 or Higher Mathematics. Core Skills Achievement OF this Unit gives automatic certification of the following Core Skills component: Complete Core Skill None Core Skill component Using Number at SCQF level 6 There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes for this Unit specification. Context for delivery If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes. The Assessment Support Pack (ASP) for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website (http:// www.sqa.org.uk/sqa/46233.2769.html). Equality and inclusion This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements. SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 3 Unit specification: statement of standards Unit title: Engineering Mathematics 2 (SCQF level 7) Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA. Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion. Outcome 1 Solve trigonometric and hyperbolic function problems. Knowledge and/or Skills ¨ Inverse trigonometric ratios ¨ Compound angle formulae ¨ Basic trigonometric identities ¨ Hyperbolic functions ¨ Basic hyperbolic identities Outcome 2 Use differentiation techniques to solve Engineering problems. Knowledge and/or Skills ¨ Differentiation of standards functions ¨ Chain Rule ¨ Second derivatives ¨ Rates of change ¨ Optimisation Outcome 3 Use integration techniques to solve Engineering problems. Knowledge and/or Skills ¨ Indefinite and definite integrals ¨ Integration of standard functions ¨ Applications of integration Evidence Requirements for this Unit A sampling approach will be used in the assessment of the Knowledge and/or Skills in this Unit. Learners will need to provide written and/or recorded oral evidence to demonstrate their Knowledge and/or Skills across all Outcomes by showing that they can: SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 4 Outcome 1 Provide evidence of three out of the five Knowledge and/or Skills in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled: ¨ Evaluate any two of the following trigonometric functions:sec cosec cot a a a, , or for a given value (s) ofa ¨ Solve one problem using one of the following compound angle formulaesin( )x b± orcos( )x b± ¨ Solve one problem using one or more of the following trigonometric identitiescos cos – cos cos – sin sin cos sin sin cos a a a a a a a a a + = = = = 2 2 2 2 2 2 2 1 2 2 2 1 ¨ Evaluate any two of the following hyperbolic functions:sinh cosh tanh a a a, or for a given value (s) ofa ¨ Solve one problem involving hyperbolic identities Outcome 2 Provide evidence of three out of the five Knowledge and/or Skills in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled: ¨ Use standard derivatives to solve two problems involving differentiation (standard derivatives to include( )n n ax ax b+, , trigonometric, hyperbolic,ln( )ax b+ and( ) e ax b+) ¨ Differentiate a function which requires the use of the chain rule ¨ Apply first and second derivatives to determine the position and nature of a turning point on a curve ¨ Use differentiation to determine the rate of change of a variable in an Engineering problem ¨ Apply differentiation techniques to find the optimum solution to a problem Outcome 3 Provide evidence of two out of the three Knowledge and/or Skills in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled: ¨ Solve one indefinite and one definite integral ¨ Solve two integrals using integrals of standard functions (standard functions to include( )n n ax ax b+, , trigonometric, hyperbolic,ln( )ax b+ and( ) e ax b+) ¨ Apply integration techniques to the solution of an Engineering problem It is recommended that the assessment for all three Outcomes takes places at a single end of Unit assessment event. Outcomes may also be assessed individually. All re-assessments SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 5 should be based on a different assessment instrument. This should re-assess all three Outcomes or a full individual Outcome reflecting the format of the original assessment. All re-assessments should be based on a different sample of Knowledge and/or Skills. All assessments should be unseen, closed-book and carried out under supervised, controlled conditions. Computer algebra must not be used in the assessment of this Unit. SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 6 Unit specification: support notes Unit title: Engineering Mathematics 2 (SCQF level 7) Unit Support Notes are offered as guidance and are not mandatory. While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours. Guidance on the content and context for this Unit This Unit is one of a suite of five Units in Mathematics developed for SQA Advanced Qualifications across a range of Engineering disciplines. The five Units are: Engineering Mathematics 1 Engineering Mathematics 2 Engineering Mathematics 3 Engineering Mathematics 4 Engineering Mathematics 5 In the development of this Unit a list of topics expected to be covered by lecturers has been identified. Recommendations have also been made on how much time lecturers should spend on each Outcome. The use of this list of topics is strongly recommended to ensure continuity of teaching and learning and adequate preparation for the assessment of the Unit. Consideration of this list of topics alongside the Assessment Support Pack developed for this Unit will provide clear indication of the standard expected in this Unit. Outcome 1 (12 hours) Solve trigonometric and hyperbolic function problems ¨ Definitions of secant, cosecant and cotangent ratios ¨ Evaluation of secant, cosecant and cotangent ratios for given angles ¨ Distinguish between secant, cosecant and cotangent andcos sin tan- - -1 1 1 , and ¨ State compound angle formulae (egsin( ) sin cos sin cos a b a b b a+ = ± and( )cos cos cos sin sin a b a b a b± = ¨ Apply compound angle formulae to trigonometrical problems (eg( )sin sin q q+ = -180 ¨ Statesin cos sin s cos cos – sin cos cos – in cos sin a a a a a a a a a a a + = = = - = 2 2 2 2 2 2 2 2 2 1 or 1 1 2 2 2 and 2 , , ¨ Use trigonometrical equations in previous bullet point to simplify trigonometrical identities and solve trigonometrical equations ¨ Define sinh x, cosh x, tanh x, cosech x, sech x and coth x SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 7 ¨ Use the following hyperbolic identities to prove identities and modify equations containingex ande x- :( ) 2 2 e cosh sinh e cosh sinh cosh – sinh sinh sinh cosh cosh sinh cosh cosh sinh sinh se differentiation techniques to solve Engineering problems ¨ Revise indices including negative and fractional indices ¨ Introduce the concept of differentiation from first principles (not assessable) ¨ Introduce standard derivatives to include( )n n ax ax b+, , trigonometric, hyperbolic,ln( )ax b+ and( ) e ax b+ ¨ Use standard derivatives to find the derivatives of functions containing one or more of the terms in the previous bullet point ¨ State the chain rule, egdy dy du dx du dx = ′ ¨ Apply the chain rule to functions such as (3x4 + 7)3; sin (t2 + 1); 5esinu etc. ¨ Define higher derivatives (ie second, third, etc) ¨ Use the first and second derivatives to find the maximum and minimum of a function ¨ Use differentiation to evaluate rates of change problems in Engineering ¨ Apply differentiation to optimise a parameter or parameters of a problem (eg the condition under which the maximum electrical power will be transferred from a voltage source to load) Outcome 3 (8 hours) Use integration techniques to solve Engineering problems ¨ Define what is meant by integration (eg as anti-differentiation, as the area bounded by curves, etc ¨ Define indefinite and definite integrals ¨ Solve indefinite and definite integrals using standard integrals (standard integrals to include( )n n ax ax b+, , trigonometric, hyperbolic,ln( )ax b+ and( ) e ax b+) ¨ Apply integration to solve problems in Engineering (area under a velocity time curve giving distance travelled, work done by an expanding gas, first and second moments of area, centroids, mean values, root mean square values, etc) SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 8 Guidance on approaches to delivery of this Unit This Unit provides core mathematical principles and processes which underpin much of the studies undertaken in a number of SQA Advanced Qualifications across a range of Engineering disciplines. It is recommended that the Unit be delivered towards the beginning of these awards. Centres may deliver the Outcomes in any order they wish, it is recommended that Outcome 1 is delivered first followed by Outcomes 2 and then Outcome 3. It is recommended that Unit delivery is principally undertaken using a didactic approach. All teaching input should be supplemented by a significant level of formative assessment in which learners are provided with opportunities to develop their knowledge, understanding and skills of the mathematical topics covered in the Unit. Computer software and computer algebra may be used to support learning (egto confirm the solutions of mathematical problems), but it is strongly recommended that such learning resources are only used in a supportive capacity and not as the principal means of delivering Unit content. Guidance on approaches to assessment of this Unit Evidence can be generated using different types of assessment. A recommended approach is the use of an examination question paper. The question paper should be composed of an appropriate balance of short answer, restricted response and structured questions. All assessment papers should be unseen by learners prior to the assessment event and at all times, the security, integrity and confidentiality of assessment papers must be ensured. Assessment should be conducted under closed-book, controlled and invigilated conditions. The questions in the examination should not be grouped by Outcome or be labelled in terms of the Outcomes they relate to when a single end-of-Unit examination is used. The summative assessment of all three Outcomes — whether individually or at a single assessment event - should not exceed two hours. When assessing a learner's responses to summative assessment lecturers should concentrate principally on the learner's ability to apply the correct mathematical technique and processes when solving problems. Learners should not be penalised for making simple numerical errors. An appropriate threshold score may be set for the assessment of this Unit. A threshold score should be used for each assessment if Outcome level assessment is used. Learners should be provided with a formulae sheet appropriate to the content of this Unit when undertaking their assessment. Computer algebra should not be used in the assessment of this Unit. It is the learners' responsibility to ensure that any calculator they use during assessment are not designed or adapted to offer any of the following facilities: ¨ language translators ¨ symbolic algebra manipulation ¨ symbolic differentiation or integration ¨ communication with other machines or the internet SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 9 In addition, any calculator used by learners should have no retrievable information stored in them. This includes: ¨ databanks ¨ dictionaries ¨ mathematic formulae Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education. Opportunities for e-assessment E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment. Opportunities for developing Core and other essential skills This Unit has the Using Number component of Numeracy embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show that they have achieved Using Number at SCQF level 6. SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 10 Administrative information Version Description of change Date © Scottish Qualifications Authority 2014, 2017 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 11 General information for candidates Unit title: Engineering Mathematics 2 (SCQF level 7) This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment. The Engineering Mathematics 2 Unit is one of a suite of five Units in Mathematics developed for SQA Advanced Certificates and Diplomas across a range of Engineering disciplines. The five Units help develop the mathematical skills required for workplace roles and for more advanced studies in Engineering, for example, articulation to degree study at university. The Unit is mandatory in a number of SQA Advanced Diplomas in Engineering. This Unit is designed to develop the necessary mathematical skills required of learners seeking to use an SQA Advanced Diploma in Engineering as an exit qualification for an Engineering workplace role or as a pathway to further studies in mathematics at an advanced level. You will be introduced to differential calculus which is used widely to solve Engineering problems. This will include differentiating functions using standard derivatives, determining rates of change and finding optimum solutions to Engineering problems. You will also be introduced to integral calculus which is in many ways the reverse process of differentiation. You will learn to solve indefinite and definite integrals using standard integrals and use integration to solve Engineering problems. It is likely that Unit delivery will comprise of a significant teaching input from your lecturer. This will be supplemented by tutorial exercises which will allow you to develop the knowledge, understanding and skills to apply the mathematic principles and processes covered in the Unit to a range of Engineering problems. Depending on which centre you attend, formal assessment may be conducted on an Outcome by Outcome basis or by one holistic assessment. Assessment will be conducted under closed-book, controlled and invigilated conditions. Learners considering taking this Unit will normally be expected to have passed the Engineering Mathematics 1 SQA Advanced Unit or equivalent.ply the mathematic principles and processes covered in the Unit to a range of Engineering problems. Depending on which centre you attend, formal assessment may be conducted on an se differentiation techniques to solve Engineering problems ¨ Revise indices including negative and fractional indices ¨ Introduce the concept of differentiation from first principles (not assessable) ¨ Introduce standard derivatives to include( )n n ax ax b+, , trigonometric, hyperbolic,ln( )ax b+ and( ) e ax b+ ¨ Use standard derivatives to find the derivatives of functions containing one or more of the terms in the previous bullet point ¨ State the chain rule, egdy dy du dx du dx = ′ ¨ Apply the chain rule to functions such as (3x4 + 7)3; sin (t2 + 1); 5esinu etc. ¨ Define higher derivatives (ie second, third, etc) ¨ Use the first and second derivatives to find the maximum and minimum of a function ¨ Use differentiation to evaluate rates of change problems in Engineering ¨ Apply differentiation to optimise a parameter or parameters of a problem (eg the condition under which the maximum electrical power will be transferred from a voltage source to load) Outcome 3 (8 hours) Use integration techniques to solve Engineering problems ¨ Define what is meant by integration (eg as anti-differentiation, as the area bounded by curves, etc ¨ Define indefinite and definite integrals ¨ Solve indefinite and definite integrals using standard integrals (standard integrals to include( )n n ax ax b+, , trigonometric, hyperbolic,ln( )ax b+ and( ) e ax b+) ¨ Apply integration to solve problems in Engineering (area under a velocity time curve giving distance travelled, work done by an expanding gas, first and second moments of area, centroids, mean values, root mean square values, etc) SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 8 Guidance on approaches to delivery of this Unit This Unit provides core mathematical principles and processes which underpin much of the studies undertaken in a number of SQA Advanced Qualifications across a range of Engineering disciplines. It is recommended that the Unit be delivered towards the beginning of these awards. Centres may deliver the Outcomes in any order they wish, it is recommended that Outcome 1 is delivered first followed by Outcomes 2 and then Outcome 3. It is recommended that Unit delivery is principally undertaken using a didactic approach. All teaching input should be supplemented by a significant level of formative assessment in which learners are provided with opportunities to develop their knowledge, understanding and skills of the mathematical topics covered in the Unit. Computer software and computer algebra may be used to support learning (egto confirm the solutions of mathematical problems), but it is strongly recommended that such learning resources are only used in a supportive capacity and not as the principal means of delivering Unit content. Guidance on approaches to assessment of this Unit Evidence can be generated using different types of assessment. A recommended approach is the use of an examination question paper. The question paper should be composed of an appropriate balance of short answer, restricted response and structured questions. All assessment papers should be unseen by learners prior to the assessment event and at all times, the security, integrity and confidentiality of assessment papers must be ensured. Assessment should be conducted under closed-book, controlled and invigilated conditions. The questions in the examination should not be grouped by Outcome or be labelled in terms of the Outcomes they relate to when a single end-of-Unit examination is used. The summative assessment of all three Outcomes — whether individually or at a single assessment event - should not exceed two hours. When assessing a learner's responses to summative assessment lecturers should concentrate principally on the learner's ability to apply the correct mathematical technique and processes when solving problems. Learners should not be penalised for making simple numerical errors. An appropriate threshold score may be set for the assessment of this Unit. A threshold score should be used for each assessment if Outcome level assessment is used. Learners should be provided with a formulae sheet appropriate to the content of this Unit when undertaking their assessment. Computer algebra should not be used in the assessment of this Unit. It is the learners' responsibility to ensure that any calculator they use during assessment are not designed or adapted to offer any of the following facilities: ¨ language translators ¨ symbolic algebra manipulation ¨ symbolic differentiation or integration ¨ communication with other machines or the internet SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 9 In addition, any calculator used by learners should have no retrievable information stored in them. This includes: ¨ databanks ¨ dictionaries ¨ mathematic formulae Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education. Opportunities for e-assessment E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment. Opportunities for developing Core and other essential skills This Unit has the Using Number component of Numeracy embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show that they have achieved Using Number at SCQF level 6. SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 10 Administrative information Version Description of change Date © Scottish Qualifications Authority 2014, 2017 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification HP49 47 Engineering Mathematics 2 (SCQF level 7) 11 General information for candidates Unit title: Engineering Mathematics 2 (SCQF level 7) This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment. The Engineering Mathematics 2 Unit is one of a suite of five Units in Mathematics developed for SQA Advanced Certificates and Diplomas across a range of Engineering disciplines. The five Units help develop the mathematical skills required for workplace roles and for more advanced studies in Engineering, for example, articulation to degree study at university. 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This will be supplemented by tutorial exercises which will allow you to develop the knowledge, understanding and skills to apply the mathematic principles and processes covered in the Unit to a range of Engineering problems. Depending on which centre you attend, formal assessment may be conducted on an Outcome by Outcome basis or by one holistic assessment. Assessment will be conducted under closed-book, controlled and invigilated conditions. Learners considering taking this Unit will normally be expected to have passed the Engineering Mathematics 1 SQA Advanced Unit or equivalent.ply the mathematic principles and processes covered in the Unit to a range of Engineering problems. Depending on which centre you attend, formal assessment may be conducted on an Expand the product of two functions using series forms (eg ( ) ,e ln e tanx x x x+1 etc.) (learners could be provided with a table showing the series expansion of standard functions such as ( ), , ,e sin cos nx x x x+1 etc) ¨ Develop a linear approximation of one polynomial or one non-linear function (eg , ,sin cos e x x x - etc) Outcome 4 (12 hours) Solve first order differential equations ¨ Introduction to differential equations — explain the meaning of dependent and independent variables, order of a differential equation, linearity, initial conditions, etc. ¨ Solve first order differential equations by direct integration ¨ Introduce the separation of variables method as applying to equations of the following form ( ) ( ) dy f x g y dx = ¨ Apply the method of separation of variables to solve first order differential equations (including first order differential equations that arise in Engineering) ¨ Introduce the method of solving differential equations by substitution (eg using y vx y ax by c= = + +or ¨ Apply the method of substitution to the solution of first order differential equations ¨ Introduce the integrating factor method as applying to first order differential equations of the following form: ( ) ( ) dy p x y q x dx + = where the integrating factor ( ) e p x dxò= SQA Advanced Unit Specification HT0348, Engineering Mathematics 4 (SCQF level 8) 9 ¨ Apply the integrating factor method to the solution of first order differential equations ¨ Illustrate how some first order differential equations may be solved by more than one method ¨ Solve first order differential equations taken from Engineering with an initial value using one of the methods shown above Guidance on approaches to delivery of this Unit This Unit provides many of the core mathematical principles and processes required when studying Engineering at a more advanced level. Given the nature of the subject matter in the Unit it is advisable that the Unit is not delivered until learners have studied Engineering Mathematics 3. Centres may deliver the Outcomes in any order they wish. The Unit may be delivery using a didactic approach. All teaching input should be supplemented by a significant level of formative assessment in which learners are provided with opportunities to develop their knowledge, understanding and skills of the mathematical topics covered in the Unit. Alternatively, as learners taking this Unit may be preparing to enter an degree course at university (possibly at an advanced level) the Unit could be delivered as a series of lectures supported by tutorial sessions to help learners prepare better for future university studies. Computer software and computer algebra may be used to support learning (eg to confirm the solutions of mathematical problems), but it is strongly recommended that such learning resources are only used in a supportive capacity and not as the principal means of delivering Unit content. Guidance on approaches to assessment of this Unit The recommended approach is the use of an examination question paper. The question paper should be composed of an appropriate balance of short answer, restricted response and structured questions. The questions in the examination should not be grouped by Outcome or be labelled in terms of the Outcomes they relate to. All assessment papers should be unseen by the learners prior to the assessment event and at all times, the security, integrity and confidentiality of assessment papers must be ensured. Assessment should be conducted under closed-book, controlled and invigilated conditions. The summative assessment of all four Outcomes should not exceed two hours. When assessing a learner's responses to summative assessment lecturers should concentrate principally on the learner's ability to apply the correct mathematical technique and processes when solving problems. Learners should not be penalised for making simple numerical errors. An appropriate threshold score may be set for the assessment of this Unit. Learners should be provided with a formulae sheet appropriate to the content of this Unit when undertaking their assessment. Computer algebra should not be used in the assessment of this Unit. SQA Advanced Unit Specification HT0348, Engineering Mathematics 4 (SCQF level 8) 10 SQA Advanced Unit Specification: Support notes Unit title: Engineering Mathematics 4 (SCQF level 8) It is the learners' responsibility to ensure that any calculator they use during assessment are not designed or adapted to offer any of the following facilities: ¨ language translators ¨ symbolic algebra manipulation ¨ symbolic differentiation or integration ¨ communication with other machines or the internet In addition, any calculator used by learners should have no retrievable information stored in them. This includes: ¨ databanks ¨ dictionaries ¨ mathematic formulae Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education. Opportunities for e-assessment E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment. Opportunities for developing Core and other essential skills This Unit has the Using Number component of Numeracy embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show that they have achieved Using Number at SCQF level 6. SQA Advanced Unit Specification HT0348, Engineering Mathematics 4 (SCQF level 8) 11 History of changes to Unit Version Description of change Date 02 Outcome 2 – Evidence requirements 2 – amended. 06/02/2020 © Scottish Qualifications Authority 2014, 2017, 2020 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification HT0348, Engineering Mathematics 4 (SCQF level 8) 12 General information for learners Unit title: Engineering Mathematics 4 (SCQF level 8) This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment. The Engineering Mathematics 4 Unit is one of a suite of five Units in Mathematics developed for SQA Advanced Certificates and Diplomas across a range of Engineering disciplines. The five Units help develop the mathematical skills required for workplace roles and for more advanced studies in Engineering, for example, articulation to degree study at university. The Unit is optional in a number of SQA Advanced Diplomas in Engineering. This Unit is designed to develop the mathematical skills required by learners who wish to use their SQA Advanced Diploma in Engineering to articulate to university degree study. You will learn about complex numbers (otherwise known as imaginary numbers) and the algebra that underpins the use of these numbers. Complex numbers arise in many branches of Engineering (eg ac electrical circuits). You will also learn to apply matrix techniques which are particularly useful when, for example, solving systems of linear equations containing several variables. You will develop the knowledge, understanding and skills to use Taylor's and MacLaurin's series to represent functions, and finally you will be introduced to a range of techniques for solving an important class of equations known as first order differential equations which arise extensively in many areas of Engineering. Unit delivery may comprise of a significant teaching input from your lecturer supplemented by tutorial exercises which will allow you to develop the knowledge, understanding and skills to apply the mathematic principles and processes covered in the Unit to a range of Engineering problems. Alternatively, in order to prepare you for studies at university the centre where you are taking this Unit may choose to deliver it as a series of lectures supported by tutorials. Formal assessment will be through an examination. Assessment will be conducted under closed-book, controlled and invigilated conditions. Learners considering taking this Unit will normally be expected to have pasSQA Advanced Unit specification General information Unit title: Engineering Mathematics 5 (SCQF level 8) Unit code: HT1N 48 Superclass: RB Publication date: August 2017 Source: Scottish Qualifications Authority Version: 01 Unit purpose This Unit is designed to develop the mathematical skills required by learners who wish to use their SQA Advanced Diploma in Engineering to articulate to university degree study. The Unit will provide learners with the opportunities to develop knowledge, understanding and skills to solve second order, constant coefficient differential equations; use partial differentiation and double integration techniques to solve a range of mathematical problems, solve first and second order differential equations using Laplace Transforms and use eigenvalues and eigenvectors to solve linear system equations. Outcomes On successful completion of the Unit the learner will be able to: 1 Solve second order, constant coefficient differential equations. 2 Solve mathematical problems using partial differentiation. 3 Solve mathematical problems using double integration techniques. 4 Solve differential equations using Laplace Transforms. 5 Use eigenvalues and eigenvectors to solve linear system equations. Credit points and level 1 SQA Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8) SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 2 Recommended entry to the Unit Entry requirements are at the discretion of the centre. However, it would be advantageous if learners had a good knowledge and understanding of differential and integral calculus which included techniques for solving first order differential equations; a sound knowledge and understanding of basic matrix techniques together with strong numerical and algebraic skills. This knowledge and understanding may be evidenced by possession of the SQA Advanced Units Engineering Mathematics 3 and Engineering Mathematics 4. Core Skills Achievement OF this Unit gives automatic certification of the following Core Skills component: Complete Core Skill None Core Skill component Using Number at SCQF level 6 There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes for this Unit specification. Context for delivery If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes. The Assessment Support Pack (ASP) for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website (http://www.sqa.org.uk/sqa/46233.2769.html). Equality and inclusion This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements. SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 3 SQA Advanced Unit Specification: Statement of standards Unit title: Engineering Mathematics 5 (SCQF level 8) Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA. Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion. Outcome 1 Solve second order, constant coefficient differential equations. Knowledge and/or Skills ¨ Homogenous ¨ Non-Homogenous ¨ General solution of second order differential equations ¨ Linear Approximation Techniques Outcome 2 Solve mathematical problems using partial differentiation. Knowledge and/or Skills ¨ Partial Differentiation ¨ Chain/ Product/Quotient Rules ¨ Higher Order Partial Derivatives ¨ Stationary points Outcome 3 Solve mathematical problems using double integration techniques. Knowledge and/or Skills ¨ Rectangular Domain ¨ Polar Domain ¨ Change order of integration in double integrals ¨ Volumes or surface areas SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 4 Outcome 4 Solve differential equations using Laplace Transforms. Knowledge and/or Skills ¨ Laplace Transforms ¨ Inverse Laplace Transforms ¨ Shift theorems ¨ Dirac Delta Function ¨ First and Second Order Differential Equations Outcome 5 Use eigenvalues and eigenvectors to solve linear system equations. Knowledge and/or Skills ¨ Eigenvalues and Eigenvectors ¨ Eigenvalue related problems Evidence Requirements for this Unit A sampling approach will be used in the assessment of the Knowledge and/or Skills in this Unit. Learners will need to provide written and/or recorded oral evidence to demonstrate their Knowledge and/or Skills across all Outcomes by showing they can: Outcome 1 Provide evidence of three out of four Knowledge and/or Skills in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled: ¨ Determine the complimentary function of one second order differential equation ¨ Determine the particular integral of one second order differential equation ¨ Determine the particular solution of one second order, constant coefficient differential equation given initial conditions ¨ Use a Taylor linear approximation and solve the resulting second order non-linear differential equation Outcome 2 Provide evidence of three out of four Knowledge and/or Skills in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled: ¨ Solve one mathematical problem involving first order partial derivatives ¨ Solve one partial differentiation problem involving the use of the chain, product or quotient rules SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 5 ¨ Solve one problem involving higher order partial differentiation ¨ Solve one problem which involves finding the location and nature of a stationary point (s) for a function of the form(,)f x y Outcome 3 Provide evidence of three out of five Knowledge and/or Skills in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled: ¨ Define the domain and limits of integration ¨ Solve a double integral in the rectangular domain ¨ Solve a double integral after transforming the integrand to the polar domain ¨ Solve a double integral by changing the order in the double integration ¨ Use double integration to determine the volume or surface area of a shape or length of a curve Outcome 4 Provide evidence of three out of five Knowledge and/or Skills in this Outcome. The following evidence should be provided for the particular Knowledge and/or Skill items sampled: ¨ Determine the Laplace Transform of a function( )f t from a table of Laplace Transforms ¨ Determine the inverse Laplace Transform of a function( )f s using the completing the square or partial fraction methods ¨ Solve one problem which involves the use of the first or second shift theorems ¨ Solve one problem which involves the use of the Dirac Delta function ¨ Solve a first or second order differential equation with initial conditions using Laplace Transforms Outcome 5 Provide evidence of the following Knowledge and/or Skills each time this Outcome is assessed: ¨ Determine eigenvalue and eigenvector for one 3 × 3 matrix ¨ Determine a diagonalisation transform to solve a problem of An The assessment of all five Outcomes should take place at a single end of Unit assessment event. All re-assessments should be based on a different assessment instrument. This should re-assess all five Outcomes. All re-assessments should be based on a different sample of Knowledge and/or Skills. All assessments should be unseen, closed-book and carried out under supervised, controlled conditions. Computer algebra must not be used in the assessment of this Unit. SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 6 SQA Advanced Unit Specification:Support notes Unit title: Engineering Mathematics 5 (SCQF level 8) Unit Support Notes are offered as guidance and are not mandatory. While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours. Guidance on the content and context for this Unit This Unit is one of a suite of five Units in Mathematics developed for SQA Advanced Qualifications across a range of engineering disciplines. The five Units are: Engineering Mathematics 1 Engineering Mathematics 2 Engineering Mathematics 3 Engineering Mathematics 4 Engineering Mathematics 5 In the development of this Unit a list of topics expected to be covered by lecturers has been identified. Recommendations have also been made on how much time lecturers should spend on each Outcome. The use of this list of topics is strongly recommended to ensure continuity of teaching and learning and adequate preparation for the assessment of the Unit. Consideration of this list of topics alongside the Assessment Support Pack developed for this Unit will provide clear indication of the standard expected in this Unit. Outcome 1 (6 hours) Solve second order, constant coefficient differential equations. ¨ Introduce the general form of a constant coefficient, second order linear differential equation as follows:( ) 2 2 d y dy a b cy f x dx dx + + = where a, b, c are constants ¨ Provide examples of second order differential equations from engineering SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 7 ¨ Explain that solving a second order linear differential equation involves the following three stages: — Finding the complementary function, ycf — Finding a particular integral, ypi — Determining the general solution by adding together the complementary function and the particular integral (y = ycf + ypi) and applying initial conditions where known ¨ Explain the difference between homogeneous and non-homogenous in the context of second order differential equations ¨ Introduce the auxiliary equation (characteristic equation) and explain that when finding roots of the auxiliary equation there are three cases we need to consider ¨ Explain that to find the complementary function one is finding the solution to the equation2 2 0 d y dy a b cy dx dx + + = ¨ Find the complementary functions of second order differential equations using solutions of the form y=ekx ¨ Explore the various forms a complementary function can take ¨ Explain that the particular integral is any function which satisfies the following equation( ) 2 2 d y dy a b cy f x dx dx + + = ¨ Explain that for special classes of( )f x we can use the Method of Undetermined Coefficients to find the particular integral ¨ Find the general solution of second order differential equations including applying initial conditions Outcome 2 (5 hours) Solve mathematical problems using partial differentiation. ¨ Introduce partial differentiation as the process of differentiating functions of two or more variables ¨ Identify the notation used in partial differentiation ¨ For any function(,)f x y differentiate with respect to x treating all terms in y as constant ¨ For any function(,)f x y differentiate with respect to y treating all terms in x as constant ¨ Undertake partial differentiation involving the use of the chain, product or quotient rules ¨ Introduce higher order partial derivatives ¨ Demonstrate the way in which to determine higher order derivatives ¨ Introduce examples of partial differential equations (solutions not required) which occur in engineering ¨ Explain and demonstrate the way in which to find the location and nature of a stationary point for a function of the form(,)z f x y= SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 8 Outcome 3 (5 hours) Solve mathematical problems using double integration techniques. ¨ Explain that double integration involves integrating a function(,)f x y as follows:( ), R dyf y dxxòò where R is the region of integration in the x – y plane ¨ Explain that the process of double integration normally comprises the following three stages: — Work out the limits of integration if these are not known — Determine the inner integral assuming terms in x are constant — Determine the outer integral ¨ Perform double integration where the limits are known and where they have to be determined ¨ Demonstrate that changing the order of integration can sometimes make double integration easier or possible to perform ¨ Demonstrate the way in which double integration may be performed by transforming variables from the rectangular domain to the polar domain ¨ Use double integration to determine the volume or surface areas of objects or the length of a curve Outcome 4 (6 hours) Solve differential equations using Laplace Transforms. ¨ Explain that the Laplace transform method is an integral transform method in which a linear constant coefficient differential equations is transformed into an algebraic equation. The corresponding algebraic equation is then solved and the transform reversed to find the solution of the differential equation. ¨ Introduce the Laplace Transform of( )f t as:( ) e ( ) 0 st F s f t dt ¥ - = ò (non-assessable) ¨ Determine one or two simple Laplace Transforms using the above equation ¨ Direct learners to tables of Laplace Transforms and Inverse Laplace Transforms ¨ Demonstrate techniques for finding the inverse of functions of( )F s using completing the square and partial fractions ¨ Introduce the first and second shift theorems ¨ Demonstrate the application of the two theorems ¨ Introduce the Dirac Delta function (simple treatment only) — provide engineering analogies (eg a power supply spike or a hammer striking an object) SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 9 ¨ State the Laplace transform of the Dirac Delta function as(( )) e as L t a d - - = ¨ Solve differential equations involving the use of the Dirac Delta function ¨ Solve first and second order differential equations with initial conditions using Laplace Transforms ¨ Solve systems of linear differential equations using Laplace Transforms if time permits Outcome 5 (6 hours) Use eigenvalues and eigenvectors to solve linear system equations ¨ Introduce the idea of a trivial and non-trivial solution in the context of matrix theory ¨ Define the concept of an eigenvalue (in terms of, for example, the characteristic equation0A I- =) ¨ Determine eigenvalues for 2 × 2 and 3 × 3 matrices ¨ Introduce the concept of eigenvectors as the non-trivial solutions X of the equationAX X l= ¨ Find the eigenvectors for 2 × 2 and 3 × 3 matrices ¨ Solve eigenvalue/eigenvector problems (eg diagonalisation matrices/transformation matrices) Guidance on approaches to delivery of this Unit This Unit provides many of the core mathematical principles and processes required when studying engineering at a more advanced level. Given the nature of the subject matter in the Unit it is advisable that the Unit is not delivered until learners have studied Engineering Mathematics 4. Centres may deliver the Outcomes in any order they wish. The Unit may be delivery using a didactic approach. All teaching input should be supplemented by a significant level of formative assessment in which learners are provided with opportunities to develop their knowledge, understanding and skills of the mathematical topics covered in the Unit. Alternatively, as learners taking this Unit may be preparing to enter an degree course at university (possibly at an advanced level) the Unit could be delivered as a series of lectures supported by tutorial sessions to help learners prepare better for future university studies. Computer software and computer algebra may be used to support learning (eg to confirm the solutions of mathematical problems), but it is strongly recommended that such learning resources are only used in a supportive capacity and not as the principal means of delivering Unit content. SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 10 Guidance on approaches to assessment of this Unit The recommended approach is the use of an examination question paper. The question paper should be composed of an appropriate balance of short answer, restricted response and structured questions. The questions in the examination should not be grouped by Outcome or be labelled in terms of the Outcomes they relate to. All assessment papers should be unseen by the learners prior to the assessment event and at all times, the security, integrity and confidentiality of assessment papers must be ensured. Assessment should be conducted under closed-book, controlled and invigilated conditions. The summative assessment of all four Outcomes should not exceed two hours and thirty minutes. When assessing a learner's responses to summative assessment lecturers should concentrate principally on the learner's ability to apply the correct mathematical technique and processes when solving problems. Learners should not be penalised for making simple numerical errors. An appropriate threshold score may be set for the assessment of this Unit. Learners should be provided with a formulae sheet appropriate to the content of this Unit when undertaking their assessment. Computer algebra should not be used in the assessment of this Unit. It is the learners' responsibility to ensure that any calculator they use during assessment are not designed or adapted to offer any of the following facilities: ¨ language translators ¨ symbolic algebra manipulation ¨ symbolic differentiation or integration ¨ communication with other machines or the internet In addition, any calculator used by learners should have no retrievable information stored in them. This includes: ¨ databanks ¨ dictionaries ¨ mathematic formulae Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education. SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 11 Opportunities for e-assessment E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment. Opportunities for developing Core and other essential skills This Unit has the Using Number component of Numeracy embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show that they have achieved Using Number at SCQF level 6. SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 12 History of changes to Unit Version Description of change Date © Scottish Qualifications Authority 2014, 2017 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification HT1N 48, Engineering Mathematics 5 (SCQF level 8) 13 General information for learners Unit title: Engineering Mathematics 5 (SCQF level 8) This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment. The Engineering Mathematics 5 Unit is one of a suite of five Units in Mathematics developed for SQA Advanced Certificates and Diplomas across a range of Engineering disciplines. The five Units help develop the mathematical skills required for workplace roles and for more advanced studies in Engineering, for example, articulation to degree study at university. The Unit is optional in a number of SQA Advanced Diplomas in Engineering. This Unit is designed to develop the mathematical skills required by learners who wish to use their SQA Advanced Diploma in Engineering to articulate to university degree study. You will learn a range of techniques for solving second order differential equations. These equations arise frequently in many areas of engineering. You will develop the knowledge, understanding and skills to perform partial differentiation and double integration. You will also learn about the very powerful Laplace Transforms method for solving a wide range of differential equations. You will also be introduced to eigenvalues and eigenvectors which are used in the solution of linear system equations. Unit delivery may comprise of a significant teaching input from your lecturer supplemented by tutorial exercises which will allow you to develop the knowledge, understanding and skills to apply the mathematic principles and processes covered in the Unit to a range of engineering problems. Alternatively, in order to prepare you for studies at university the centre where you are taking the Engineering Mathematics 4 Unit may choose to deliver it as a series of lectures supported by tutorials. Formal assessment will be through an examination. Assessment will be conducted under closed-book, controlled and invigilated conditions. Learners considering taking this Unit will normally be expected to have passed the Engineering Mathematics 3 SQA Advanced Unit or equivalent. It also recommended that you have passed the Engineering Mathematics 4 SQA Advanced Unit.sed theHT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 1 SQA Advanced Unit specification General information Unit title: Fundamentals of Control Systems and Transducers (SCQF level 7) Unit code: HT1R 47 Superclass: VE Publication date: August 2017 Source: Scottish Qualifications Authority Version: 01 Unit purpose This Unit is designed to provide learners with a fundamental knowledge of control systems and their components. It allows learners to study the structure and general behaviour of different types of control systems including open and closed loop types. This Unit also enables learners to develop the knowledge and skills to allow them to understand the operation and application of a range of transducer devices. Learners are provided with the opportunity to construct circuits and systems that incorporate transducers. This Unit acts as a good foundation Unit for more in depth studies in the specialist area of control systems behaviour. Outcomes On successful completion of the Unit the learner will be able to: 1 Explain control system elements and signals. 2 Explain the operation and application of a range of transducers used in control systems. 3 Describe the structure and behaviour of control systems. 4 Demonstrate the application of transducers in control systems. Credit points and level 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7) SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 2 Recommended entry to the Unit Learners should have a general knowledge and understanding of electrical and electronic concepts. This may be evidenced by possession of the SQA Advanced Units: HP46 47 DC and AC Principles, HT7J 46 Analogue Electronics: An Introduction and HT7L 47 Digital Electronics. However, entry requirements are at the discretion of the centre. Core Skills Opportunities to develop aspects of Core Skills are highlighted in the Support Notes for this Unit specification. There is no automatic certification of Core Skills or Core Skill components in this Unit. Context for delivery This Unit has been developed for the SQA Advanced Certificate and SQA Advanced Diploma in Electrical Engineering. If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes. The Assessment Support Pack (ASP) for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website (http://www.sqa.org.uk/sqa/46233.2769.html). Equality and inclusion This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements. SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 3 Unit specification: Statement of standards Unit title: Fundamentals of Control Systems and Transducers (SCQF level 7) Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA. Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion. Outcome 1 Explain control system elements and signals. Knowledge and/or skills ¨ Functions of control system elements and signals ¨ Characteristics of analogue and digital signals ¨ Transmission of analogue signals ¨ Transmission of digital signals ¨ Functions of signal conditioning devices Outcome 2 Explain the operation and application of a range of transducers used in control systems. Knowledge and/or Skills ¨ Operation and application of a range of transducers suitable for measuring the following variables: temperature, flow, displacement, velocity, pressure, strain, position, level and light ¨ Properties of transducers ¨ Identification of suitable transducers for various control systems SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 4 Outcome 3 Describe the structure and behaviour of control systems. Knowledge and/or Skills ¨ Sequence control systems ¨ On-off control systems ¨ Block diagram representation of open and closed loop systems ¨ Transient and steady state behaviour of open loop systems in response to the application of a Unit step input ¨ Transient and steady state behaviour of closed loop systems in response to the application of a Unit step input ¨ The use of controllers to modify open loop system responses ¨ The use of controllers to modify closed loop system responses Outcome 4 Demonstrate the application of transducers in control systems. Knowledge and/or Skills ¨ Construct and demonstrate circuits and systems that incorporate transducers ¨ Operation of circuits and systems that incorporate transducers ¨ Measurement of transducer transfer characteristics Evidence Requirements for Outcomes 1-3 Written and/or Oral recorded evidence is required for outcomes 1-3 which will be provided on a sample basis. In any assessment of the Outcomes three out of five Knowledge and/or Skills items should be sampled from Outcome 1, two out of three Knowledge and/or Skills items from Outcome 2, and four out of seven Knowledge and/or Skills items from Outcome 3. In order to ensure that learners will not be able to foresee what items they will be questioned on, a different sample of three out of five Knowledge and/or Skills items from Outcome 1, two out of three Knowledge and/or Skills items from Outcome 2, and four out of seven Knowledge and/or Skills items from Outcome 3 is required each time the Unit is assessed. Learners must provide a satisfactory response to all items. Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed-book conditions and as such learners must not be allowed to bring any textbooks, handouts, manuals or notes to the assessment. SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 5 Where sampling takes place, a learner's response can be judged to be satisfactory where the evidence shows the learner can: Outcome 1 ¨ Describe the function of five of the following: controller, error detector, regulator, actuator, transducer, manipulated variable, controlled variable, set point, external output ¨ Describe the characteristics of analogue and digital signals, and compare the advantages/disadvantages of each ¨ Describe the effects of a transmission path on an analogue signal, and describe the desirable properties of a suitable cable used for transmitting analogue signals in a control system ¨ Explain the difference between serial and parallel data transmission, state at least three interface standards and, for each standard, state an appropriate application ¨ Explain the function of three signal conditioning devices Outcome 2 ¨ Explain the operation and application of transducers suitable for measuring two variables from the following list: temperature, flow, displacement, velocity, pressure, strain, position, level and light ¨ Explain four of the following properties of a transducer: range, accuracy, repeatability, sensitivity, resolution, linearity, hysteresis ¨ State a suitable transducer for a given control system Outcome 3 ¨ State an example of a sequence control system and describe the component parts ¨ Describe the behaviour of an on-off type of control system and give an example of an application ¨ Draw a block diagram of a specified closed loop control system consisting of a controller, external input (set point), error detector, error signal, actuator, regulator, manipulated variable, process, controlled variable, feedback loop, transducer and any appropriate signal conditioning devices ¨ Draw a voltage/time graph showing the transient and steady state response of an open loop system in response to a Unit step input. The graph should be labelled with final value, steady state error, and time to settle ¨ Draw a voltage/time graph showing the transient and steady state response of a closed loop system in response to a Unit step input. The graph should be labelled with steady state error, time to peak, time to settle, overshoot and final value ¨ Draw labelled graphs showing the effect of increasing and decreasing gain in an open loop system ¨ Draw labelled graphs showing over damped, under damped, and critically damped behaviour in a closed loop system SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 6 Evidence Requirements for Outcome 4 This is a practically based Outcome and all of the Knowledge and/or Skills items should be assessed. The evidence should be presented in response to a practical, laboratory assignment in which each learner is set the task of constructing and demonstrating the operation of a circuit or system that incorporates a transducer. A learner's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the learner is able to: ¨ Construct and demonstrate correct operation of a circuit or system that incorporates a transducer ¨ Describe the operation of the circuit or system that has been constructed ¨ Measure and plot on a graph, the transducer's output in response to changes at its input Evidence of the practical aspects of this assignment should be recorded by centres in the form of a checklist for each learner. Each learner is required to construct a circuit or system independently, and then demonstrate to the Assessor its correct operation. If the learner's circuit or system does not operate properly, then the learner should be allowed to correct the faults and retest the operation at the same assessment event. On completion of the practical laboratory exercise, learners are required to submit a written laboratory report. This report should include the following sections of information: ¨ purpose of the circuit or system, and relevant circuit or system diagram ¨ brief description of method of construction ¨ description of operation of the circuit or system ¨ record of measured input and output values for the transducer ¨ graph of transducer's transfer characteristic (o/p versus i/p values) ¨ record of observations of the operation of the circuit or system ¨ analysis of recorded values, graph and observations ¨ conclusion conveying the success of the operation of the circuit or system Centres should provide learners with details of the required report format. Although it should be encouraged, it is not a requirement that learners use software packages to produce documentation for their reports. Centres should make every reasonable effort to ensure that each report is the learner's own work. The circuit or system that the learner is required to construct and demonstrate can be built using discrete components, pre-constructed modules or a combination of both. Learners should be issued with the circuit or system diagram along with a brief description of its purpose. The circuit or system should be constructed in the laboratory under controlled, supervised conditions, and the written report can be completed outwith the laboratory in the learner's own study time. SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 7 Unit Support Notes Unit title: Fundamentals of Control Systems and Transducers (SCQF level 7) Unit Support Notes are offered as guidance and are not mandatory. While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours. Guidance on the content and context for this Unit This Unit has been written to in order to allow learners to develop knowledge, understanding and skills in the following areas: 1 Explain control system elements and signals. 2 Explain the operation and application of a range of transducers used in control systems. 3 Describe the structure and behaviour of control systems. 4 Demonstrate the application of transducers in control systems. This Unit is at SCQF level 7 and is included within the SQA Advanced Certificate in Electronics and SQA Advanced Diploma in Electronics. However this does not preclude the use of this Unit in other awards where award designers feel this to be appropriate. In designing this Unit, the Unit writer has identified the range of topics expected to be covered by lecturers. The writer has also given recommendations as to how much time should be spent on each Outcome. This has been done to help lecturers decide what depth of treatment should be given to the topics attached to each of the Outcomes. Whilst it is not mandatory for centres to use this list of topics, it is recommended that they do so since the assessment exemplar pack for this Unit is based on the Knowledge and/or Skills and list of topics in each of the Outcomes. A list of topics for each Outcome is given below. Lecturers are advised to study this list in conjunction with the assessment exemplar pack so that they can get a clear indication of the standard of achievement expected of learners in this Unit. SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 8 1 Explain control system elements and signals (10.5 hours) The following topics could be covered whilst referring to a variety of specific control system examples: ¨ Purpose of a control system ¨ Practical examples of the requirement for a control system ¨ Element parts of a control system – controller, error detector, actuator, regulator, process, feedback loop and transducer ¨ Signals in a control system – external inputs and outputs, set point, error signal, manipulated variable, controlled variable, and disturbance variables ¨ Characteristics of analogue and digital signals ¨ Comparative advantages/disadvantages of analogue and digital signals ¨ Transmission of analogue and digital signals over short and long distances, and in industrial environments ¨ Serial and Parallel methods of digital signal transmission ¨ Serial and Parallel Standards (eg RS 232, RS 423, RS 422, RS 485, IEEE 488 and IEEE 1284) and their applications ¨ Need for, and functions of signal conditioning devices eg amplifier, filter, A/D and D/A, linearisation circuit, V/I and I/V conversion 2 Explain the operation and application of a range of transducers used in control systems (8 hours) Basic construction, operation and application of a range of transducers suitable for measuring variables such as temperature, flow, displacement, velocity, pressure, strain, position, level and light. Examples of devices that could be covered are potentiometers, capacitive displacement transducers, tacho-generators, strain gauges, flow meters, manometers, bourdon tubes, bellows, resistance thermometers, thermocouples, shaft encoders, linear variable differential transformers, photo diodes, light dependant resistors, piezo-electric transducers. Transducer properties including range, accuracy, repeatability, sensitivity, resolution, linearity and hysteresis Selection of transducers suitable for specific example control systems. This Outcome should be taught through practical demonstrations and 'hands on' experience of the practical use of transducers in model control systems. This Outcome could be delivered in conjunction with Outcome 4. SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 9 3 Describe the structure and behaviour of control systems (12 hours) ¨ Operation of and examples of sequence control systems eg plc control of industrial processes ¨ Behaviour and example applications of on-off control systems ¨ Behaviour and examples of open loop systems ¨ Behaviour and examples of closed loop systems ¨ Representation in block diagram format of open and closed loop systems ¨ Transient and steady state behaviour of open loop systems in response to the application of a Unit step input: — Draw a voltage/time graph showing the transient and steady state response of an open loop system in response to a Unit step input. The graph should be labelled with final value, steady state error, and time to settle — The use of controllers to modify open loop system responses — Draw labelled graphs showing the effect of increasing gain in an open loop system ¨ Transient and steady state behaviour of closed loop systems in response to the application of a Unit step input: — Draw a voltage/time graph showing the transient and steady state response of a closed loop system in response to a Unit step input. The graph should be labelled with steady state error, time to peak, time to settle, overshoot and final value ¨ The use of controllers to modify closed loop system responses: — Draw labelled graphs showing over damped, under damped, and critically damped behaviour in a closed loop system — Show that controllers can be used to obtain any desired closed loop performance (with respect to peak, overshoot, settling time, steady state error etc.) ¨ Throughout this Outcome, practical illustrative examples of control systems should be available in the laboratory to allow learners the opportunity to observe their operation and obtain some 'hands on' experience. These could be actual or model control systems that allow the learners to observe and analyse the effects of gain changes, input condition changes etc. 4 Demonstrate the application of transducers in control systems (6 hours) This is a practically based Outcome. Laboratory exercises are required to allow learners to: ¨ Construct and then investigate the operation of simple control circuits and systems that incorporate transducers ¨ Measure the output of transducers in response to changes in the input quantity ¨ Plot the transfer characteristics for transducers (graphs of output values versus input values) ¨ From the graphs identify any non-linear characteristics and hysteresis The circuits and systems can be built using discrete components, pre-constructed modules, or a combination of both. SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 10 Unit Assessment: Written Paper 2 hours Practical Laboratory Assignment 2 hours Guidance on approaches to delivery of this Unit Throughout the delivery of this Unit, reference should be made to practical examples of control systems. A range of transducers should be available for learners to view. Practical demonstrations and/or laboratory exercises showing the operation of transducers and model control systems should be provided throughout the Unit. This Unit has been developed as part of the SQA Advanced Certificate and SQA Advanced Diploma in Electrical Engineering awards. Where this Unit is incorporated into other Group Awards it is recommended that it be delivered in the context of the specific occupational area(s) that the award is designed to cover. Details on approaches to assessment are given under Evidence Requirements and Assessment guidelines under each Outcome in the SQA Advanced Unit specification: statement of standards section. It is recommended that these sections be read carefully before proceeding with assessment of learners. The written assessment paper should take place after delivery of the Unit is complete. The practical laboratory assignment can be carried out during the delivery of the Unit. Guidance on approaches to assessment of this Unit Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners. Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education. The assessment for all Outcomes 1, 2 and 3 in this Unit should be combined together into one written assessment paper. This paper should be taken by learners at one single assessment event that should last two hours. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions. This assessment should be carried out at the end of the delivery of the Unit and be conducted under controlled, supervised conditions. SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 11 Outcome 4 should be assessed by a practical, laboratory assignment in which each learner is set the task of constructing and demonstrating the operation of a circuit or system that incorporates a transducer. On successful completion of the practical aspects of this assignment, learners should be required to submit a written laboratory report. The time that should be allocated in the laboratory for this assignment is 2 hours. However, learners should be allowed to complete the written report outwith the laboratory in their own study time. The assessment for Outcome 4 should be carried out at a suitable time during the delivery of the Unit. Assessment Guidelines Outcomes 1-3 The assessment for Outcomes 1, 2 and 3 should be combined together to form one assessment paper. This single assessment paper should be taken at a single assessment event lasting two hours and be carried out under supervised, controlled conditions. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured questions. This assessment should be taken at the end of the Unit. Outcome 4 The assessment of this Outcome should take the form of a practical, laboratory assignment which can be carried out at a suitable time during the delivery of the Unit. The time that should be allocated in the laboratory for this assignment is 2 hours. However, learners should be allowed to complete the written report outwith the laboratory in their own study time. It is recommended that centres develop checklists to support the assessment requirements for each of the Knowledge and/or Skills items. It is essential that centres ensure that evidence generated is the learner's own work. Centres can choose to issue each learner with the same circuit or system to be constructed, or a different circuit or system to be constructed. If different circuits or systems are issued then each one must possess the same degree of difficulty. Opportunities for e-assessment E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment. SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 12 Opportunities for developing Core and other essential skills There may be opportunities to gather evidence towards the following Core Skills or Core Skills components in this Unit, although there is no automatic certification of Core Skills or Core Skills components: ¨ Written Communication (Reading) at SCQF level 6 ¨ Written Communication (Writing) at SCQF level 6 ¨ Using Graphical Information at SCQF level 6 ¨ Critical Thinking at SCQF level 6 ¨ Working with Others at SCQF level 4 SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 13 History of changes to Unit Version Description of change Date Ó Copyright SQA 2005, 2017 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 14 General information for learners Unit title: Fundamentals of Control Systems and Transducers (SCQF level 7) This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment. A control system consists of a number of components (which can be electrical, mechanical, thermal or hydraulic) that act together to maintain a desired output in a process. Control systems are used extensively in industries such as oil refining, electrical generation, chemical processing, and manufacturing and production. Our homes and offices also use control systems to regulate temperature and air conditioning. This Unit has been designed to enable you to develop the necessary knowledge and skills so you to understand the structure and general behaviour of different types of control systems. The Unit takes a non-mathematical approach to control systems. You will learn how to explain control system concepts, use block diagrams to model systems, and use graphical methods to describe their behaviour. You will begin the Unit by learning about the types of component parts that make up control systems. You will also learn how information is transferred between the component parts by means of analogue and digital signals. You will discover that the operation of a control system is heavily influenced by its environment, and that the choice of equipment and signal types depends on the location of the system. The need for signal conditioning devices such as filters and amplifiers will be covered. As you progress through the Unit, you will learn about different methods of controlling the output of a process. Basic methods such as open loop control will be covered. However, these have limitations and disadvantages. Therefore, you will learn about the need for closed loop control systems which have the facility to measure the output variable being controlled, so as to sense changes and enable corrective action to be taken to ensure that the output of the system is maintained at the desired value. Such control systems include temperature control and flow control of liquids. You will also develop knowledge and skills to enable you to understand how controllers can be used to modify the way open and closed loop control systems respond (with respect to speed of response, damping, and transient and steady state response). Closed loop control systems incorporate devices called transducers. These accept energy in one form eg heat and produce output energy in some other form such as an electrical signal. You will study the operation and application of a range of transducers suitable for measuring variables such as temperature, flow, displacement, velocity, pressure, strain, position, level and light. In addition, you will have the opportunity to construct circuits and systems that incorporate transducers. You will measure the characteristics of transducers, and study the overall operation of the circuits and systems that you build. By the end of this Unit you should possess the knowledge and skills to enable you to: explain control system elements and signals; explain the operation and application of a range of transducers; describe the structure and behaviour of control systems; and demonstrate the application of transducers in control systems. SQA Advanced Unit Specification HT1R 47, Fundamentals of Control Systems and Transducers (SCQF level 7) 15 The formal assessment for the Unit will consist of a both a written assessment paper lasting two hours and a laboratory assignment lasting two hours. The written assessment paper will be conducted under closed-book conditions and you will not be allowed to take notes, textbooks etc into the assessment. You will sit this assessment paper at the end of the delivery of the Unit. The laboratory assignment will require you to construct and demonstrate the operation of a circuit or system that incorporates a transducer. This will be carried out during a two hour laboratory session at a suitable time during the delivery of the Unit. On successful completion of the practical aspects of this assignment, you will be required to submit a written laboratory report. Engineering Mathematics 3 SQA Advanced Unit or equivalent. QA Advanced Certificate and SQA Advanced Diploma qualifications provide practical skills and theoretical knowledge that meet the needs of employers. The SQA Advanced Certificate in Electrical Engineering at SCQF 7 covers areas such as: Electrical Principles Information Technology Three Phase Induction Motors Power Electronics Inspection and Testing of Low Voltage Electrical Installations Programmable Logic Controllers Electrical Systems in Hazardous Environments Control Systems Further Mathematical studies Electrical Installation Skills Engineering Quality The SQA Advanced Diploma in Electrical Engineering at SCQF 8 builds on the knowledge and skills of the SQA Advanced Certificate and covers areas such as: Inspection and Testing of Low Voltage Installations Programmable Logic Controllers Electrical Systems in Hazardous Environments Analogue and Digital Electronics Quality Management Electrical Installation Skills Industrial Plant Maintenance Synchronous Machines Electrical Motor Drive Systems Three Phase Induction Motors High Level Engineering Software Additional Control Systems studies Power Supply Circuits Switchgear and Protection Standby Systems Electrical Installation Design: Computer Aided Advanced Mathematical studies Qualification structure SQA Advanced Certificate in Electrical Engineering Group award code: GP6D 47 (96 SCQF credit points) SQA Advanced Certificate in Electrical Engineering at SCQF level 7 consists of 9 mandatory units. SQA Advanced Diploma in Electrical Engineering Unit title: High Level Engineering Software Unit code: HP41 47 Unit purpose: This Unit is designed to give candidates knowledge and understanding and apply basic software engineering concepts to solving electrical and electronic engineering problems that require a software solution. The emphasis in this Unit is on writing and testing and documenting I/O programs using the basic structures available in most high level languages. This Unit provides the candidates with the opportunity to develop skills in system design (top-down design), detailed design (using flow charts or program design language), implementation in the design in a high level language and verification of the design. This Unit also allows the candidates to develop their communication skills by generating the documentation for the designed solution. On completion of the Unit the candidate should be able to: 1 Write, test and document linear programs using I/O statements. 2 Write, test and document I/O programs using conditional statements. 3 Write, test and document I/O programs using iterative loop statements. 4 Write, test and document an I/O program, incorporating subroutines. Credit value: 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*) *SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates. Recommended prior knowledge and skills: Candidates should have a basic knowledge of electronics, logic operations and number systems. This may be evidenced by possession of a Higher in Electronics or the following National Qualification Units D134 11 Combinational Logic or E9LG 11 Computing in Engineering 1 or D980 11 Programmable Systems. Core Skills: There may be opportunities to gather evidence towards Core Skills in this Unit, although there is no automatic certification of Core Skills or Core Skills components. Context for delivery: This Unit was developed for the SQA Advanced Certificate/Diploma in Electronics award. If the Unit is used in another Group Award(s) it is recommended that it should be taught and assessed within the context of the particular Group Award(s) to which it contributes. The platform for this Unit may be a micro-controller system or a standard personal computer with access to I/O ports. SQA Advanced Unit Specification Unit HP41 47: High Level Engineering Software 2 Assessment: It is recommended that this Unit be assessed via a logbook or portfolio and programming projects or assignments that cover the knowledge and skill presented in each Outcome. Centres should take every reasonable effort to ensure that reports are the candidates' own work. It may be possible to issue each candidate with a slightly different specification of equal complexity, or alternatively where there is a suspicion of copying or plagiarism, an appropriate response may be to interview candidates. A checklist should be used to record oral evidence of the candidates' understanding. Centres are recommended to develop appropriate checklists to support the assessment requirements for each of the knowledge and skills items. Centres are also recommended to produce a marking schedule based on the Evidence Requirements listed indicating clearly the required content of the report. Candidates who do not meet the standard should be obliged to correct and resubmit their work. SQA Advanced Unit Specification Unit HP41 47: High Level Engineering Software 3 Unit specification: statement of standards Unit title: High Level Engineering Software Unit code: HP41 47 The sections of the Unit stating the Outcomes, knowledge and/or skills, and Evidence Requirements are mandatory. Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion. Outcome 1 SQA Advanced Unit Specification Unit HP41 47: High Level Engineering Software 4 Evidence Requirements Evidence for the Knowledge and/or Skills in this Outcome will be provided on a sample basis in the form of a portfolio. The candidate's response will be judged to be satisfactory where evidence provided is sufficient to show that the candidate is able to: Write, test and document ONE non-linear I/O program involving: ¨ conditional statements with logic operators ¨ multi-way selection statement Outcome 3 Write, test and document I/O programs using iterative loop statements Knowledge and/or Skills ¨ Flowcharts/pseudo code: FOR...DO, REPEAT…UNTIL, WHILE… loops ¨ Statements: FOR...DO, REPEAT…UNTIL, WHILE… ¨ Loops to manipulate data arrays: — output array data to a port — read port data into an array ¨ Testing of iterative loops ¨ Test plan and actual results Evidence Requirements Evidence for the Knowledge and/or Skills in this Outcome will be provided on a sample basis in the form of a portfolio. The candidate's response will be judged to be satisfactory where evidence provided is sufficient to show that the candidate is able to: Write, test and document ONE non-linear program involving an iterative loop ¨ the program must include a conditional statement inside the iterative loop OR and iterative loop must be a part of the conditional statement Outcome 4 Write, test and document an I/O program, incorporating subroutines Knowledge and/or Skills ¨ Procedures/functions ¨ Bit-wise logical operations: AND, OR and EOR ¨ Identifying port signals and their functions ¨ Test plan and actual results ¨ Documentation Evidence Requirements Evidence for the Knowledge and/or Skills in this Outcome will be provided on a sample basis in the form of a portfolio. The candidate's response will be judged to be satisfactory where evidence provided is sufficient to show that the candidate is able to: SQA Advanced Unit Specification Unit HP41 47: High Level Engineering Software 5 Write, test and document a basic input/output ports program, which includes: ¨ procedures/functions ¨ bit-wise logical operation. ¨ a conditional statement ¨ an iterative loop the documentation to include: ¨ statement of the problem ¨ flowchart/algorithm ¨ program coding with comments ¨ testing and actual results ¨ conclusion SQA Advanced Unit Specification Unit HP41 47: High Level Engineering Software 6 Administrative information Unit code: HP41 47 Unit title: High Level Engineering Software Superclass category: CB Original date of publication: August 2017 Version: 01 History of changes: Version Description of change Date Source: SQA © Scottish Qualifications Authority 2004, 2009, 2017 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification Unit HP41 47: High Level Engineering Software 7 Unit specification: support notes Unit title: High Level Engineering Software This part of the Unit specification is offered as guidance. The support notes are not mandatory. While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours. Guidance on the content and context for this Unit This Unit has been written in order to allow candidates to develop the knowledge, understanding and skills in the area of Software Engineering by writing and testing I/O programs. The following processes illustrate Software Engineering: ¨ user requirements ¨ problem specification ¨ system design (partitioning into manageable tasks) ¨ detailed design (design of individual modules) ¨ implementation (coding into chosen programming language) ¨ program verification (software testing) ¨ program maintenance (extending the program for the future) With validation and documentation taking place at all the stages. This Unit was designed to permit the candidates to apply the software engineering techniques to formulate the solutions to engineering tasks involving input and output ports. Software may be developed for a PC or single board computer or a micro-controller in conjunction with an applications board. Candidates may be provided with subprograms to configure and read/write input/output ports. This Unit was developed as one of four SQA Advanced Certificate/Diploma in Engineering Programming options and is at SCQF level 7. This Unit should be completed before tackling the level 8 Unit, High Level Language: External I/O Transfer. The Unit has identified the topics that are expected to be covered by lecturers. The Unit also gives recommendations as to how much time should be spent on each Outcome. This has been done to help lecturers to decide what depth of treatment should be given to the topics attached to each of the Outcomes. Whilst it is not mandatory for a centre to use this list of topics it is strongly recommended that they do so to ensure continuity of teaching and learning across the Engineering Computing Units and because the assessment exemplar pack for this Unit is based on the Knowledge and/or Skills and list of topics in each of the Outcomes. A list of topics is given below. Lecturers are advised to study this list in conjunction with the assessment exemplar pack for this Unit so they can get a clear indication of the standard of achievement expected of candidates taking the Unit. 1 Write, test and document linear programs using I/O statements (10 hours) User Requirements and analysis Problem Specification Top-down design Hardware SQA Advanced Unit Specification SQA Advanced Unit Specification Guidance on the delivery and assessment of this Unit This is the first engineering programming Unit on the SQA Advanced Certificate/Diploma Electronics and for many candidates this may be their first encounter with programming. In this respect it may be advisable to deliver this Unit on a free-standing basis. Each candidate should have access to a computer loaded with appropriate OS and High Level Language software. Additionally workstations should be available on which candidates are able to test I/O based programs. Delivery of all the Outcomes may be carried out using an LCD projector so that the candidates can view the actual code of the sample programs and see their execution with prepared test data in real terms. SQA Advanced Unit Specification Unit HP41 47: High Level Engineering Software 10 This introductory Unit should be used to develop the candidate's confidence in the basic programming concepts and as such should be taken before considering assembly language programming. It is suggested that the Unit assessment take the form of a logbook or portfolio covering the four Outcomes. For example, assuming a two-hour class per week, then over a 20-week period the assessment schedule may be: Weeks 1 to 5 Linear programming Outcome 1 assignments completed (2hours) Weeks 6 to 10 Non-linear programming for I/O ports using selection statements Outcome 2 assignments completed (2hours) Weeks 11 to 15 Non-linear I/O programming using iterative loops Outcome 3 assignments completed (2hours) Weeks 16 to 20 I/O programming using bit-wise operations Outcome 4 assignments completed (4hours) Open learning This Unit is more suitable for laboratory delivery however it could be delivered by distance learning provided the candidate has the appropriate hardware. This may require some degree of on-line support. However, with regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that assessment whether done at a single or at multiple events was conducted under controlled, supervised conditions. To keep administrative arrangements to a minimum, it is recommended that a single assessment paper (taken by candidates at a single assessment event) be used for distance learning candidates. Equality and inclusion This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements. SQA Advanced Unit Specification Unit HP41 47: High Level Engineering Software 11 General information for candidates Unit (HV2K 47): Industrial Plant Maintenance 1 SQA Advanced Unit Specification General information for centres Unit title: Industrial Plant Maintenance Unit code: HV2K 47 Unit purpose: This Unit is designed to introduce candidates to the planning and organisation of maintenance programmes for industrial plant. The Unit allows candidates to develop the knowledge and skills necessary to select an appropriate style of maintenance program suitable for a particular industrial setting, whilst implementing the necessary health and safety procedures. On completion of the Unit the candidate should be able to: 1. Explain standard techniques involved in plant maintenance. 2. Explain typical health and safety regulations pertaining to plant maintenance systems. 3. Develop a maintenance strategy for a given simple industrial scenario. Credit points and level: 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*) *SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates. Recommended prior knowledge and skills: Candidates should have a basic knowledge of either mechanical or electrical principles and technology. However, entry requirements are at the discretion of the centre. Core Skills: There may be opportunities to gather evidence towards the following Core Skills or Core Skills components in this Unit, although there is no automatic certification of Core Skills or Core Skills components: ¨ Written Communication (reading) at SCQF level 6 ¨ Written Communication (writing) at SCQF level 6 ¨ Using Graphical Information at SCQF level 5 ¨ Using Information Technology at SCQF level 5 ¨ Problem Solving at SCQF level 6 ¨ Working with Others at SCQF level 4 Context for delivery: This Unit was developed for the SQA Advanced Diploma in Electrical Engineering award. If the Unit is to be used in another group award it is recommended that it should be taught and assessed within the subject area of the group award to which it contributes. SQA Advanced Unit Specification Unit (HV2K 47): Industrial Plant Maintenance 2 Assessment: The assessment for this Unit will consist of two parts. An assessment paper is used to cover Outcomes 1 and 2 and an assignment/report to assess Outcome 3. Candidates will sit the assessment paper at one single assessment event lasting one and a half hours. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions. This assessment should be conducted under controlled, supervised conditions. For Outcome 3, candidates will devise a maintenance plan for a given industrial scenario, and write a short report justifying the plan. The assessment paper should be carried out after the delivery of Outcome 2 and the assignment should be submitted after the completion of the Unit. SQA Advanced Unit Specification Unit (HV2K 47): Industrial Plant Maintenance 3 SQA Advanced Unit Specification: statement of standards Unit title: Industrial Plant Maintenance The sections of the Unit stating the Outcomes, knowledge and/or skills, and evidence requirements are mandatory. Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on Outcome 1 Explain standard techniques involved in plant maintenance. Knowledge and/or skills ¨ Reactive Maintenance (RM) ¨ Planned Preventative Maintenance (PPM) ¨ Total Productive Maintenance (TPM) ¨ Reliability Centred Maintenance (RCM) ¨ Condition Monitoring (CM) Outcome 2 Explain typical health and safety regulations pertaining to plant maintenance systems. Knowledge and/or skills ¨ Basic understanding of the typical health and safety issues arising as a result of plant maintenance procedures. ¨ Awareness of the need to comply with all statutory health and safety requirements. ¨ Basic understanding of Risk Assessment ¨ Basic understanding of COSHH, noise related health and safety regulations, PPE ¨ Understanding of Permit to Work procedures. Evidence Requirements Evidence for the knowledge and/or skills in Outcomes 1 and 2 will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer correctly, questions based on a sample of the items shown under the knowledge and skills shown above. In any assessment of this Outcome three out of five knowledge and/or skills items should be sampled for Outcome 1 and three out of five knowledge and/or skills items should be sampled for Outcome 2. SQA Advanced Unit Specification Unit (HV2K 47): Industrial Plant Maintenance 4 In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of three out of five knowledge and/or skills items from Outcome 1 and three out of five knowledge and/or skills items from Outcome 2 are required each time the Unit is assessed. Candidates must provide a satisfactory response to all items. Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to: Outcome 1 ¨ Describe Reactive Maintenance, discuss the advantages and disadvantages of RM. ¨ Explain Planned Preventative Maintenance, giving examples of industrial scenarios where PPM is valid. ¨ Explain Total Productive Maintenance (TPM) ¨ Explain the basic principles of Reliability Centred Maintenance (RCM). ¨ Describe the application of Condition Monitoring in industrial plant maintenance. Outcome 2 ¨ Explain the typical health and safety issues arising as a result of plant maintenance procedures. ¨ Explain the duties of employees and employers with regard to complying with relevant health and safety legislation. ¨ Explain the basic procedure involved in Risk Assessment ¨ Explain specific legislation relating to health and safety, such as, COSHH, noise, PPE. ¨ Explain typical permit to work systems. Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates will be permitted to use scientific calculators during the assessment. Assessment guidelines The assessment for Outcomes 1 and 2 should be combined together to form one assessment paper. This single assessment paper should be taken at a single assessment event lasting one and a half hours and carried out under supervised, controlled conditions. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured questions. Outcome 3 Develop a maintenance strategy for a given simple industrial scenario. Knowledge and/or skills ¨ Requirements of a Maintenance Policy. ¨ Role of Plant records and history. ¨ Use of bar charts for planning maintenance work. SQA Advanced Unit Specification Unit (HV2K 47): Industrial Plant Maintenance 5 ¨ Basic understanding of how CMMS (Computerised Maintenance Management system) software can contribute to setting up and running of plant maintenance systems. ¨ The various factors affecting cost effectiveness. ¨ Appreciate importance of skills and qualifications of workforce. ¨ Understand the need to prioritise tasks based on critical path analysis. Evidence Requirements All knowledge and /or skills items in Outcome 3 should be assessed. Evidence for Outcome 3 will be provided by means of an assignment. The candidate will compile a maintenance program suitable for a given simple industrial scenario. This should be an electrical/mechanical plant setting appropriate to the candidate's own industrial experience or area of study. The candidate's response will include the necessary documentation such as, maintenance schedules, standard operating procedures and relevant health and safety considerations. CMMS software, if available, can be employed in completing the assignment. A report of not less than 800 words plus diagrams, appendices etc. justifying the chosen strategy should be submitted as part of the assignment. The report should also include an explanation of how CMMS software, where used, is employed in the maintenance program, or alternatively where the software is not used, how it would be employed if available. The industrial scenario will be of sufficient complexity, that the response, along with the report, will cover the knowledge and skills items listed for Outcome 3. Outcome 3 ¨ Demonstrate awareness of typical organisational requirements of a Maintenance Policy. ¨ Demonstrate awareness of the role of plant records and history. ¨ Demonstrate the use of bar charts/graphs etc in the planning of maintenance work. ¨ Explain/demonstrate how CMMS software can contribute to the running of plant maintenance systems. ¨ Explain the various factors affecting cost effectiveness of a maintenance policy. ¨ Explain the importance of skills and qualifications of the workforce. ¨ Explain the necessity to prioritise tasks based on critical path analysis. Assessment Guidelines Evidence for this Outcome should be gathered by means of the candidate preparing a maintenance program and a report, related to a given industrial scenario. This should cover all the knowledge and skills items for this Outcome. Centres may wish to issue candidates with guidance notes relating to both the assignment itself and the report. SQA Advanced Unit Specification Unit (HV2K 47): Industrial Plant Maintenance 6 Administrative Information Unit code: HV2K 47 Unit title: Industrial Plant Maintenance Superclass category: VG Date of publication: November 2017 Version: 01 Source: SQA Ó Copyright SQA 2005, 2017 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification Unit (HV2K 47): Industrial Plant Maintenance 7 SQA Advanced Unit Specification: support notes Unit title: Industrial Plant Maintenance This part of the Unit specification is offered as guidance. The support notes are not mandatory. While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours. Guidance on the content and context for this Unit This Unit has been written in order to allow candidates to develop their knowledge and competence in the following areas: 1. Standard techniques involved in plant maintenance. 2. Typical health and safety regulations pertaining to plant maintenance systems. 3. Organisational requirements of successful plant maintenance systems and the role of CMMS software. Guidance on the delivery and assessment of this Unit Delivery of this Unit should relate to Current Codes of Practice and legislation eg ¨ Health and Safety at Work Act, 1974 (HSW Act) ¨ Electricity at Work Regulations 1989 ¨ The Management of Health and Safety at Work Regulations 1999 ¨ IEE Wiring Regulations (current edition) BS7671 1. Explain standard techniques involved in plant maintenance. (14 hours) ¨ RM: advantages/disadvantages, where applicable. ¨ PPM: highlight where PPM is applicable. Discuss advantages such as: more even spread of maintenance work, better budgetary control, fewer emergency breakdowns, extension of working life of plant, scheduling of maintenance at organisationally convenient or economically beneficial time. ¨ TPM: advantages. Highlight the importance of staff training/ cooperation. Discuss overall equipment effectiveness (OEE). ¨ RCM: explain how this stresses the maintenance of items critical to the continued reliable operation of plant. Attempts to maximise reliability. Seeks to eliminate unnecessary preventative maintenance. ¨ Condition Monitoring: explain CM, Monitoring vibration, temperature, thermal imaging, allows recording of trends and comparisons with initial base line measurements. Allows remedial measures to be taken before breakdown. Give examples such as monitoring of high voltage cables, steam turbines and generators. Explain that conditions are monitored according to the most likely failure modes expected. CM Software allows viewing of history in graphs, charts etc and publishing of reports. SQA Advanced Unit Specification Unit (HV2K 47): Industrial Plant Maintenance 8 2. Explain typical health and safety regulations pertaining to plant maintenance systems. (11 hours) ¨ Highlight the necessity of being informed of, and complying with, all statutory health and safety requirements. ¨ Responsibilities for personnel under Health and Safety at Work Act 1974, Management of Health and Safety at Work Regulations 1999. Explain Hazard and risk and give typical examples. Explain the rudiments of sensible risk assessment procedure. ¨ Explain provisions of COSHH regulations. The need to protect personnel from potentially dangerous substances either through removal of substance or provision of appropriate PPE. Explain noise hazards. Noise related health and safety regulations. ¨ Explain the purpose of the permit to work procedure and the need to identify all potentially hazardous work activities to be carried out and the measures required to minimise any risks. Highlight the need for an operational plan involving safe isolation and locking off. ¨ Give examples of typical health and safety issues, which arise as a result of plant maintenance procedures pertinent to the industry, within which the candidate is involved. 3. Develop a maintenance strategy for a given simple industrial scenario. (14 hours) This Outcome should provide the candidate with an opportunity to apply the principles of plant maintenance learned, to a given industrial scenario. ¨ Organisational requirements of a maintenance Policy, administrative structures, analysis of particular industrial scenarios so that appropriate maintenance strategies, including safe systems of work, are employed. ¨ Recording of information and updating plant records, spares inventories and standard operating procedures for plant. ¨ Value of using charts and graphs in analysing the history of particular systems and planning of plant maintenance. ¨ Importance of employing cost effective strategies for maintenance. ¨ Importance of ensuring skills and qualifications of workforce are adequate, diagnostic skills, fitting skills, electrical engineers, plant servicing skills, etc. Vocational qualifications and experience. ¨ Value of critical path network analysis techniques. ¨ Contribution of CMMS software in the management of plant maintenance systems. Assessment : The assessment for this Unit will be composed of two parts. A single assessment paper lasting one and a half hours carried out under supervised controlled conditions and an assignment. It is recommended that the assignment is presented to the candidates toward the conclusion of Outcome 2 and should be completed before the end of the delivery of the Unit. Open learning This Unit could be delivered on an open learning basis. The centre would have to ensure that the written assessment was carried out under controlled and supervised conditions. SQA Advanced Unit Specification Unit (HV2K 47): Industrial Plant Maintenance 9 Equality and inclusion This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements. SQA Advanced Unit Specification Unit (HV2K 47): Industrial Plant Maintenance 10 General information for candidates Unit title: Industrial Plant Maintenance This Unit has been designed to allow you to develop the knowledge and skills involved in setting up a plant maintenance policy. The initial part of the course involves an introduction to current standard techniques employed in plant maintenance. In the maintenance of industrial plant there are often many issues relating to health and safety, therefore Outcome 2 focuses on the typical health and safety regulations pertaining to plant maintenance systems. Permit to work, risk assessment and responsibilities of employers and employees under the health and safety at work act are all examined. During the delivery of the concluding Outcome you will have the opportunity to develop an understanding of computerised maintenance management system software. Also you will able to apply what you are learning, by way of an assignment and report. In this, you will develop a program of maintenance for an industrial scenario and a report justifying your program. The particular industrial setting will be drawn as closely as possible from your own industrial experience or area of study. Formal assessment will be composed of two parts: 1. A written test lasting one and a half hours based on what you have learned in the first two Outcomes in the Unit. 2. A combined assignment and report. SQA Advanced Unit Specification General information Unit title: Information Technology: Applications Software 1 (SCQF level 7) Unit code: HP6L 47 Superclass: CY Publication date: August 2017 Source: Scottish Qualifications Authority Version: 01 Unit purpose This unit is designed to enable students to use Information Technology (IT) systems and applications independently to support a range of information processing activities. The unit is designed to develop a broad knowledge of the theoretical concepts, principles, boundaries and scope of IT applications. These activities will be centred on using software applications packages to meet complex information requirements while paying attention to security and the needs of other users. Outcomes On successful completion of the unit the learner will be able to: 1 Operate a range of IT equipment independently, giving attention to security and to other users. 2 Use a range of software application packages to meet complex information requirements. Credit points and level 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7) SQA Advanced Unit Specification HP6L 47, Information Technology: Applications Software 1 (SCQF level 7) 2 Recommended entry to the Unit Access to this unit will be at the discretion of the Centre, however it is recommended that learners should have sound keyboard and mouse skills and a thorough familiarity with computers and software packages. These skills may be evidenced by the achievement of appropriate National Units or Courses but they may also have been acquired in an informal or work environment. For Core Skills it would be beneficial if learners had some IT skills. This could be demonstrated by the achievement of the Core Skill Using Information Technology at SCQF level 5 or equivalent. Core Skills Opportunities to develop aspects of Core Skills are highlighted in the Support Notes for this unit specification. This unit gives automatic certification of the core skill: Using Information Technology at SCQF level 6. Context for delivery This unit is included in the framework of a number of SQA Advanced Group Awards. It is recommended that it should be taught and assessed within the particular Group Award to which it contributes. The Assessment Support Pack (ASP) for this unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. Equality and inclusion This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements. SQA Advanced Unit Specification HP6L 47, Information Technology: Applications Software 1 (SCQF level 7) 3 Unit specification: statement of standards Unit title: Information Technology: Applications Software 1 (SCQF level 7) Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA. Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion. Outcome 1 Operate a range of IT equipment independently, giving attention to security and to other users. Knowledge and/or Skills ¨ The different components of a computer system and how to use them, (ie mouse or other pointing device, keyboard, monitor, disk drive, processor, printer, scanner, etc) ¨ The functions of tools such as file managers, print managers, control panels and how to use these ¨ The ways in which data can be kept secure, (eg encryption, passwords, back ups, virus protection) and how security procedures can be used to meet the needs of all users of a computer system ¨ The causes of some common software and hardware problems, (eg cable connections, device settings, software option settings) and what action to take to resolve these Outcome 2 Use a range of software application packages to meet complex information requirements. Knowledge and/or Skills ¨ Methods for assessing information requirements and designing solutions using IT ¨ How to use straightforward and complex features of a range of software application packages (these can be word processing, spreadsheet, database, simulation, graphics, communications, (ie internet, intranet, email, etc), audio/music, animation, video, multimedia, desktop publishing, data logging and retrieval, control or other packages) ¨ How to integrate data types within a software application package ¨ How to integrate information from more than one software application package ¨ The content and search facilities of a range of computer data sources ¨ Factors to consider when working out a search strategy when using a computer data source ¨ How to extract information from a local and a remote computer data source SQA Advanced Unit Specification HP6L 47, Information Technology: Applications Software 1 (SCQF level 7) 4 Evidence Requirements for this Unit Learners will need to provide evidence to demonstrate their Knowledge and/or Skills across all Outcomes by showing that they can: Outcome 1 ¨ Use five hardware devices, (eg mouse, keyboard, printer, monitor, disk drive, scanner) ¨ Start up and close down the operating system ¨ Open and close software packages ¨ Locate data and applications ¨ Use a filing system, (eg to organise folders and sub-directories applying naming conventions) ¨ Use two tools within the operating system, (eg file managers, print managers and control panels) ¨ Implement security measures responsibly and with consideration for the needs of other users, (eg passwords, backups, virus protection) ¨ Resolve one hardware and one software problem, (eg printer off-line, sound not working, too many open programs, system freeze, software option settings, etc) Outcome 2 ¨ Identify the information requirements of users and how these requirements can be met ¨ Select software applications packages which are appropriate to meet the identified information requirements ¨ Use four or more software applications packages to process the identified information requirements and which output two or more different data types, (eg text, number, graphics, audio, video) in the form of documents, designs, compositions, models or presentations ¨ Carry out three searches to extract and present relevant information from suitable local and remote computer data sources. A minimum of two searches must be from remote computer data sources. To do this the learner will be required to: — Plan how to find the information and make decisions about searches taking account of efficiency in terms of time, cost, effective filtering and Outcome — Extract information, (eg text, number, graphics, audio, video) which matches several search criteria, (eg keywords, fields, file names, screen grabber, digital camera or scanner). Searches must be different from each other, eg searching two different sources, or searching the same source for two different forms of information ¨ Integrate two or more different data types, (eg text, number, graphics, audio, video) from more than two software applications packages into a single product. The product may be in the form of a document, design, composition, model or presentation ¨ Format the product so that the final output meets the identified information requirements and is clear and helpful to users The evidence for this Outcome should be in the form of a document, design, composition, model or presentation covering all the Evidence Requirements shown above. SQA Advanced Unit Specification HP6L 47, Information Technology: Applications Software 1 (SCQF level 7) 5 Unit support notes Unit title: Information Technology: Applications Software 1 (SCQF level 7) Unit Support Notes are offered as guidance and are not mandatory. While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours. Guidance on the content and context for this Unit This unit provides a solid basis on which further IT skills can be built. It will enable learners to use IT systems with minimal support, paying due regard to security. Electronic data sources are to be used, learners are expected to achieve effective results when using IT software in an unfamiliar context by using on-line help facilities and suppliers' handbooks. Basic configuration and fault-finding skills are to be taught. Files should be provided for learners as appropriate to negate the need for them to enter large amounts of text or data. This unit is very much aimed at enabling learners to obtain and use data and software applications packages associated with the internet and email, ie electronic communications. Therefore, there should be considerable emphasis placed upon providing access to appropriate data and software associated with electronic communications. Candidates should then be encouraged to learn for themselves the benefits of being able to integrate information from diverse sources and produce documents, designs, compositions, models or presentations of a complex nature. The unit can be approached from the standpoint of using information technology to support a range of information processing activities. The learner should be able to plan for, develop and produce the relevant information requirements of users. Candidates should achieve the level of competence required of a regular user of IT applications software in a commercial or professional situation. Candidates will require individual access to a personal computer/workstation. It is suggested that, wherever possible, commercially available current versions of industry standard software be used. The component parts of an integrated software package along with its operating environment can be used to achieve all Outcomes. This should not be prohibitive in the case of the centres, but may be an issue if being undertaken in the workplace. It is generally assumed that the environment for this unit will be, for example, Microsoft Windows and Office 97/2000 or Lotus, or other vendor equivalents, however, this is not specified and the Outcome requirements are deliberately generic in nature. Outcome 1 looks at the components of hardware, the functions of operating system tools and how these are used. Data security measures, resolving common hardware and software problems are also pre-eminent. All of the elements should be taught in the context of giving attention to the needs of other users of a computer system. SQA Advanced Unit Specification HP6L 47, Information Technology: Applications Software 1 (SCQF level 7) 6 Outcome 2 looks at using a range of software packages to meet complex information requirements. Centres can choose four or more packages (a minimum of four different packages must be used) from the whole range of applications packages available. The software application packages chosen must be relevant to the vocational area of the Group Award undertaken by the learner. The emphasis in this Outcome should be on producing complex information in a context that is unfamiliar to the learner. Candidates should be able to integrate data types, (eg text, number, graphics, audio, video) into a single product and to format the product so that the final output is clear and helpful to users. Candidates should show that they can plan for the information requirements; select and use software packages appropriate to information requirements; select suitable computer data sources for information and extract suitable information from these computer data sources to meet relevant requirements. An indication of the range of activities that learners are expected to be able to carry out when using a variety of software applications packages during the course of this unit is given below for some of the 'standard' applications that centres may use. This should not be taken to be a 'prescriptive', or indeed, an exhaustive list of requirements but should help to serve as a guide to the level of skills required. 1 Selection and use of appropriate software applications packages and electronic data sources from both local and remote computers. 2 Selection and use of document layout, page layout and format facilities, eg: views, use of toolbars, rulers, guides, zoom, fonts, bullets and numbering, borders and shading, tabs, case, dropped capitals, columns, themes, backgrounds, styles, frames, colours and lines, alignment, templates, auto-format. 3 Use of on-line help and tutorial support facilities. 4 File Handling, eg properties, naming conventions, saving, saving for use with web and other applications, retrieving, retrieving from web and other applications, copying, renaming, importing, exporting, emailing, attachments, routing, and faxing. 5 Editing, eg undo, repeat, cut, copy, paste, paste special, select all, fill, clear, find, replace, go to, rename, links, and objects. 6 Selection and use of insertions, eg headers and footers, page breaks, comments, footnotes, captions, numbering, symbols, date and time, index and tables, bookmarks, pictures, objects, hyperlinks, graphics, movies, sounds, tables, queries, forms and reports, functions, charts, comments, fields, records and files. 7 Use of 'tools', eg spelling and grammar checker; thesaurus; search and replace; auto- correction; sort; merge; customisation; options; security; protection; macros (simple); on- line facilities; send and receive; address books, synchronisation, message rules, messenger services, newsgroups and accounts. 8 Printing, eg printer selection; printer properties; printer set up, eg paper size, paper type, scaling, orientation, etc; print preview; use of print preview facilities, eg zoom, multiple pages, ruler, scaling, etc. 9 Searching should involve several criteria, eg key terms or fields, and requires decisions to be made about an effective strategy for their application, eg with due regard for time, cost, effective filtering and result. 10 Extracting and presenting relevant information - relevant data may be records in a database, a photographic image, a video or audio clip. Selection/importation may involve tools such as screen grabbers, digital or video cameras and scanners. This unit is designed to enable students to use IT systems and applications independently to support a range of information processing activities. The unit is designed to develop a knowledge of the theoretical concepts, principles, boundaries and scope of IT applications. These activities will be centred on using several software application packages to meet complex information requirements. SQA Advanced Unit Specification HP6L 47, Information Technology: Applications Software 1 (SCQF level 7) 7 Instrument of assessment There are two Outcomes, both largely of a practical nature. Outcome 1: Prove Knowledge and/or Skills of: the different components of a computer system, the function of tools such as file manager, print manager and control panel, the ways in which data can be kept secure and the causes of common software and hardware problems and how to resolve them. Outcome 2: Uses a range of software application packages, (at least four) to meet complex information requirements. The learners will be given a comprehensive checklist of all evidence required to successfully complete this Outcome. They will then have to create a technical manual and player guide indicating on the checklist exactly where each requirement has been met. Given the complexity of the technical manuals and user guides shipped with today's games, this should make for a demanding, but hopefully enjoyable experience. Guidance on approaches to delivery of this Unit This unit is designed to enable learners to use IT systems independently to support a range of information processing activities. Early inclusion of this unit in the Group Award is preferable as students should then be able to present work for other Units using the skills learned in this unit. During the course of the unit learners should have several opportunities to develop their practical skills and should then be assessed appropriately. Assessment should be by one project or case study. Candidates should have access to on- line help, tutorial support and/or suppliers' manuals as required. Individual centres will need to plan Outcome 2 to ensure that such resources as the internet service provider, compact discs, available telephone lines, modems, software application packages and operating systems updates are available prior to commencement of the unit. If this unit is being delivered as part of a Professional Development Award which receives endorsement from a vendor such as Microsoft, it must be delivered and evidence generated as detailed in the document 'Approval to certification' which is associated with that particular vendor and the Professional Development Award. Guidance on approaches to assessment of this Unit Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners. Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education. Outcome 2 The emphasis in this Outcome should be on producing complex information in a context which is unfamiliar to the learner. Centres may wish to complete an observation checklist to keep track of the learner's development in the use of the four chosen software applications SQA Advanced Unit Specification HP6L 47, Information Technology: Applications Software 1 (SCQF level 7) 8 packages. The software application packages chosen must be relevant to the vocational area of the Group Award undertaken by the learner. Opportunities for e-assessment E-assessment may be appropriate for some assessments in this unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment. Opportunities for developing Core and other essential skills This unit gives automatic certification of the core skill: Using Information Technology at SCQF level 6. SQA Advanced Unit Specification HP6L 47, Information Technology: Applications Software 1 (SCQF level 7) 9 Administrative information History of changes to Unit Version Description of change Date © Scottish Qualifications Authority 2001, 2007, 2017 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification HP6L 47, Information Technology: Applications Software 1 (SCQF level 7) 10 General information for learners Unit title: Information Technology: Applications Software 1 (SCQF level 7) This section will help you decide whether this is the unit for you by explaining what the unit is about, what you should know or be able to do before you start, what you will need to do during the unit and opportunities for further learning and employment. This unit is designed to enable you to use IT systems and applications independently to support a range of information processing activities. You should develop a broad knowledge of the theoretical concepts, principles, boundaries and scope of IT applications. By the end of the unit you should have learned how to plan for, develop and produce the relevant information requirements of users. To meet the requirements of users you will be required to use and develop a broad range of skills in a range of software applications packages, (a minimum of four), such as, word processor, spreadsheet, database, simulation, graphics, communications, (ie internet, intranet, email, etc), audio/music, animation, video, multimedia, desktop publishing, data logging and retrieval, control or other packages. On successful completion of the unit you will be able to: 1 Operate a range of IT equipment independently, giving attention to security and to other users. 2 Use a range of software packages to meet complex information requirements. In Outcome 1 you will learn about the components of hardware, the functions of operating system tools and how these are used. You will also learn about data security measures and resolving common hardware and software problems. You will learn about all of the elements above in the context of meeting the needs of all users of a computer system. In Outcome 2 you will learn about how to use a range of software packages to meet complex information requirements. You will learn about a minimum of four different software packages from the whole range of applications packages available. The emphasis in this Outcome will be on producing complex information in a context that is unfamiliar to you. You will learn how to integrate data types, (eg text, number, graphics, audio, video) into a single product and to format the product so that the final output is clear and helpful to users. You will find out how to: plan to meet users' information requirements; select software packages appropriate to information requirements; select suitable computer data sources for information and extract suitable information from these computer data sources to meet relevant user requirements. To complete this unit successfully, you must demonstrate a satisfactory level of performance in a number of tasks covering the Outcomes listed above. You must provide evidence of the work you carry out for each assessment task in the form of a set of printed documents with a front cover: each print having details of your name, the date and the task. You will be encouraged to access on-line help facilities, tutorial support and/or suppliers' manuals as required. More detailed guidance on the content, amount, style and quality required of your work will be made available to you during your progress through the unit. Your assessor will observe you carrying out the assessment tasks, and will complete an observation checklist to certify that each of your prints is your own work and whether or not it has reached the required standard.Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 1 SQA Advanced Unit Specification General information for centres Unit title: Inspection and Testing of Low Voltage Electrical Installations Unit code: HV2L 47 Unit purpose: The purpose of this Unit is to enable candidates to demonstrate knowledge, understanding and competence in testing and inspection of electrical installations. On completion of the Unit the candidate should be able to: 1. Explain the general requirements for the inspection and testing of an electrical installation during its normal life-cycle. 2. Explain the recommended tests to verify the integrity of an electrical installation. 3. Explain the requirements and precautions for testing electrical installations. 4. Carry out appropriate testing procedures which conform to British Standard requirements. Credit points and level: 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*) *SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates. Recommended prior knowledge and skills: Candidates should possess a general knowledge and understanding of electrical principles and electrical installation. This may be evidenced by the possession of the SQA Advanced Unit, HP46 47 DC and AC Principles. A knowledge of the requirements of the current edition of the IEE Wiring Regulations (BS7671) would be beneficial. However, entry requirements are at the discretion of the centre. Core skills: There may be opportunities to gather evidence towards the following listed Core Skills or Core Skills components in this Unit, although there is no automatic certification of Core Skills or Core Skills components: ¨ Written Communication (reading) at SCQF level 6 ¨ Written Communication (writing) at SCQF level 5 ¨ Critical Thinking at SCQF level 6 ¨ Planning and Organising at SCQF level 5 ¨ Reviewing and Evaluating at SCQF level 5 SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 2 Context for delivery:. This Unit was developed for the SQA Advanced Certificate and SQA Advanced Diploma in Electrical Engineering awards. If this Unit is delivered as part of another group award, it is recommended that it should be taught and assessed within the subject area of the group awards to which it contributes. Assessment: The assessment for Outcomes 1, 2 and 3 of this Unit should be combined together into one written assessment paper. This paper should be taken by candidates at one single assessment event that should last one and a half hours. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions. This assessment should be conducted under controlled, supervised conditions Outcome 4 will be assessed by practical exercises, the evidence being recorded using an observation checklist, the production of a short report and the completion of standard test result sheets and an inspection report during the testing procedures. The completion of documentation is extremely important in this Unit and all assessments should be based on the IEE Certificates for Inspection, Testing and Certification of Electrical Systems. These practical exercises should incorporate both a visual inspection of an electrical installation, lasting 30 minutes and a series of installation tests along with the completion of the required certification. The testing and certification section of the exercise should last 60 minutes. NOTE: the electrical installation should contain a minimum of two faults which must be found during the testing exercise. The first assessment (Outcomes 1, 2 and 3) should be carried out after delivery of Outcome 3 and the second assessment (Outcome 4) should be carried out at the end of the delivery of this Unit. It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in order to successfully achieve the Unit. SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 3 SQA Advanced Unit Specification: statement of standards Unit title: Inspection and Testing of Low Voltage Electrical Installations Unit code: HV2L 47 The sections of the Unit stating the Outcomes, knowledge and/or skills, and evidence requirements are mandatory. Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion. Outcome 1 Explain the general requirements for the inspection and testing of an electrical installation during its normal life-cycle. Knowledge and/or skills ¨ Methods of initial inspection ¨ Recommended sequence of initial tests to be carried out ¨ Reason for periodic inspection and testing ¨ Procedures to be adopted for alterations and additions to an installation Outcome 2 Explain the recommended tests to verify the integrity of an electrical installation. Knowledge and/or skills ¨ Procedures for testing electrical installations ¨ The need to measure the maximum prospective fault current and external earth fault loop impedance at the point of origin of the installation. Outcome 3 Explain the requirements and precautions for testing electrical installations. Knowledge and/or skills ¨ The reasons for permit-to-work and sanction-for-test documents being required in certain work environments. ¨ The reasons for intrinsically safe test instruments being required in potentially explosive environments. ¨ The use of test instruments and precautions. SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 4 Evidence requirements Evidence for the knowledge and /or skills in Outcomes 1 to 3 will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that she/he can answer correctly questions based on a sample of the items shown under the knowledge and skills items in all three Outcomes. In any assessment of the Outcomes three out of four knowledge and/or skills items should be sampled from Outcome 1, two out of two knowledge and skills items from Outcome 2 and two out of three knowledge and skills items for Outcome 3. In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of three out of four knowledge and/or skills items from Outcome 1, and two out of three knowledge and skills items from Outcome 3 are required each time the Unit is assessed. Candidates must provide a satisfactory response to all items. Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to: Outcome 1 ¨ Explain the methods of initial inspection ¨ List the recommended sequence of initial tests to be carried out ¨ Describe the reason for periodic inspection and testing ¨ Explain the procedures to be adopted for alterations and additions to an installation Outcome 2 ¨ Describe the procedures for testing electrical installations ¨ Explain the need to measure the maximum prospective fault current and external earth fault loop impedance at the point of origin of the installation. Outcome 3 ¨ Explain why in certain work environments permit-to-work and sanction-for-test documents are required. ¨ Explain why in potentially explosive environments intrinsically safe test instruments are required. ¨ Explain the use of test instruments and precautions. Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates will be provided with current codes of practice, BS7671 or other relevant legislative documentation for use during the assessment. SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 5 Assessment guidelines The assessment for Outcomes 1 to 3 should be combined together to form one assessment paper. This single assessment paper should be taken at a single assessment event lasting one and a half hours and carried out under supervised, controlled conditions. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured questions. This assessment should be taken after delivery of Outcome 3. Outcome 4 Carry out appropriate testing procedures which conform to British Standard. Knowledge and/or skills ¨ Technical data requirements to enable testing and inspection to take place correctly. ¨ Safe isolation procedure on a simulated electrical installation ¨ Visual inspection of an electrical installation ¨ Testing of an electrical installation ¨ Schedules of testing results and a periodic inspection report Evidence requirements Evidence for the knowledge and/or skills in Outcome 4 will be provided by the candidate carrying out a visual inspection and a series of tests on a simulated electrical installation and completing the required documentation. This exercise is intended to be undertaken on a simulated installation operating at a safe level of working voltage. The simulated installation rig(s) should be supplied from a three-phase isolator and feed a single- phase distribution board from which lighting circuits and power circuits are supplied. A three phase motor circuit should be provided for. A residual current device or devices should be included in the design. The design of the rig(s) is not critical but must be such that all the tests can be performed effectively. Different rigs can be used to cover the complete range of tests. Candidates will be required to carryout the following tests in the sequence prescribed in BS 7671 Part 7: ¨ Continuity of protective conductors including main and supplementary equipotential bonding ¨ Continuity of ring final circuit conductors ¨ Insulation resistance ¨ Polarity ¨ Earth electrode resistance ¨ Earth fault loop impedance ¨ Prospective fault current ¨ Residual Current Device (RCD) testing SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 6 A total of TWO fault conditions will be built into the test circuits to verify the candidate's ability to interpret the test results obtained. The candidate will be expected to identify the fault results and highlight these in his/her inspection report. Observation checklists should be used to record the candidate's performance for the inspection and each of the testing procedures. The candidate should be given the necessary work instructions to carry out the inspection and testing. A selection of the necessary hand tools and a range of test instruments should be provided. During the tests, the candidate will be expected to record all relevant information and tests results for all circuits on a standard test results sheet and to complete a periodic inspection report. Safe working practice must be observed throughout the inspection and testing procedure. Written evidence should be produced to show the candidate's ability to explain the technical data requirements to enable testing and inspection to take place and to outline the safe isolation procedure which will be implemented prior to the testing procedures taking place. A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to: ¨ Explain the technical data requirements to enable testing and inspection to take place correctly. ¨ Demonstrate a safe isolation procedure on a simulated electrical installation. ¨ Perform an inspection of the simulated electrical installation ¨ Perform the listed tests on a simulated electrical installation ¨ Complete the schedules of testing results and a periodic inspection report Evidence should be generated through assessment under controlled, supervised conditions. Assessment should be conducted under closed-book conditions and, as such, candidates must not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates will be provided with current codes of practice, BS7671 or other relevant legislative documentation for use during the assessment. Assessment guidelines Outcome 4 should be assessed by practical testing exercises on a simulated electrical installation rig(s). Evidence of the candidate's ability to carry out the inspection and testing procedures should be recorded using observation checklists. The candidate will also be required to complete the standard test result sheet and an inspection report which should include identification of the two fault condition results. A report, of approximately 400 words plus diagrams, charts etc, along with completion of a 'Periodic Inspection Report for and Electrical Installation' (Appendix 6, BS7671), should be produced by the candidate to show his/her ability to explain the technical data requirements to enable testing and inspection to take place and to outline the safe isolation procedure which will be implemented prior to the testing procedures taking place. The assessment of the Outcome 4 should be undertaken at the end of the Unit. SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 7 Administrative Information Unit code: HV2L 47 Unit title: Inspection and Testing of Low Voltage Electrical Installations Superclass category: TH Date of publication: November 2017 Version: 01 Source: SQA Ó Copyright SQA 2005, 2017 This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged. SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications. FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form. SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 8 SQA Advanced Unit Specification: support notes Unit title: Inspection and Testing of Low Voltage Electrical Installations This part of the Unit specification is offered as guidance. The support notes are not mandatory. While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours. Guidance on the content and context for this Unit This Unit has been written in order to allow candidates to develop their knowledge and competence in the following areas: 1. General requirements for the inspection and testing of an electrical installation during its normal life-cycle. 2. Recommended tests to verify the integrity of an electrical installation. 3. Requirements and precautions for testing electrical installations 4. Testing procedures which conform to British Standard requirements In designing this Unit, the unit writer has identified the range of topics expected to be covered by lecturers. The writer has also given recommendations as to how much time should be spent on each Outcome. This has been done to help lecturers decide what depth of treatment should be given to the topics attached to each of the Outcomes. Whilst it is not mandatory for centres to use this list of topics, it is recommended that they do so since the assessment exemplar pack for this Unit is based on the knowledge and/or skills and list of topics in each of the Outcomes. A list of topics for each Outcome is given below. Lecturers are advised to study this list in conjunction with the assessment exemplar pack so that they can get a clear indication of the standard of achievement expected of candidates in this Unit 1 Explain the general requirements for the inspection and testing of an electrical installation during its normal life-cycle. (10 hrs) This Outcome should provide candidate with an understanding of the general requirements for inspection and testing of an electrical installation when it is newly installed, the periodicity of re- inspecting and testing and the action that should be taken if alterations or additions are made. The requirements of part seven of BS7671 provided the technical foundation for developing the subject and the IEE guidance notes on Inspection and Testing (ISBN 0-85296-991-0) develop the regulations. ¨ Safety ¨ Required competence ¨ The Client ¨ Record keeping ¨ Purpose of initial verification ¨ Frequency of subsequent installations ¨ Initial inspection Consideration should also be given to the following: Electrical installation: TN-S; TN-C-S; TT. Nominal voltage 230V and 400V; rating of over current protective devices at the origin of the installation not to exceed 100A; work environment is domestic; commercial and light industrial. SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 9 Initial Inspection: connection and identification of conductors; cable routing; current carrying capacity; voltage drop; connection of control devices; connection of accessories; equipment; fire barriers; methods of protection against electric shock; labelling, presence of notices; erection methods; presence of under-voltage protection; adequate access to switchgear and equipment; protection methods for direct and indirect contact; adequate earthing arrangements; selection of equipment and protective measures appropriate to external influences; position of devices for isolation and switching location. Reasons for periodic testing and inspection; legislative requirements; verification of continued compliance with BS7671; change of ownership or tenancy of premises; alterations or additions to existing installation to change electrical loading. 2 Explain the recommended tests to verify the integrity of an electrical installation (10 hrs) This Outcome should provide the candidate with an understanding of why the tests are being carried out; the requirements that have to be met to satisfy part seven of BS7671 and the methods of tests that are to be performed. The Outcome should provide candidates with an understanding of why it is necessary to know the value of the prospective short circuit current and the external earth loop impedance and also provide an explanation of how to approach the measurement of these. ¨ Purpose of periodic inspection and testing ¨ Necessity for periodic inspection and testing ¨ Initial testing Electrical installation: TN-S; TN-C-S; T.T. Systems Tests: Continuity of protective conductors main and supplementary bonding, continuity of ring final circuit conductors; insulation resistance; polarity tests; earth electrode resistance; earth fault loop impedance; operation of residual current devices; measurement of characteristics of supply at the origin of the circuit. 3 Explain the requirements and precautions for testing electrical installations (10 hrs) This Outcome should provide the candidate with an understanding of why safety documentation is essential before work is carried out in organisations that specify permits-to-work and sanction-to-test documents as part of their safety policy. The responsibility of the electrical contractor to comply with safety procedures and the delegation of authorised signatories by the company to the contractor, for safety documents, should be discussed. The need to recognise that intrinsically safe instruments are required in installations designated as hazardous should be emphasised. Reference only is required to the zoning of areas and the types of environment where more specialist testing consideration is necessary. Relevant requirements of the Health and Safety at Work Act and the Electricity at Work Regulations in an industrial environment, where additional hazards may be present, permits-to-work and sanctions-for-test. SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 10 Requirements: instrument accuracy; field and instrument errors; routine calibration and checking of low resistance ohmmeter; insulation resistance ohmmeter; applied voltage tester; earth fault loop impedance testers; earth electrode, test sets; RCD Testers. 4 Carry out appropriate testing procedures which conform to British Standard requirements (10 hrs) This Outcome should provide the candidate with the opportunity to prepare for inspection and testing and carry out inspection and testing. The centre will require a simulated test rig(s) to enable the tests specified in the range statement to be carried out effectively. It is recommended that the rig(s) should be supplied from a three-phase isolator and feed a single-phase distribution board from which lighting circuits and power circuits are supplied. A three phase motor circuit should be provided for. A residual current device or devices should be included in the design. The design of the rig or rigs is not critical providing all the tests can be performed effectively. Different rigs can be used to cover the complete range of tests. Observation checklists are required for each of the tests. The candidate should be given the necessary work instructions to carry out the testing. A selection of the necessary hand tools and a range of test instruments should be provided. During the test the candidate will be expected to record all relevant information and tests results for all circuits on an appropriate results sheets; safe working practice must be observed throughout the inspection and testing procedure. Technical data: available diagrams; charts; previous test results for inspection; test certificates; general characteristics of installation; access to design data (new installation). Isolation procedure: isolate; lock off; issue permit-to-work; complete permit documentation; test for dead. Test of external earth loop impedance and prospective short circuit current (PSCC); protective conductors continuity: continuity of ring final circuit conductors; insulation resistance; polarity; Earth fault loop impedance; earth electrode resistance; operation of residual current devices A candidate-centred learning approach is recommended. Underpinning theory should be reinforced by use of short testing exercises where a hands-on-approach should be encouraged. Throughout the Unit the importance of accurate documentation should be stressed. Safety procedures and practices should be observed at every stage of the unit. Guidance on the delivery and assessment of this Unit The purpose of this Unit is to enable candidates to demonstrate knowledge, understanding and competence in the testing and inspection of electrical installations. The Unit is aimed at those with previous electrical installation knowledge and some knowledge of BS7671. SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 11 This Unit was developed within the Options section of the SQA Advanced Certificate and SQA Advanced Diploma in Electrical Engineering awards. It should be seen as being complementary to the SQA Advanced Units Electricity Power Systems, Electrical Safety, Electrical Installation Skills and Electrical Installation Design. Details on approaches to assessment are given under Evidence requirements and Assessment guidelines under each Outcome in the SQA Advanced Unit Specification: statement of standards section. It is recommended that these sections be read carefully before proceeding with assessment of candidates. Open learning This Unit may be delivered by distance learning however, due to the practical nature of Outcome 4, a considerable degree of centre support will be required. With regard to assessment, planning would be required by the centre to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that the assessments were conducted under controlled, supervised conditions. For information on normal open learning arrangements, please refer to the SQA guide Assessment and Quality Assurance of Open and Distance Learning (SQA 2000) Equality and inclusion This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements. SQA Advanced Unit Specification Unit (HV2L 47): Inspection and Testing of Low Voltage Electrical Installations 12 General information for candidates Unit title: Inspection and Testing of Low Voltage Electrical Installations This Unit has been designed to allow you to gain knowledge of the requirements of the16th Edition Wiring regulations (BS7671) inspection and testing techniques and of the test instruments required to carry out these tests. You will gain the opportunity to practice using these instruments and evaluating the test readings taken. In addition, you will be instructed on the mandatory and general requirements for inspection and testing of electrical installations. You will be supported in developing an understanding of the following topics: ¨ General requirements for inspection and testing of an electrical installation. ¨ Periodicity of re-inspection and testing ¨ Actions to be taken when alterations or additions are made to an electrical installation ¨ Reason for testing ¨ How to perform tests as detailed in BS7671 ¨ Test to be performed ¨ Continuity of protective conductors ¨ Continuity of ring circuit conductors ¨ Polarity ¨ Insulation resistance ¨ Earth loop impedance ¨ Prospective fault current ¨ RCD Test ¨ Safety documentation (permits-to-work) ¨ Why use calibrated instruments ¨ Use of standard test certificates as per Appendix 6 of BS 7671 This Unit is predominantly practical with a strong emphasis on understanding why and how to inspect and test low voltage electrical installations.HV2W 47, Electrical Design Systems: An Introduction (SCQF level 7) 1 SQA Advanced Unit Specification: general information Unit title: Electrical Design Systems: An Introduction Unit code: HV2W 47 Superclass: XJ Publication date: November 2017 Source: Scottish Qualifications Authority Version: 01 Unit purpose This Unit has been designed to allow candidates to develop their knowledge, understanding and skills of a range of services provided by the distribution of power and network communication cabling throughout an electrical installation. More specifically candidates will study earthing systems and how protection from touch voltages is achieved. This Unit also introduces candidates to the design procedures involved in selecting conductors to supply single and three-phase equipment located in small modern electrical distribution systems. On completion of the Unit the candidate should be able to: 1 Examine the principles of protective earthing systems. 2 Apply electrical design procedures when selecting current carrying conductors. 3 Investigate structured distribution data cable systems for communication networks. Recommended prior knowledge and skills Entry to this Unit is at the discretion of the centre, however candidates should have a basic knowledge and understanding of electrical systems, equipment and protective devices, or have technical experience of electrical systems within building services. This may be evidenced by possession of Electrical Installation Units from the National Certificate(s) in Electrical Engineering. HV2W 47, Electrical Design Systems: An Introduction (SCQF level 7) 2 Credit points and level 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*) *SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates. Core Skills Opportunities to develop aspects of Core Skills are highlighted in the Support Notes of this Unit specification. There is no automatic certification of Core Skills or Core Skill components in this Unit. Context for delivery If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes. Assessment The assessment for this Unit is in two parts. An assessment lasting one and a half hours, which should be conducted under controlled supervised conditions and should follow after the delivery of Outcomes 1 and 2. An investigation should be completed for the design specification of standard network cabling for voice and data communication systems for a small modern building. Candidates will be expected to produce a report of between 1,000–1,200 words or equivalent that includes diagrams and appendices on the specification for the network system. Teaching and learning and assessments do not have to be presented to the candidates in any specific order. HV2W 47, Electrical Design Systems: An Introduction (SCQF level 7) 3 SQA Advanced Unit Specification: statement of standards Unit title: Electrical Design Systems: An Introduction Unit code: HV2W 47 The sections of the Unit stating the Outcomes, Knowledge and/or Skills, and Evidence Requirements are mandatory. Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion. Outcome 1 Outcomes are assessed. Candidates must provide a satisfactory response to all items. Where sampling takes place, a candidates response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to: summarised below. Centres are advised to check SQA's APS Navigator to confirm they are using the up to date qualification structure. NOTE: Where a Unit is revised by another Unit: ¨ No new centres may be approved to offer the Unit which has been revised. ¨ Centres should only enter candidates for the Unit which has been revised where they are expected to complete the Unit before its finish date. Version number Description Date 15 Addition of Unit: FY7L 35 Electrical Installation Design added to the optional section of the HNC framework 01/05/24 14 Addition of Units: J0HA 34 Computer Programming and J0H9 34 Data Security added as Optional units to HNC and HND frameworks 29/03/19 13 Revision of Unit: DE1K 33 Workplace Communication in English has been revised by H8T2 33 and finishes on 31/07/2016. 08/05/15 12 Removal of finish date from unit DG4P 35 Mathematics for Engineering 3. Addition of Credit Transfer Table see Pages 39 and 40. 15/01/15 11 Revision of Units: D77G 34 Communication: Practical Skills revised by H7MB 34. DG4H 33 Mathematics for Engineering 1: Electronics and Electrical revised by H7K0 33 Engineering Mathematics 1. DG4L 34 Mathematics for Engineering 2 revised by H7K1 34 Engineering Mathematics 2 on HNC and HND frameworks finishing 31/07/2016. 21/10/14 10 Engineering Mathematics 3 (H7K2 34), Engineering Mathematics 4 (H7K3 35) and Engineering Mathematics 5 (H7K4 35) added as optional Units to HND framework. 19/08/14 09 Project Management: An Introduction (A6AX 34) added as an optional Unit to HND framework. 15/08/14 08 Addition of optional Units: Energy Overview (H4J5 34) and Energy Technologies (H4J6 35). 09/08/13 07 Due to the HN Review the following Units have been amended and recoded: DN4F 35, DN48 33, DN4L 34, DN4J 34, DN42 34, DG2X 34 and DG54 34. 26/04/12 06 Optional section of framework on page 17 updated to include three missed Units. 18/10/11 05 Credit transfer amended on Communication Unit from full to partial. January 2011 04 Units added to HND within optional area of the framework to give direct articulation in to year 3 of Robert Gordon's University BEng Course. December 2009 03 Broadening and other Units added to HNC and HND. 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These two awards were developed under the new SQA Design Principles, were validated in March2005, and replace the existing HNC Engineering: Electrical and the HND Engineering: Electrical. This Document includes details on the background to the development of the new awards, their aims (both general and specific), recommended access requirements, information about the structure of the awards, recommendations on delivery and assessment and other guidance for centres. 2 Rationale for the Revisions of the Awards 2.1 Electrical Engineering The term Electrical Engineering in the context of this document covers the range of subjects traditionally included in SQA Higher Nationals in Electrical Engineering, namely power, plant and electrical installation. The title Electrical Engineering is intended to provide candidates, lecturers, Higher Education, employers and professional bodies with a clear, unambiguous title. Electronics has not been included in the HNC and HND Electrical Engineering titles as only sufficient electronics has been included in both awards to underpin studies in the various branches of electrical engineering. 2.2 HN Engineering Frameworks In 1996 the SQA validated nationally a large number of new HN Engineering awards including two awards entitled HNC Engineering: Electrical and HND Engineering: Electrical. A major difference between these and previous awards were that they all sat within an HN Engineering Framework which in general terms consisted, for both HNCs and HNDs, of a common core of Units (Units common to all HNC and HND Engineering awards), a principles/technology and optional sections. The benefits of this Framework structure were seen to include the following: ¨ provide a wide range of HN Engineering qualifications to meet the needs of different engineering sectors ¨ improve the credibility and esteem of individual HN Engineering awards ¨ clarify those competencies that were general to all incorporated engineers and those that were specific to particular engineering disciplines ¨ provide opportunities for the efficient delivery of HN Engineering Units by, for example, incorporating Units that were common to a number of different HN awards ¨ facilitate better progression between HNC, HND and Degree engineering awards Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 2 Prior to the development of any HN Engineering awards a major consultation exercise was undertaken on the overarching HN Engineering Framework to test the validity of the Framework. This consultation comprised of the following five strands: ¨ a questionnaire survey with stakeholders of HN Engineering awards ¨ a series of meetings with various interested stakeholders of HN Engineering awards ¨ desk based research ¨ discussions (followed by endorsement) of a proposed HN Engineering Framework at a HN Engineering Steering Group meeting ¨ a major consultation event with FE colleges on 24 May 2002 which included a questionnaire survey The consultation revealed continuing strong support for an overarching HN Engineering Framework but with the following modifications: ¨ a reduction in the number of common core Units ¨ a strengthening of the Principles/Technology section with an even stronger emphasis on the teaching of core engineering principles and technologies Optional sections are retained in all HNC and HND Engineering awards. The revised HNC and HND Engineering Frameworks are shown in block diagram form in Figures 2.1 and 2.2. It should be noted that the PDAs shown in both diagrams may be developed as more HN Units come on stream; currently none of these PDAs exist. Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 3 HNC Engineering Framework Figure 2.1 Communication: Practical Skills 1 credit Mandatory Unit HNC 8 Principles/Technology credits 2 optional credits Strong emphasis on core principles/technologies A limited degree of specialisation within the engineering specialist area Corresponding HND award in the same engineering discipline area Graded Unit Examination 1 credit PDA Specialist Engineering Areas Team Working & Leadership Supervisory Skills Information Technology Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 4 HND Engineering Framework Figure 2.2 Communication: Practical Skills Information Technology: Applications Software 1 Business Awareness & CPD 3 credits of Mandatory Units Corresponding HNC Engineering award in the same Engineering discipline area embedded as the first year of the HND HND 17* Principles/Technology credits 7 optional credits More advanced engineering principles High level of specialisation in engineering specific subject areas(s) *Includes the 8 Principles/Technology credits in the HNC HNC Graded Unit Examination 1 credit PDA Specialist Engineering Areas Team Working & Leadership Supervisory Skills Information Technology 2 Graded Units HND Engineering Project 2 credits HNC Engineering Examination 1 credit Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 5 2.3 History and Market Research to support the HNC and HND Electrical Engineering 2.3.1 History of the HNC and HND Electrical Engineering awards The introduction of the SCOTVEC Advanced Courses Development Programme lead to the replacement of the 132 HND in Electrical and Electronic Engineering award by a competence based HND in Electronic and Electrical Engineering in 1989. Shortly after an HNC in Electronic and Electrical Engineering was introduced as part of a national development and replaced the 101 HNC in Electrical and Electronic Engineering. However, there continued to be little commonality between the new HNC and HND awards. The first attempt to harmonise the two awards took place as part of a consortium development in the early nineties. In 1995 and 1996 the two awards were totally harmonised (eg the HNC Electrical becoming effectively the first year of the HND) as part of a major SCOTVEC national development which saw the introduction of an overarching HN Engineering Framework. The two new awards represent a further development of Higher National Engineering awards taking full account the new HN Design Principles and providing an opportunity to update the awards in light of technological and educational developments. 2.3.2 Market Research The development of the new HNC and HND Electrical Engineering awards included extensive market research which is summarised below in Table 2.3. Stakeholder Method All Major desk based research gathering and analysing data from various sources (eg SEMTA, FutureSkills Scotland etc.) Delivery Centres Initial postal survey of all delivery centres followed by two National seminars. Draft Units, assessment exemplars and outlines of graded Units were made available to centres. Employers Surveys of employers were carried out at the commencement of the development of the two awards and when the two award structures and Units were nearing finalisation. Information obtained from employers helped to inform both structure and Unit development Higher Education Letters of support for articulation between the new HNC and HND Electrical Engineering and Degree awards were received from seven Higher Education institutions. Professional Bodies The Chair of the Institute of Incorporated Engineers was a member of the Validation Panel and provided a broad measure of support for the two new developments at the Validation Event which was later confirmed in writing. Table 2.3 Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 6 Stakeholder Method Health and Safety Executive A representative from the Health and Safety Executive provided some invaluable input into the development of the Electrical Safety Unit and other Units with significant safety content. Students Whilst not consulted directly the student experience of the current HNC and HND Engineering: Electrical was taken fully into account in the new developments. Table 2.3 (continued) 2.4 Candidates 2.4.1 HNC Candidates Candidates at HNC level may already be in employment and will attend centres on a day-release or other part-time basis. The HNC framework structure is flexible enough to allow centres to deliver the HNC award by various modes of delivery for example, two-year day-release, evening attendance etc. The options chosen by employed candidates may reflect the branch of industry in which they are employed or may be used to gain knowledge of other areas within electrical engineering in order to improve their career opportunities in the employment market. Part-time candidates may also use the HNC award to gain entry to Degree level studies. Full-time HNC candidates may be school leavers intending to articulate to a University Degree Course, or candidates who wish to progress from an appropriate National Certificate qualification. Full-time candidates may also be more mature persons who are seeking a change of employment. Since the HNC award forms an integral part of the HND award, full-time candidates will complete 15 Unit credits in the first year of the course, 12 of these meeting the HNC requirements. Full-time candidates will therefore have completed the first year of the HND programme and may, if they wish, continue to the second year of the HND award. In addition to University entrance, successful full-time HNC candidates have enhanced their prospects of gaining employment in the Electrical Engineering industry. 2.4.2 HND Candidates The HND award programme will normally be delivered on a two-year full-time basis, although this does not preclude other delivery patterns. This being the case, HND candidates may be school leavers who have an interest in some aspect of electrical engineering and wish to include this in their career path. This may be candidates who wish to progress from an appropriate National Certificate qualification or candidates who have previously completed the HNC award and wish to progress to the HND. The typical HND candidate will therefore be a young person intending to articulate to a University Degree Course. The Units of the Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 7 HNC/D framework have been designed to introduce candidates to electrical engineering and to take topics to a more advanced level than is possible in the HNC. Mature candidates may also embark on the HND programme. The HN Electrical Development Team and Unit writers were aware that such candidates may not have studied for some time and will require additional support in developing their learning skills. The HN Electrical Units have been designed as far as possible to provide candidates with opportunities to develop critical knowledge and understanding of theory and practical hands-on skills required by practising electrical incorporated engineers. 3 Aims of the Awards 3.1 General Aims of the HNC Electrical Engineering The general aims of this award are to: 3.1.1 enhance candidates' employment prospects 3.1.2 support candidates' Continuing Professional Development and career development 3.1.3 enable progression within the SCQF (Scottish Credit and Qualifications Framework) 3.1.4 develop candidates' ability to apply analysis and synthesis skills to the solution of electrical engineering problems 3.1.5 develop learning and transferable skills (including Core Skills). 3.2 Specific Aims of the HNC Electrical Engineering The specific aims of this award are to: 3.2.1 provide an award that will allow candidates to work now, or in the future, as electrical technicians or incorporated electrical engineers 3.2.2 provide an award that creates a route towards meeting the academic requirements for Incorporated Engineer status 3.2.3 develop an award that on successful completion will allow candidates to progress to HND Electrical Engineering and/or a Degree in Electrical Engineering or related subject discipline area The development of this new HNC award will also allow candidates to: 3.2.4 develop a range of Communication knowledge and skills relevant to the needs of electrical incorporated engineers Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 8 3.2.5 develop knowledge, understanding and skills in a range of core electrical principles, electrical power systems, electrical machine principles and electrical safety at Higher National level (these studies in core electrical principles and technologies are underpinned by a mandatory Unit in Mathematics) 3.2.6 develop knowledge and skills in the use of electrical and electronic instruments 3.2.7 achieve a degree of specialisation within the following areas: Electrical Principles, Information Technology, Three Phase Induction Motors, Power Electronics, Inspection and Testing of Low Voltage Electrical Installations, Programmable Logic Controllers, Electrical Systems in Hazardous Environments, Control Systems, further Mathematical studies, Electrical Installation Skills and Engineering Quality 3.2.8 on successful completion of the award, achieve the Core Skill Communication at Higher level and the component Using Number of the Core Skill Numeracy at Higher level. The candidate will also be provided with opportunities to develop the following Core Skills: Information Technology at Higher level, the component Using Graphical Information of the Core Skill Numeracy at Higher level, Problem Solving at Higher level and Working with Others at Intermediate 1 level. 3.3 General Aims of the HND Electrical Engineering The same as for the HNC Electrical Engineering award but with the addition of the following: 3.3.1 develop candidates' knowledge and skills in planning and project management 3.3.2 develop investigation skills 3.4 Specific Aims of the HND Electrical Engineering The same as for the HNC Electrical Engineering but with the addition of the following: 3.4.1 develop an award that on successful completion will allow candidates' to progress to a Degree in Electrical Engineering or related subject discipline area. The development of this new HND award will also allow candidates to: 3.4.2 develop knowledge and understanding of the external and internal factors that influence the performance of modern companies 3.4.3 recognise the important role Continuing Professional Development plays in career development 3.4.4 expand on the range of knowledge, understanding and skills in core electrical principles, electrical machines and systems and electrical installation Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 9 3.4.5 allow for further specialisation within the following subject areas: Inspection and Testing of Low Voltage Installations, Programmable Logic Controllers, Electrical Systems in Hazardous Environments, Analogue and Digital Electronics, Quality Management, Electrical Installation Skills, Industrial Plant Maintenance, Synchronous Machines, Electrical Motor Drive Systems, Three Phase Induction Motors, High Level Engineering Software, additional Control Systems studies, Power Supply Circuits, Switchgear and Protection, Standby Systems, Electrical Installation Design: Computer Aided, advanced Mathematical studies and Employment Experience 3.4.6 on successful completion of the award, achieve the Core Skills in Communication at Higher level, Information Technology at Higher level, Problem Solving at Higher level and the Using Number component of the Core Skill Numeracy at Higher level. Candidates will be provided with opportunities to develop the Core Skill Using Graphical Information component of the Numeracy Core Skill at Higher level and the Working with Others Core Skills at Intermediate 1 level. Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 10 3.5 How the General Aims are met in the HNC and HND Award Structures and Content Aim No How it is met in HNC and HND 3.1.1 For many years HNC and HND Electrical Engineering qualifications have equipped candidates to seek employment in a wide range of manufacturing, service and public sector organisations. Market research indicates that HNC and HND Electrical Engineering awards are still regarded as the minimum qualifications required by many organisations to work at electrical technician or incorporated engineer level. 3.1.2 There has been a long tradition of candidates in employment taking HNC Electrical and Electronic awards on a part-time basis to increase their knowledge of Electrical and Electronic Engineering and enhance their career development. In recent years, with increased commonality between HNC and HND Electrical Engineering awards and greater flexibility in the way these awards are delivered, candidates in employment have increasingly taken HNDs on a part-time basis to expand their knowledge and skills in Electrical and Electronic Engineering and improve their career prospects. The two new awards contain a balance of core principles and up to date knowledge and skills in Electrical Engineering which lends themselves to the Continuous Professional Development and career development of candidates working at electrical technician and incorporated engineer levels. Furthermore, the award structures have been designed to allow for easy progression between HNC and HND awards. 3.1.3 All Units within the new HNC and HND Electrical Engineering awards have been levelled at SCQF levels 6, 7 or 8. The two new awards also conform to the SQA levelling requirements for HNC and HND awards. Thus, successful completion of one or both awards will allow progression within the SCQF. 3.1.4 The nature of Electrical Engineering as a discipline lends itself to both the analysis and synthesis of problems. For example, when a complex electrical and electronic system is analysed (using, say, a block diagram approach) by breaking it down into separate functional parts or alternatively the synthesis of a complex system from simpler electrical and electronic systems. The two new awards allow these important skills to be developed further both in the technical subjects and in the core Communication, Information Technology ands Business Awareness and Continuing Professional Development Units. Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 11 Aim No How it is met in HNC and HND 3.1.5 The new HNC and HND Electrical Engineering awards provide centres with an opportunity to enhance learning skills not least by creating opportunities for candidates to combine theory and practice to achieve a real understanding of a subject. For example, some Units recommend significant use of practical work and/or computer simulation to reinforce learning. It is also anticipated that centres will use innovative delivery approaches that may make use of sophisticated electrical and electronic laboratory equipment and/or on-line delivery and/or Virtual Learning Environments to enhance candidate learning. By their very nature Engineering courses require the transfer of technical knowledge and skills form one area to another. For example, a significant level of Electrical Principles and Mathematics has been included in both HNC and HND Electrical Engineering awards because these subjects provide underpinning knowledge, understanding and skills which are used elsewhere in both awards. Candidates will also have an opportunity to use the Communication and Information Technology knowledge and skills developed in the mandatory core Units in other parts of the awards to support such activities as report writing, presentation and the application of specialist software packages. Core skills in general, and problem solving in particular, have been regarded as very important by the HN Electrical Development Team since it is recognised that a good level of competence in these is essential in the work of an incorporated electrical technician. 3.3.1 The double credit (16 SCQF points) Engineering Project Graded Unit in the HND Electrical Engineering award provides opportunities for candidates to develop both their planning and project management knowledge and skills. 3.3.2 The Business Awareness and Continuing Professional Development Unit provides candidates with the opportunities to develop their investigative skills by exploring the external and internal factors that affect the performance of a modern company and the different ways that people learn. The Engineering Project also requires candidates to undertake some investigations into the background to and a range of solutions for their engineering project. Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 12 3.6 How the Specific Aims are met in the HNC and HND Award Structures and Content Aim No How it is met in HNC and HND 3.2.1 An HNC and HND Electrical Engineering award has been recognised for many years by employers and other stakeholders of these awards as appropriate qualifications for persons wishing to work at electrical technician or senior technician levels. Market research indicates that there is a growing demand for people with technician level skills in electrical and electronic engineering especially as companies automate a lot more of their processes. Thus, it is confidently anticipated that those achieving the HNC and HND Electrical Engineering awards will find employment as electrical technicians and incorporated electrical engineers in a wide range of small, medium and large companies. 3.2.2 & 3.2.3 An HNC or HND no longer satisfies fully the academic requirements for Incorporated Engineer status although these qualifications continue to completely satisfy Engineering Technician requirements. The minimum qualification for Incorporated Engineer is an ordinary Degree. Given the clear progression routes that have been established between existing HNC and HND Electrical Engineering awards and Degree courses by many FE colleges and universities, it is strongly anticipated that similar progression routes will also be developed between the new HNC and HND Electrical Engineering awards and Degree courses. Thus, HNC and HND Electrical Engineering awards will continue to form very important 'stepping stones' towards candidates achieving Degrees (and, thus, satisfy fully the academic requirements for Incorporated Engineer status). Progression arrangements between HNCs, HNDs and Degrees can only be strengthened with the full implementation of the SCQF. Seven letters have been received from Scottish Universities confirming articulation arrangements between the new HNC and HND Electrical Engineering awards and Degree programmes. Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 13 Aim No How it is met in HNC and HND 3.2.4 The current HNC and HND Engineering awards contain separate Communication and Information Technology Applications Units within their mandatory cores. The market research information gathered through various consultations indicates that there continues to be solid support for the inclusion of a distinct Communication Unit in the mandatory core of the HNC and a Communication and Information Technology Units within the mandatory core of the HND Engineering award. The benefit of having separate Communication and Information Technology Units is that it significantly improves the prospect of sufficient attention being given to the teaching of these two key subjects. Separate Units also make it possible to ensure that the Communication and Information Technology core skills at Higher level are fully embedded within the respective Units within the HND. Award designers considered this a more appropriate way to ensure that these core skills are included in HN Engineering awards than trying to embed such core skills across, say, a range of engineering Units, except at HNC level where they believe there is considerable opportunities to develop Information Technology Core Skills within Electrical Units. A number of respondents to various surveys have expressed their concerns about Communication and Information Technology not being seen as relevant by candidates because they are not delivered and assessed within an engineering context. The HNC/D Electrical Development Team has addressed this concern by supporting the production of Communication and Information Technology assessment exemplar materials specifically contextualised to engineering. 3.2.5 Market research shows that employers place a high priority on employees having the correct technical and practical skills to function effectively in their job. Whilst there continues to be a debate about the precise nature of such technical and practical skills it is clearly important that electrical technicians and incorporated engineers have a sound knowledge and understanding of core electrical principles. Such knowledge and understanding will serve candidates well in employment and provide the platform for learning more advanced technical skills. The Mandatory section of the new HNC Electrical Engineering award reflects this concentration on core principles by providing studies in the key areas of Electrical Engineering namely: electrical principles, electrical power systems, electrical machine principles and electrical safety. The HN Electrical Development Team also took the view that a knowledge and understanding of Mathematics is fundamental to the work of electrical technicians and has included a Mathematics Unit (containing the Using Number component of the Core Skill Numeracy at Higher level) within the Mandatory section of the HNC Electrical Engineering award. The inclusion of Mathematics within the Mandatory section was widely supported during various consultation processes. 3.2.6 The correct use of electrical and electronic instruments is very important to electrical technicians and incorporated engineers. The Electrical Development Team regard such skills as so important that it has included a Unit on the use of electrical and electronic instruments in the Mandatory section of the HNC. Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical Engineering (G7TC 16) 14 Aim No How it is met in HNC and HND 3.2.7 In the 2-credit optional section candidates will be able to specialise further in the following areas: Electrical Principles, Information Technology, Three Phase Induction Motors, Power Electronics, Inspection and Testing of Low Voltage Electrical Installations, Programmable Logic Controllers, Electrical Systems in Hazardous Environments, Control Systems, further Mathematical studies, Electrical Installation Skills and Quality Management. The HN Electrical Development Team strongly recommends that candidates with little or no practical electrical experience take the Electrical Installation Skills Unit as part of their optional studies. Analysis of candidate uptake of Units in the optional section of the current HNC Engineering: Electrical award revealed that many Units had low entry numbers. The HN Electrical Development Team took the view that given the resources available for Unit development purposes, efforts should be concentrated on the development of optional Units where there was a reasonable confidence of high candidate uptake. This explains why there are only a limited number of Units in the optional section. Consultation with the FE sector and other stakeholders has indicated that the choice of Units in the optional section is correct. One advantage of limiting the number of optional Units is that more attention has been given to these Units resulting, in the view of the Development Team, in better quality Unit specifications. The HN Electrical Development Team does not preclude additional Units being added to the optional section especially where demand for such Units can be demonstrated. 3.2.8 The Communication Core Skill at Higher level has been incorporated into the HNC Electrical Engineering award through the mandatory Unit, Communication: Practical Skills. There was strong support for the inclusion of the Numeracy core skill at Higher within both HNC and HND Engineering awards. The Electrical Development Team has adopted the Unit Mathematics for Engineering 1: Electronics and Electrical (taken from the HNC and HND Electronics awards). The Core Skill component Using Number at Higher is embedded in this Unit. Opportunities to develop the Core Skills Information Technology, Problem Solving and Working with Others are signposted within individual Unit specifications. Candidates may achieve the Information Technology and Working with Others Core Skills at Higher level if they take the optional Units in Information Technology: Applications Software 1 in the HNC and Employment Experience 2 within the HND, respectively. 3.4.1 See comments under 3.2.2 and 3.2.3. Arrangements Document: HNC Electrical Engineering (G7TA 15) and HND Electrical until Electrical Engineering Principles 2. Arrangements Document: PDA/HNC Engineering Practice 28 Table 5.6: Credit Transfer Opportunities (continued) Existing Unit No. Existing Unit Title New Unit No. New Unit Title Level of Credit Transfer Comments D5R4 04 Introduction to Advanced Pattern Development DV9H 33 Advanced Pattern Development: An Introduction 100% D4KD 04 Plant Systems: Services DW7M 34 Plant Systems: Utilities 40% O.1 to O.3 in existing Unit — no equivalent O.4 in existing Unit equivalent to O.3 on boilers in new Unit. O.5 in existing Unit equivalent to O.4 on commissioning in new Unit D4KC 04 Plant Systems: Utilities DW7N 34 Plant Systems: Utilities Plant Services: Services 50% 25% Pumps and fans and refrigeration systems common O.2 Outcome on compressed air systems equivalent to O.1 and O.2 on compressed air systems in new Unit O.4 on air-conditioning in old Unit — no equivalent Arrangements Document: PDA/HNC Engineering Practice 29 Table 5.6: Credit Transfer Opportunities (continued) New Unit Title New Unit Code Old Unit Title Old Unit Code Credit Transfer Conditions Engineering Mathematics 1 H7K0 33 Mathematics for Engineering 1:Electronics and Electrical DG4H 33 To gain credit transfer to the new unit candidates will have to provide additional evidence relating to functions as specified in the Evidence requirements in respect of the first three knowledge/skills in Outcome 1 and relating to vectors as specified in the first three knowledge/skills in outcome 3. Engineering Mathematics 1 H7K0 33 Mathematics for Engineering 1:Mechanical and Manufacturing DT5X 33 To gain credit transfer to the new unit candidates will have to provide additional evidence relating to functions as specified in the Evidence requirements in respect of the first three knowledge/skills in Outcome 1 and relating to 3D vectors and complex numbers as specified in the knowledge/skills in outcome 3. Engineering Mathematics 2 H7K1 34 Mathematics for Engineering 2 DG4L 34 To gain credit transfer to the new unit candidates will have to provide additional evidence relating to trigonometric and hyperbolic functions as specified in the Evidence requirements in respect of Outcome 1. Arrangements Document: PDA/HNC Engineering Practice 30 6 Approaches to delivery and assessment 6.1 Delivery As mentioned in Section 2.3 the QDT were firmly of the view that the PDA/HNC Engineering Practice suite of awards are principally for candidates in employment and would, therefore, normally be studied by candidates who attend a centre on a day-release or other part-time basis. The PDA/HNC Engineering Practice award structures are sufficiently flexible enough to allow centres to deliver the awards by various modes of delivery for example, two-year day-release, evening attendance, block-release etc. Where centres decide to offer a PDA/HNC Engineering Practice on a full-time basis it is strongly recommended that candidates are provided with opportunities to take a number of practical engineering Units in conjunction with Units in the relevant award structure so that they can acquire some useful practical skills and gain some exposure to what it may be like working in a practical engineering environment (s). Centres are also encouraged to arrange a number of industrial visits for their candidates so that they can see some applications of subjects learnt on their course in practical engineering environments. With regard to timetabling centres may timetable a PDA and the HNC Engineering Practice in sequence (ie the six PDA Units first followed by the six HNC Engineering Practice Units) as illustrated in the first timetable for a PDA in Engineering Practice: Engineering Manufacture at SCQF level 7/HNC Engineering Practice in Appendix 1. Alternatively, centres may mix the timetabling of a PDA and HNC Engineering Practice Units to meet different candidate and employer needs as illustrated in the second timetable for the PDA in Engineering Practice: Electrical Engineering at SCQF level 7/HNC Engineering Practice in Appendix 1. Centres should take account of information contained in the Recommended Prior Knowledge and Skills statements in Unit specifications in sequencing the delivery of Units (eg it would be normal to deliver the Electrical Engineering Principles 1 Unit before the Electrical Engineering Principles 2 Unit). Centres, working on their own or in partnership, might also wish to consider the following approaches to delivering the PDA/HNC Engineering Practice awards: ¨ Identification and sharing of good candidate learning support materials on the internet ¨ Use of the Internet by candidates to undertake more in-depth investigations in given subject areas ¨ Development or purchase of paper based and/or electronic candidate learning support and assessment materials for individual Units (eg for certain optional Units) ¨ Development of on-line Unit and Graded Unit assessment materials ¨ Use of e-mentoring arrangements to support candidates who study at a distance One of the key reasons the QDT has sought to reduce the time candidates have to spend on summative Unit assessment is to provide lecturers with more time to deliver Units. Lecturers are encouraged, in particular, to use this additional time to reinforce learning in core engineering and supervisory concepts and principles and in the transfer of knowledge, understanding and skills across subject boundaries. Arrangements Document: PDA/HNC Engineering Practice 31 Lecturers may use a variety of teaching and learning approaches in delivering the Units in the PDA/HNC Engineering Practice awards. These may include lecturing, group work, laboratory and practical work, computer simulation (using appropriate software packages), project work and case studies. The use of open and distance learning and on-line materials may help to supplement and support the learning that takes place in the classroom, laboratory or workshop. Lecturers should also seek opportunities to integrate Core Skills within their teaching and learning programmes. Such opportunities may include the following: - Communication ¨ Providing candidates opportunities to develop their oral skills by allowing them to give full answers to questions asked by the lecturer ¨ Developing complex, vocationally specific reading skills (eg Communication: Practical Skills.) ¨ Developing report writing skills in a number of Units (eg Computer Aided Manufacture, Value Engineering) ¨ Allowing candidates to develop their Communication skills in group work activities (eg Communication: Practical Skills, Engineering Supervision: Teamworking and Continuing Professional Development) Numeracy ¨ Reinforcing Numeracy and Mathematical skills when teaching engineering principles (eg Mechanical Engineering Principles, Electrical Engineering Principles 1, Electrical Engineering Principles 2) ¨ Reinforcing Using Graphical Information skills by use of a range of graphical representations (eg Electrical Installation Design (Computer Aided): An Introduction, Containers: Design and Manufacture) Information and Communication Technology ¨ Develop Information and Communication Technology skills through the application of IT within engineering systems (eg Computer Aided Draughting for Engineers, Quality Management: An Introduction) Problem Solving Skills ¨ Develop Critical Thinking Skills through the application of engineering concepts and principles to solve engineering systems (eg Lighting Design in Buildings, Value Engineering) ¨ Develop Planning and Organisational Skills within an engineering and supervisory context (eg Industrial Plant Maintenance, Engineering Supervision: Teamworking and Continuing Professional Development) ¨ Develop review and evaluation skills within an engineering and supervisory context (eg Inspection Systems, Value Engineering) Arrangements Document: PDA/HNC Engineering Practice 32 Working with Others ¨ Develop Working with Others skills through identifying approaches to developing high performance team and group discussions on the solution to engineering problems (eg Engineering Supervision: Teamworking and Continuing Professional Development, Containers: Design and Manufacture) Opportunities for candidates to develop some Core Skills components as part of the delivery of PDA mandatory Units are identified in Table 6.1(a). Likewise Core Skill component development opportunities within the HNC Engineering Practice are shown in Table 6.1(b). Centre staff are asked to refer to individual optional Unit specifications for details of other PDA/HNC Engineering Practice Core Skill component development opportunities. Arrangements Document: PDA/HNC Engineering Practice 33 Table 6.1(a) PDA — Core Skills development opportunities in mandatory Units Note: CT = Critical Thinking: P and O = Planning and Organisation and R and E = Reviewing and Evaluating Unit Title Communication Numeracy Information and Communication Technology Problem Solving Working with Others Read Write Oral Using Number Using Graphical Inform. Using Information Technology CT P and O R and E Working with Others PDA in Engineering Practice: Fabrication and Welding Welding Principles and Applications 1 Higher Higher Higher Higher Higher Higher Higher Higher Containers: Design and Manufacture Higher Higher Higher Higher Higher Higher Higher Higher Intermediate 2 Inspection Systems Higher Higher Higher Higher Higher Fabrication: Steelwork Preparation, Joining and Assembly Higher Higher Higher Higher Arrangements Document: PDA/HNC Engineering Practice 34 Table 6.1(a) PDA — Core Skills development opportunities in mandatory Units (continued) Unit Title Communication Numeracy Information and Communication Technology Problem Solving Working with Others Read Write Oral Using Number Using Graphical Inform. Using Information Technology CT P and O R and E Working with Others PDA in Engineering Practice: Engineering Manufacture Mechanical Engineering Principles Int. 2 Int. 2 Computer Aided Draughting for Engineers Higher CNC Int. 2 Higher Engineering Measurement Higher PDA in Engineering Practice: Engineering Maintenance Plant Systems: Services Higher Higher Plant Systems: Utilities Higher Higher Arrangements Document: PDA/HNC Engineering Practice 35 Table 6.1(a) PDA — Core Skills development opportunities in mandatory Units (continued) Unit Title Communication Numeracy Information and Communication Technology Problem Solving Working with Others Read Write Oral Using Number Using Graphical Inform. Using Information Technology CT P and O R and E Working with Others PDA in Engineering Practice: Engineering Maintenance (continued) Mechanical Engineering Principles Int. 2 Int. 2 Industrial Plant Maintenance Higher Int.2 Int.2 Higher Higher Int. 1 PDA in Engineering Practice: Electrical Engineering Electrical Principles 1 Int.2 Int.2 Electrical Engineering Applications of Electrical and Electronic Instruments Higher Int.2 Int.2 Int.2 Electrical motors and motor starting Int. 2 Higher Arrangements Document: PDA/HNC Engineering Practice 36 Table 6.1(b) HNC Engineering Practice — Core Skills development opportunities in mandatory Units Note: CT = Critical Thinking: P and O = Planning and Organisation and R and E = Reviewing and Evaluating Unit Title Communication Numeracy Information and Communication Technology Problem Solving Working with Others Read Write Oral Using Number Using Graphical Inform. Using Information Technology CT P and O R and E Working with Others Communication: Practical Skills Higher Embed -ded Higher Embed -ded Higher Engineering Supervision: Team working and Continuing Professional Development Higher Higher Higher Higher Quality Management: An Introduction Higher Higher Higher Higher Value Engineering Higher Higher Higher Higher Higher Higher Higher Engineering Practice: Graded Unit 1 Higher Higher Higher Arrangements Document: PDA/HNC Engineering Practice 37 6.2 Assessment 6.2.1 Introduction From the outset of developments the QDT recognised the need to have an appropriate assessment strategy in place for the Advanced Certificate/HNC Engineering Practice (now re-titled PDA/HNC Engineering Practice) awards. Such a strategy was developed and is shown below: Aims The aims of the strategy are to ensure that: 1 consistent, rigorous and efficient approaches are adopted to the development and administration of PDA/HN Engineering Practice assessment instruments at both Unit and Graded Unit levels, which satisfy nationally agreed standards; 2 the assessment load on candidates and staff is sensible and that assessment does not unduly detract from teaching and learning; 3 as far as possible reliable and rigorous moderation processes are put in place in order to ensure that consistent national standards are achieved for all PDA/HNC Engineering Practice assessments. Objectives Listed below are the measures that have been put in place to meet the aims: 1 Develop nationally one assessment exemplar pack for the mandatory Units in each of the PDA and the HNC Engineering Practice that clearly sets out the standards of assessment expected in Units. 2 Adopt a holistic approach to Unit assessment. The implications of this are as follows: i Assessment instruments will normally be designed only to sample knowledge and skills in a Unit (this is consistent with the new HN Unit format) ii A Unit assessment strategy will be adopted, where possible, to produce a single assessment instrument for the whole Unit. Where this is not possible the assessment strategy will seek to ensure that the minimum number of assessment instruments is required consistent with maintaining agreed national standards. 3 Whilst not seeking to be entirely prescriptive with regard to the time spent on assessment in each HN Unit, over assessment should be avoided if the following guideline is adopted for the maximum time spent on HN Unit assessment: One and a half hours per Unit credit for HN Units at SCQF levels 6 and 7 and two hours per Unit credit for HN Units at SCQF level 8. Arrangements Document: PDA/HNC Engineering Practice 38 4 Produce assessment exemplar packs for the Graded Unit. In addition, for the Graded Unit examination produce at least one sample exam paper to show the standards expected in such a paper 5 Actively encourage centres to work in partnership in producing Graded Unit assessment materials, which meet nationally agreed standards reducing, in turn, the workload on staff in individual colleges. 6 Ensure that consistent and rigorous internal and external moderation procedures operate through both HN Unit level and Graded Unit assessment procedures. This places a clear responsibility on both centres and the SQA. As far as has been practical the above objectives have been adhered to when developing assessment exemplar and Graded Unit materials. 6.2.2 Graded Units The purpose of the Graded Unit within the PDA/HNC Engineering Practice award structure is to assess the candidate's ability to apply and integrate knowledge and/or skills gained within individual Units. By this means candidates will demonstrate that they have achieved the aims of the awards as detailed in Section 3. The Graded Unit also provides the means by which candidate achievement can be graded. PDA/HNC Engineering Practice candidates will undertake a one credit Graded Unit at SCQF level 7. This will be in the form of a 3-hour written examination. Engineering Practice: Graded Unit 1 — Examination The specifications for the Engineering Practice: Graded Unit 1 can be found on the SQA website (www.sqa.org.uk). The Graded Unit draws on the Outcomes in the mandatory sections of the relevant PDA and the HNC Engineering Practice award. The examination paper consists of the following two sections: Section A; Section B. Section A should be subdivided into up to four individual sub-sections to reflect the four different engineering disciplines candidates may have studied for their PDA level: namely Fabrication and Welding, Engineering Manufacture, Engineering Maintenance and Electrical Engineering. Each sub-section should comprise of a suitable balance of between 8 to 12 short answer, restricted response and structured questions. Candidates should answer all questions in the relevant sub-section of Section A. Candidates should be able to score up to a maximum of 50% from the section that they have answered questions from. Section B should comprise of a Case Study based around the HNC Engineering Practice mandatory Units in which candidates will have to answer questions on appropriate engineering supervisory issues and problems. All candidates, irrespective of which engineering discipline they have studied at PDA level, should answer all questions in Section B. The question paper associated with the Case Study should comprise of between 6 and 10 restricted response questions. Candidates should be able to score a maximum of 50% from Section B. Candidates Arrangements Document: PDA/HNC Engineering Practice 39 should be given a copy of the Case Study only, a minimum of 14-days before they sit the examination. The examination should be conducted under closed-book, supervised conditions with candidates only being allowed to bring into the examination up to 3 sides of A4 hand written notes they have prepared on the Case Study. These notes should be handed to the invigilator at the end of the examination. Candidates should be allowed to bring a scientific calculator into the examination. It is recommended that candidates do not sit the Graded Unit examination until the end of the PDA/HNC Engineering Practice programme of study given the range of Units that the Graded Unit draws on. 6.2.3 Assessment Exemplar Materials Assessment exemplar packs have been produced for the following mandatory Units in the four PDAs and HNC Engineering Practice award. DR2G 34 Welding Principles and Applications: 1 DR23 34 Containers: Design and Manufacture DR26 34 Inspection Systems DR26 34 Fabrication: Preparation, Joining and Assembly DV9G 34 Mechanical Engineering Principles DR1X 34 Computer Aided Draughting for Engineers DT5P 34 CNC DT9R 34 Engineering Measurement DW7M 34 Plant Systems: Services DW7N 34 Plant Systems: Utilities DN40 34 Industrial Plant Maintenance DW6W 33 Electrical Engineering Principles 1 DW6X 34 Electrical Engineering Principles 2 DN48 33 Application of Electrical and Electronic Instruments DV9M 34 Electrical Motors and Motor Starting D77G 34 Communication: Practical Skills DW71 34 Engineering Supervision: Teamworking and Continuing Professional Development DT8Y 34 Quality Management: An Introduction DW7K 34 Value Engineering An assessment exemplar pack and an additional sample examination paper has been produced for DW92 34 Engineering Practice: Graded Unit 1. 6.2.4 Formative Assessment Formative assessment should be used throughout the delivery of Units to reinforce learning, build candidates' confidence and prepare candidates for summative assessment. Arrangements Document: PDA/HNC Engineering Practice 40 6.3 Resources Practical Resources Centre staff are advised to read individual Unit specifications carefully to identify the consumables, equipment and/or software requirements to deliver Units. Some Units have specific requirements. For example, the Computer Aided Draughting in Engineering and Electrical Installation Design (Computer Aided): An Introduction require candidates to use industrially specific software. The Computer Integrated Manufacture Unit requires candidates to be able to access CNC equipment. While not all Units require practical resources, centres are strongly recommended to provide candidates with access to practical workshop facilities appropriate to the particular PDA. For example, candidates undertaking the PDA in Engineering Practice: Fabrication and Welding at SCQF level 7 should have access to practical fabrication and welding facilities. Such access will allow candidates to relate the theory they are being taught to practice. When teaching subjects such as pumps, fans, electrical motors etc centres should allow candidates to see these pieces of plant so that they can gain a greater appreciation of the construction of these items of plant. A good chart or other visual aid showing the various parts of an item of plant can also be a very good teaching aid. The QDT strongly recommend the use of simulation software to support teaching and learning. However, the Team do not believe that such software should be used at the expense of practical workshop and laboratory activities. The Team strongly considers that such practical activities represent the best way for candidates to relate the theory they learn in the classroom to practical engineering. The QDT believe that there is a very rich and varied range of teaching and learning resources available to deliver individual PDA and HNC Engineering Practice Units. Such learning resources include textbooks, reports, papers, standards, CDs, DVDs and numerous sites on the Internets. Some centres may already have good learning resources in their learning libraries/Virtual Learning Environments. It is anticipated that the Qualification Support Team (QST) for the PDA/HNC Engineering Practice will provide a useful forum for the identification and sharing of learning resources. Continuing Professional Development The QDT are firmly of the view that active staff CPD is essential if the delivery and assessment of individual PDAs and HNC Engineering Practice Units are to be kept up to date, relevant and interesting. Staff CPD activities could be in subject areas such as the following (the list is not intended to be exhaustive): ¨ Learning to use specialist engineering software ¨ Modern manufacturing methods ¨ New or revised standards and regulations ¨ Issues relating to health and safety ¨ Quality Control and Quality Assurance ¨ Value Engineering ¨ New teaching and assessment methodologies ¨ E-learning Arrangements Document: PDA/HNC Engineering Practice 41 6.4 Open and Distance Learning Advice on the use of open and distance learning is given in individual Unit specifications. However, where it is used with regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangement would be required to be put in place to ensure that the assessment or assessments were conducted under the conditions specified in the Unit specification. For example, in the case of a Unit which involved a Unit end test a centre would have to make arrangements for the test to be conducted under controlled, supervised conditions. Likewise, where a Unit involves a practical based assessment, a centre would have to make arrangements for candidates to come into the centre, or another appropriate venue, to undertake the assessment under the conditions specified in the Unit specification. It should be noted that the same requirements as specified in the previous paragraph apply where part or all of a Unit is delivered on-line. 7 General information for centres Candidates with disabilities and/or additional support needs The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering alternative Outcomes for Units. Further advice can be found in the SQA document Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs (www.sqa.org.uk). Internal and external moderation All instruments of assessment used within this/these Group Award(s) should be internally moderated, using the appropriate policy within the centre and the guidelines set by SQA. External moderation will be carried out by SQA to ensure that internal assessment is within the national guidelines for these qualifications. Further information on internal and external moderation can be found in SQA's Guide to Assessment (www.sqa.org.uk). 8 General information for candidates The new Professional Development Award (PDA)/HNC Engineering Practice awards have been designed by an expert team of educators and industrialists with a view to allowing you to meet the educational and training requirements to work as an advanced craftsperson and engineering supervisor. The new qualifications contain up-to-date and relevant engineering and supervisory subject content and skills and have also been designed to satisfy the new SQA PDA/Higher National Design Principles. The PDA/HNC Engineering Practice award structure consists of four, 6-credit PDAs in Fabrication and Welding or Engineering Manufacture or Engineering Maintenance or Electrical Engineering. Each of these four PDAs is at SCQF level 7. You should choose to study the PDA which best meets your employment and Arrangements Document: PDA/HNC Engineering Practice 42 educational requirements. Regardless of which PDA you study, you will, along with other candidates, study the single 6-credit HNC Engineering Practice. To obtain a PDA you must successfully achieve the 6-credits in the relevant PDA award framework. To achieve an HNC Engineering Practice you must achieve a PDA and the 6-Unit credits in the HNC Engineering Practice. Studying a PDA will allow you to develop your knowledge, understanding and skills in your chosen advanced engineering craft discipline. Each PDA consists of a 4-credit mandatory section and an optional section where you can choose two Unit credits from a range of Units to suit your employment and education needs. The mandatory sections of the four PDAs contain the subjects shown in the table below: PDA Subjects in Mandatory section PDA in Engineering Practice: Fabrication and Welding at SCQF level 7 Welding principles and applications, container design and manufacture, inspection systems and fabrication steelwork preparation, joining and assembly PDA in Engineering Practice: Engineering Manufacture at SCQF level 7 Mechanical engineering principles, CAD, CNC and engineering measurement PDA in Engineering Practice: Engineering Maintenance at SCQF level 7 Plant Systems: services and utilities, mechanical engineering principles and industrial plant maintenance. PDA in Engineering Practice: Electrical Engineering at SCQF level 7 Electrical principles, applications of electrical and electronic instruments and electric motors and motor starting In the HNC Engineering Practice you will be provided with opportunities to develop much of the knowledge, understanding and skills to become an engineering supervisor. Five Unit credits in the HNC Engineering Practice are mandatory. These Units are Communication: Practical Skills, Engineering Supervision: Teamworking and Continuing Professional Development, Quality Management: An introduction, Value Engineering and the Engineering Practice examination. You will be able to choose one Unit in the HNC Engineering Practice from the following options: Mathematics (with either an electrical or mechanical bias), further supervisory studies in staffing and budget control, Production Planning and Control, Workplace Communication in English or Personal Development Planning. The teaching and learning processes that your lecturers are likely to use on a PDA/HNC Engineering Practice are as follows: lecturing, group work, practical engineering work, measurement and testing, computer simulation and project work. Industrial visits may also be included in your programme of study to allow you to see ‘real life’ engineering in action. Arrangements Document: PDA/HNC Engineering Practice 43 The Qualifications Design Team has ensured that assessment in the awards meet national standards. The awards have been designed to optimise assessment so that sufficient time is available for you to learn the advanced engineering craft and supervisory knowledge and skills that are essential to being a good craft/trades person and engineer supervisor. You can expect to do assessment at individual Unit level and at qualification level. At Unit level assessments will normally consist of written tests and/or practical exercises which will include the preparation of reports. Your lecturer should tell you at the start of the Unit what form Unit assessment(s) will take. In addition to Unit assessment there will also be a 3-hour examination. This examination will be designed to assess you on your knowledge, understanding and skills in your chosen advanced craft area and in the HNC Engineering Practice award. You should ask your lecturer for more details about the composition of the examination paper and when you will sit it. The Qualification Design Team does not wish to place any artificial barriers in the way of potential candidates wanting to study a PDA/HNC Engineering Practice award. However, it would be unfair to enrol a candidate into a PDA/HNC who did not have a realistic chance of successfully achieving the awards. The Qualification Design Team would therefore recommend that a candidate had one of the following qualifications before entering a PDA/HNC Engineering: 1 One Higher from Physics, Technological Studies or Mathematics and at least three Standard Grades 1–2/Intermediate 2 passes including Mathematics, Physics/Technological Studies and English. 2 An appropriate National Certificate in Engineering Practice or Engineering or an appropriate National Certificate in Engineering at SCQF level 5. 3 Equivalent qualifications or experience to those shown in (1) and (2). On completion of your PDA/HNC Engineering Practice award there may be opportunities for you to progress to a ‘Higher National technician qualification’ in, say, Mechanical or Electrical Engineering if that is what you prefer to do. Your PDA/HNC Engineering Practice qualification should provide you with some credit transfer opportunities towards the ‘technician HNC/HND.’ The precise nature of credit transfer will depend on the HNC/HND you decide to study. Alternatively, on completion of your PDA/HNC Engineering Practice award, you may decide to study a supervisory or management qualification. Many centres offer such qualifications and you are advised to obtain further information from centres on the range of supervisory or management qualifications they offer. Arrangements Document: PDA/HNC Engineering Practice 44 9 Glossary of terms SCQF: This stands for the Scottish Credit and Qualification Framework, which is a new way of speaking about qualifications and how they inter-relate. We use SCQF terminology throughout this guide to refer to credits and levels. For further information on the SCQF visit the SCQF website at www.scqf.org.uk SCQF credits: One HN credit is equivalent to 8 SCQF credit points. This applies to all HN Units, irrespective of their level. SCQF levels: The SCQF covers 12 levels of learning. HN Units will normally be at levels 6–9. Graded Units will be at level 7 and 8. Subject Unit: Subject Units contain vocational/subject content and are designed to test a specific set of knowledge and skills. Graded Unit: Graded Units assess candidates’ ability to integrate what they have learned while working towards the Units of the Group Award. Their purpose is to add value to the Group Award, making it more than the sum of its parts, and to encourage candidates to retain and adapt their skills and knowledge. Dedicated Core Skill Unit: This is a Unit that is written to cover one or more particular Core Skills, eg HN Units in Information Technology or Communications. Embedded Core Skills: This is where the development of a Core Skill is incorporated into the Unit and where the Unit assessment also covers the requirements of Core Skill assessment at a particular level. Signposted Core Skills: This refers to the opportunities to develop a particular Core Skill at a specified level that lie outwith automatic certification. Qualification Design Team: The QDT works in conjunction with a Qualification Manager/Development Manager to steer the development of the HNC/D from its inception/revision through to validation. The group is made up of key stakeholders representing the interests of centres, employers, universities and other relevant organisations. Consortium-devised HNCs and HNDs are those developments or revisions undertaken by a group of centres in partnership with SQA. Specialist single centre and specialist collaborative devised HNCs and HNDs are those developments or revisions led by a single centre or small group of centres who provide knowledge and skills in a specialist area. Like consortium-devised HNCs and HNDs, these developments or revisions will also be supported by SQA. 10 Appendix Appendix 1: Sample Teaching Timetables See following pages for Appendix 1. Arrangements Document: PDA/HNC Engineering Practice 45 Appendix 1: Sample Teaching Timetables 1 Two year part-time PDA in Engineering: Engineering Manufacture at SCQF level 7/HNC Engineering Practice 2 Two year part-time PDA in Engineering: Electrical Engineering at SCQF level 7/HNC Engineering Practice Arrangements Document: PDA/HNC Engineering Practice 46 Two Year, Part-Time PDA in Engineering Practice: Engineering Manufacture/HNC Engineering Practice First Year, First Semester Mechanical Engineering Principles Computer Aided Draughting for Engineers Options 1 (from the PDA in Engineering: Engineering Manufacture options) First Year, Second Semester Engineering Measurement CNC Options 2 (from the PDA in Engineering: Engineering Manufacture options) Arrangements Document: PDA/HNC Engineering Practice 47 Two Year, Part-Time PDA in Engineering Practice: Engineering Manufacture/HNC Engineering Practice (cont.) Second Year, First Semester Communication: Practical Skills Engineering Supervision:

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