THE TECHNOCRACY
STUDENTS' TECHNICAL COMMITTEE, NIT RAIPUR

AAVARTAN 24-25

VIGYAAN
DEPARTMENT OF ELECTRICAL ENGINEERING

PROBLEM STATEMENTS

EE01:- Energy Harvesting IoT Devices: Unlocking Sustainable Power Sources

Introduction:

In the ever-expanding landscape of IoT devices, sustainable power sources are critical for their continuous operation. This project aims to simplify the concept of energy harvesting, concentrating on straightforward methods to power small IoT devices using ambient energy. The objective is to make sustainability easy to grasp and implement, providing an accessible and hands-on experience for students.

Past Methodologies:

Traditional power sources for IoT devices often involve complex setups or reliance on batteries. However, these approaches come with limitations in terms of sustainability and lifespan.

Available Solutions:

Recent advancements have introduced user-friendly energy harvesting methods, such as solar-powered sensors and vibration-driven harvesters. These solutions are designed for simplicity, making them accessible for a broader range of applications.

Current Issues:

Despite progress, challenges still exist in ensuring the reliability and scalability of these simplified energy harvesting methods. Addressing these challenges is crucial for widespread adoption and practical implementation.

Scope of Application Today and in the Future:

The application of simplified energy harvesting extends to various sectors, from smart homes to environmental monitoring. Presently, these solutions enhance energy efficiency in everyday devices, and future scopes include broader integration with wearable technology and smart infrastructure.

Participant's Task: Design and Prototype:

Participants are tasked with designing and prototyping a simplified energy harvesting device for IoT applications. The focus should be on user-friendly approaches that make sustainable power sources more accessible. Considerations should include ease of implementation, scalability, and potential real-world applications for the developed prototype. In conclusion, unlocking the full potential of energy harvesting for IoT devices demands addressing efficiency challenges, improving storage solutions, and considering the environmental impact. Continued advancements will contribute to the widespread adoption of sustainable power sources, fostering a new era of energy-autonomous and environmentally conscious IoT devices.

EE02:- IoT-based Transformer Health Monitoring: Enhancing Reliability and Efficiency

Introduction:

Transformers play a crucial role in electrical power systems, and ensuring their health and reliability is paramount for maintaining overall grid stability. IoT-based solutions offer the potential for real-time monitoring and predictive maintenance, contributing to the optimization of transformer health. However, challenges exist in seamlessly integrating IoT technologies for comprehensive transformer health monitoring.

Past Methodologies:

Traditional approaches to transformer health monitoring relied on periodic inspections and manual assessments. These methods often led to reactive maintenance, increasing the risk of unexpected failures and downtime. The need for more proactive and real-time monitoring solutions prompted the exploration of IoT-based transformer health monitoring.

Available Solutions:

Recent advancements have introduced IoT solutions for transformer health monitoring, incorporating sensors, connectivity, and data analytics. These solutions enable continuous monitoring of parameters such as oil temperature, pressure, and gas levels. Machine learning algorithms analyse the collected data to predict potential issues, allowing for timely maintenance and improved transformer reliability.

Current Issues:

Despite progress, challenges persist in implementing IoT-based transformer health monitoring. Ensuring compatibility and integration with existing transformer infrastructure remains a hurdle. Cybersecurity concerns regarding data integrity and secure communication pose significant considerations. Additionally, addressing the scalability and cost-effectiveness of these solutions is crucial for widespread adoption.

Scope of Application Today and in the Future:

The application of IoT-based transformer health monitoring extends across various industries, including power distribution, manufacturing, and renewable energy. Presently, these solutions enhance the reliability of transformers in critical infrastructure. Future scopes involve broader integration with smart grids, advanced diagnostics using artificial intelligence, and the development of self-healing transformer systems.

Participant's Task: Design and Implement:

Participants are tasked with designing and implementing an IoT-based transformer health monitoring system. The system should effectively monitor key parameters, such as oil temperature, pressure, and gas levels, in real-time. Participants should also incorporate predictive maintenance algorithms to identify potential issues before they lead to failures. Considerations should be given to the system's compatibility, cybersecurity measures, and scalability for practical applications in diverse transformer setups. Participants are encouraged to provide documentation on the system's design principles, data analysis methods, and potential benefits for transformer reliability and grid stability.

In conclusion, enhancing the reliability and efficiency of transformers through IoT-based health monitoring requires addressing integration challenges, ensuring cybersecurity, and optimising scalability. Continued advancements in this field will contribute to resilient and predictive maintenance practices, ensuring the longevity and performance of critical electrical infrastructure.

EE03:- Energy Consumption Forecasting for Smart Buildings: Optimising Efficiency with AI-ML

Introduction:

The integration of smart technologies in buildings has opened avenues for optimising energy consumption. One crucial aspect is accurate energy consumption forecasting, which facilitates efficient resource allocation and sustainability. Leveraging Artificial Intelligence and Machine Learning (AI-ML) for energy consumption forecasting in smart buildings can revolutionise energy management practices.

Past Methodologies:

Historically, energy consumption in buildings was managed based on static schedules and historical usage patterns. Traditional methods lacked adaptability to changing conditions, leading to suboptimal energy utilisation. The need for real-time, dynamic forecasting prompted the exploration of AI-ML solutions.

Available Solutions:

Recent advancements have introduced AI-ML models for energy consumption forecasting in smart buildings. These models utilise historical energy data, weather patterns, occupancy schedules, and building characteristics to predict future consumption. Machine learning algorithms adapt to changing conditions, improving the accuracy of forecasts and enabling proactive energy management.

Current Issues:

Despite progress, challenges persist in AI-ML-based energy consumption forecasting for smart buildings. Integrating diverse data sources, such as IoT sensors and weather forecasts, requires careful coordination. Addressing data privacy concerns and ensuring the robustness of the models in different building types remain focal points for improvement.

Scope of Application Today and in the Future:

The application of AI-ML in energy consumption forecasting extends beyond commercial and residential buildings to include industrial complexes and smart city infrastructure. Presently, these models optimise HVAC systems, lighting, and appliance usage. Future scopes involve broader integration with energy storage solutions, grid demand response programs, and adaptive building automation, aiming for self-optimising and energy-efficient smart ecosystems.

Participant's Task: Develop an Energy Forecasting Model

Participants are tasked with developing an AI-ML-based model for energy consumption forecasting in smart buildings. The model should utilise historical energy data, weather forecasts, occupancy patterns, and any other relevant parameters to predict future energy consumption accurately. Participants are encouraged to consider real-world challenges such as data variability and privacy concerns. Additionally, they should provide documentation on the model's architecture, training methodologies, and potential applications for optimising energy efficiency in smart buildings.

In conclusion, advancing energy consumption forecasting in smart buildings with AI-ML requires addressing data integration challenges, ensuring privacy, and enhancing model robustness. Continued innovation in this field will contribute to energy-efficient smart buildings, fostering sustainability and resilience in urban environments.

EE04:- AI-Driven Intelligent Electric Vehicle Charging Infrastructure: Enhancing Efficiency and User Experience

Introduction:

The widespread adoption of electric vehicles (EVs) demands innovative solutions for intelligent and efficient charging infrastructure. Leveraging Artificial Intelligence (AI) can revolutionise the way electric vehicle charging stations operate, optimising charging schedules, grid interaction, and user experience. This problem statement focuses on developing AI-driven intelligence for electric vehicle charging infrastructure.

Past Methodologies:

Historically, electric vehicle charging stations operated on fixed schedules or user-demand patterns, leading to suboptimal charging experiences. Traditional methods lacked adaptability to real-time conditions, grid load, and user preferences. The need for intelligent, dynamic charging infrastructure prompted the exploration of AI-driven solutions.

Available Solutions:

Recent advancements have introduced AI-driven models for intelligent electric vehicle charging infrastructure. These models use machine learning algorithms to analyse real-time data, considering factors such as electricity prices, grid demand, and user preferences. AI-driven infrastructure adapts to fluctuations, optimising charging schedules for efficiency and cost-effectiveness.

Current Issues:

Despite progress, challenges persist in AI-driven intelligent electric vehicle charging infrastructure. Ensuring seamless communication between charging stations, electric vehicles, and the power grid requires careful coordination. Addressing cybersecurity concerns and optimising AI algorithms for scalability and real-world variability are key considerations.

Scope of Application Today and in the Future:

The application of AI in electric vehicle charging infrastructure extends across various urban and suburban settings. Presently, these intelligent systems optimise charging schedules based on real-time grid conditions and user preferences. Future scopes involve broader integration with smart grids, vehicle-to-grid (V2G) technology, and predictive maintenance, aiming for self-optimising and user-friendly charging ecosystems.

Participant's Task: Develop an AI-Driven Charging Infrastructure Prototype with Unconventional Features

Participants are challenged not only to create an AI-driven prototype for intelligent electric vehicle charging infrastructure but also to introduce unconventional and out-of-the-box features. In addition to optimising charging schedules based on real-time data like electricity prices, grid demand, and user preferences, consider innovative factors such as environmental conditions, user behaviours, or community engagement in your design. The goal is to encourage participants to explore creative and visionary approaches that redefine the landscape of intelligent electric vehicle charging while addressing traditional challenges like interoperability, cybersecurity, and scalability.
In conclusion, advancing electric vehicle charging infrastructure with AI requires addressing communication challenges, ensuring cybersecurity, and enhancing adaptability. Continued innovation in this field will contribute to a seamless, efficient, and user-centric electric vehicle charging experience, promoting the widespread adoption of electric mobility.

EE05:- AR-Driven Collaborative Electrical Design: Revolutionising Team Collaboration

Introduction:

Collaborative electrical design is essential for efficient and innovative project development. Augmented Reality (AR) presents an opportunity to transform the way teams collaborate on electrical design projects by providing a shared, interactive virtual environment. This problem statement focuses on developing an AR-driven platform that enables collaborative electrical design among multiple users.

Past Methodologies:

Historically, electrical design collaboration often relied on traditional planning tools, 2D diagrams, and communication through various channels. These methods lacked real-time interaction and a shared visual space for collaborative decision-making.

Available Solutions:

Recent advancements have introduced collaborative platforms for electrical design, but few leverage the immersive experience of AR. The integration of AR into collaborative design solutions allows users to interact with 3D models, share insights, and make decisions collectively in real time.

Current Issues:

Despite progress, challenges persist in AR-driven collaborative electrical design. Ensuring seamless synchronisation of 3D models across multiple users, addressing potential latency issues, and providing a user-friendly interface that encourages active participation are critical considerations.

Scope of Application Today and in the Future:

The application of AR-driven collaborative electrical design extends across industries such as engineering, construction, and manufacturing. Presently, these solutions enhance teamwork, streamline decision-making, and facilitate more efficient project development. Future scopes involve broader integration with artificial intelligence for design suggestions, enhanced visualisation tools, and compatibility with emerging technologies.

Participant's Task: Develop an Innovative AR-Driven Collaborative Design Platform

Participants are tasked with developing an AR-driven prototype for collaborative electrical design. The prototype should go beyond conventional solutions by introducing innovative features that enhance the collaborative experience. Consider elements such as real-time 3D model manipulation, intuitive user interfaces, and creative tools for team interaction. Participants are encouraged to provide documentation on the design rationale, user experience enhancements, and potential applications that distinguish their prototype in the realm of collaborative electrical design.

In conclusion, revolutionising collaborative electrical design with AR demands addressing synchronisation challenges, latency issues, and fostering active team engagement. Continued innovation in this field will contribute to more efficient, creative, and interactive approaches to electrical project development.

EE06:-Smart Helmet Integrated Safety System for Electric Vehicles

Introduction:

Ensuring rider safety is paramount, especially in the realm of electric vehicles (EVs) where innovation meets responsibility. This project focuses on designing a smart helmet with an integrated safety system that not only enhances rider safety but also ensures compliance with essential safety protocols before allowing the vehicle to start. The goal is to develop an advanced safety solution suitable for implementation by second-year undergraduate students.

Problem Statement:

The task is to design and prototype a smart helmet equipped with an integrated safety system tailored specifically for electric vehicle riders. The helmet should incorporate advanced safety features such as automatic vehicle immobilisation until the helmet is securely fastened and real-time alcohol sensing technology to prevent riding under the influence. Additionally, the helmet should include emergency contact notifications and GPS tracking capabilities for enhanced rider protection.

Key Features:

- Automatic Vehicle Immobilization**:** Integrate a mechanism that prevents the electric vehicle from starting unless the helmet is securely fastened onto the rider.
- Alcohol SensingTechnology**:** Incorporate sensors capable of detecting alcohol levels in the rider's breath to prevent riding under the influence.
- Emergency Contact Notifications**:** Implement a system that automatically alerts predefined emergency contacts in the event of an accident or collision.
- GPS Tracking**:** Include GPS tracking functionality to enable real-time location monitoring and assistance in case of emergencies or theft.
- Intelligent Communication Interface: Design a user-friendly interface for seamless communication with the rider, providing alerts and notifications as necessary.
- Impact Detection**:** Incorporate sensors capable of detecting impacts or collisions and triggering emergency response protocols.
- Weatherproof Design**:** Ensure the helmet's design is weatherproof to withstand various environmental conditions and provide reliable performance in all situations.

Participant's Task:

Participants are tasked with designing and prototyping a smart helmet integrated safety system for electric vehicle riders, incorporating advanced safety features and technologies. The focus should be on developing a comprehensive safety solution that enhances rider protection while ensuring ease of use and reliability. Considerations should be given to the integration of sensors, communication interfaces, and emergency response mechanisms to create a robust safety system.

By focusing on key safety features such as vehicle immobilisation, alcohol sensing, and emergency response capabilities, this project aims to empower students to develop innovative solutions that prioritise rider safety and enhance the overall riding experience in the realm of electric mobility.

EE07:- IoT-Based Soil Moisture Monitoring System for Precision Agriculture

Introduction:

In modern agriculture, efficient water management is essential for optimising crop yields while conserving water resources. Traditional methods of soil moisture monitoring often lack precision and real-time insights, leading to inefficient irrigation practices. This problem statement focuses on the development of an IoT-based soil moisture monitoring system to provide farmers with accurate, real-time data for optimising irrigation schedules and improving crop health.

Past Methodologies:

Historically, soil moisture monitoring relied on manual measurements or stationary sensors placed at fixed locations within fields. These methods were labour-intensive, time-consuming, and provided limited spatial coverage, leading to suboptimal irrigation decisions and uneven crop growth.

Available Solutions:

Recent advancements in IoT technology have enabled the development of wireless soil moisture sensors equipped with IoT connectivity. These sensors can be deployed across fields, providing continuous, real-time data on soil moisture levels at different depths and locations. Cloud-based IoT platforms collect, analyse, and visualise the data, allowing farmers to access insights from anywhere, at any time.

Current Issues:

Despite progress, challenges remain in implementing IoT-based soil moisture monitoring systems. Issues such as sensor accuracy, battery life, connectivity, and data security need to be addressed to ensure reliable and robust operation in diverse agricultural environments. Additionally, integrating soil moisture data with irrigation systems and crop models requires careful calibration and validation.

Scope of Application Today and in the Future:

The application of IoT-based soil moisture monitoring extends across various crops and farming practices, including row crops, orchards, vineyards, and precision agriculture. Presently, these systems help farmers optimise irrigation schedules, conserve water, and improve crop yields. Future scopes involve broader integration with predictive analytics, machine learning algorithms, and automated irrigation systems, paving the way for more efficient and sustainable agriculture practices.

Participant's Task:

Participants are tasked with designing and implementing an IoT-based soil moisture monitoring system suitable for precision agriculture applications. The system should consist of wireless soil moisture sensors, IoT connectivity modules, and a cloud-based platform for data collection, analysis, and visualisation. Participants should consider factors such as sensor accuracy, power consumption, data transmission range, and scalability for practical deployment in agricultural fields. Additionally, participants are encouraged to explore innovative features such as predictive analytics, automated alerts, and mobile applications for enhanced user experience and decision support.

In conclusion, developing an IoT-based soil moisture monitoring system offers significant benefits for precision agriculture, including optimised water management, improved crop yields, and environmental sustainability. By addressing technical challenges and leveraging IoT solutions, participants can contribute to the advancement of modern agriculture practices and the global food security agenda.

EE08:- Integration of Supercapacitors for Rapid Energy Boost in Electric Vehicles

Introduction:

Electric vehicles (EVs) have become pivotal in the transition towards sustainable transportation, yet challenges like energy density and rapid energy transfer persist. This project focuses on the integration of supercapacitors alongside traditional batteries in electric vehicles, aiming to provide a rapid energy boost during acceleration and regenerative braking.

Past Methodologies:

Historically, EVs relied solely on lithium-ion batteries for energy storage, limiting the rate at which energy could be delivered to meet sudden acceleration demands. The absence of a rapid energy transfer mechanism led to compromised performance during high-power manoeuvres.

Available Solutions:

Recent advancements involve integrating supercapacitors, known for their high power density, alongside traditional batteries. This dual-system approach allows for quick energy discharge and recharge, addressing the limitations of batteries during rapid acceleration and braking scenarios.

Current Issues:

Challenges include efficient coordination between supercapacitors and batteries, managing charge and discharge cycles, and ensuring system reliability. Addressing these issues is crucial for unlocking the full potential of rapid energy boost capabilities in electric vehicles.

Scope of Application Today and in the Future:

The integration of supercapacitors in electric vehicles has immediate applications in improving acceleration performance, especially in stop-and-go traffic. Future scopes include refining the technology for broader use, enhancing energy management algorithms, and adapting the system for various vehicle types.

Participant's Task:

Participants are tasked with designing and implementing a system that seamlessly integrates supercapacitors for rapid energy boosts in electric vehicles. The focus is on developing efficient control algorithms, optimising charge-discharge cycles, and ensuring reliable coordination between the supercapacitors and batteries.

In conclusion, this project challenges participants to contribute to the evolution of electric vehicle technology by enhancing rapid energy transfer capabilities. By addressing current challenges and refining the integration of supercapacitors, participants aim to improve the overall performance and efficiency of electric vehicles during dynamic driving scenarios.

EE09:- Designing a Low-Cost Vehicle-to-Grid (V2G) Charger for Electric Vehicles

Introduction:

As electric vehicles (EVs) become increasingly prevalent, integrating Vehicle-to-Grid (V2G) capabilities into EV charging infrastructure presents a promising avenue for sustainable energy management. This project focuses on designing a cost-effective V2G charger that allows EVs to both charge from and discharge electricity to the grid, contributing to grid stability and renewable energy integration.

Past Methodologies:

Previous approaches to V2G chargers often prioritised advanced communication protocols and sophisticated control algorithms. While effective, these methodologies may have overlooked the potential for low-cost solutions suitable for widespread adoption, especially in regions with limited resources.

Available Solutions:

Recent advancements in power electronics and control systems offer opportunities to design V2G chargers with simplified architectures and reduced component costs. Utilising off-the-shelf components and open-source software platforms can further drive down the overall cost of V2G charger development.

Current Issues:

Despite progress, challenges persist in designing low-cost V2G chargers, including balancing performance and affordability, ensuring compatibility with existing EVs, and addressing safety and regulatory requirements. Additionally, achieving optimal efficiency and reliability with limited resources remains a key consideration.

Scope of Application:

The developed low-cost V2G charger can be deployed in various settings, including residential charging stations, public EV infrastructure, and community-based energy projects. Initially, the focus may be on demonstrating feasibility and reliability in small-scale deployments before scaling up for broader applications.

Participant's Task:

Participants are tasked with designing and prototyping a low-cost V2G charger suitable for integration into existing EV charging infrastructure. The charger should support bidirectional power flow, adhere to safety standards, and incorporate features for grid interaction and energy management. Considerations should be given to cost-effective component selection, simplified control algorithms, and scalability for mass production.

In conclusion, designing a low-cost V2G charger addresses the need for affordable solutions to support the growing EV market and enable sustainable energy practices. By overcoming technical and economic challenges, participants contribute to the accessibility and scalability of V2G technology, fostering a more resilient and renewable energy future.

EE10:- Development of a Hazard Detection System for Smart Helmets in Electrical Work Environments

Introduction:

Electrical workers face various hazards in their daily tasks, including electrical shocks, arc flashes, and falls. To enhance safety and prevent accidents, this project focuses on developing a smart helmet equipped with a hazard detection system. The system aims to identify potential dangers in electrical work environments and alert the wearer in real-time, mitigating risks and improving workplace safety.

Past Methodologies:

Historically, hazard detection systems in electrical work environments relied on manual inspections and safety protocols. While effective to some extent, these methods were reactive and prone to human error. The need for proactive hazard detection solutions led to the exploration of sensor-based technologies and wearable devices.

Available Solutions:

Recent advancements have introduced sensor technologies such as infrared sensors, gas sensors, and proximity sensors, capable of detecting various hazards in electrical environments. Integration with wearable devices like helmets enables real-time monitoring and alerts, enhancing worker safety. Additionally, advancements in wireless communication allow for seamless data transmission to monitoring stations or mobile devices.

Current Issues:

Despite progress, challenges remain in developing effective hazard detection systems for smart helmets. Issues include sensor accuracy and reliability, compatibility with existing safety equipment, and user acceptance. Addressing these challenges is essential to ensure the practicality and adoption of the technology in real-world electrical work environments.

Scope of Application:

The developed hazard detection system has broad applications across electrical industries, including power distribution, construction, and maintenance. Initially, the focus may be on pilot implementations in specific work environments to evaluate system performance and user feedback. Future scopes involve wider adoption and integration with existing safety protocols to create safer work environments.

Participant's Task:

Participants are tasked with designing and prototyping a hazard detection system for smart helmets tailored to electrical work environments. The system should incorporate appropriate sensors for detecting electrical hazards such as voltage presence, arc flashes, and gas leaks. It should provide real-time alerts to the wearer and potentially to supervisors or control centres. Considerations should be given to sensor selection, data processing algorithms, and user interface design for seamless integration into existing safety gear.

In conclusion, developing a hazard detection system for smart helmets addresses the critical need for proactive safety measures in electrical work environments. By leveraging sensor technologies and wearable devices, participants contribute to improving workplace safety and reducing the risk of accidents and injuries.