



SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING

INDUSTRIAL VISIT REPORT ON
ELECTRICAL PANEL BOARDS AND MAINTENANCE
RIHAN POWER ENTERPRISES
Hegganahalli, Bengalore-560091
(Duration: 06/03/20245 to 08/03/2025)

Submitted in fulfilment of the requirements for the award of the Degree of

Bachelor of Technology

In

Electrical and Electronics Engineering

Submitted by

HEMANTH H K (R22EM032)
MANOJ T A(R22EM043)
KUSHAL T A (R22EM040)
GOWTHAM R(R22EM027)

2025

Rukmini Knowledge Park, Kattigenahalli, Yelahanka, Bengaluru-560064



SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING

REVA UNIVERSITY

RUKMINI KNOWLEDGE PARK, KATTIGENAHALLI, YELAHANKA

BANGALORE 560064

CERTIFICATE

This is to certify that the "**INDUSTRIAL VISIT**" submitted by **Hemanth H K (R22EM032), Kushal T A(R22EM040), Manoj T A(R22EM043), Gowtham R(R22EM027)** is work done by him and submitted during 2024-2025 academic year, in partial fulfillment of the requirements for the academics of **BACHELOR OF TECHNOLOGY** in **ELETICAL AND ELECTRONICS ENGINEERING** at **RIHAN POWER ENTERPRISES, HEGGANAHALLI, BENGALORE-560091**

Prof. Doddabasappa N
High Voltage course coordinator
School of EEE

Dr. Raghu C N
Director, School of EEE

INTERNSHIP COMPLETION CERTIFICATE

To

Date: 04/03/2025

The General Manager
Rihan Power Enterprises.
64/5, Ground Floor,
Hegganahalli, Srigandha Kavalu.
Bengaluru Karnataka 560091

Dear Sir,

Subject: Request for Permission to Visit Rihan Power Enterprises.

School of Electrical & Electronics Engineering of REVA University has implemented practical teaching and Project based learning in our curriculum. We have included high voltage engineering and industrial automation. The industrial visit will help our students to a great extent to have a good exposure on functioning of High voltage testing and Industrial instruments used in the industry.

Keeping in view the importance of technical visit, we request you to provide an opportunity to our 6th semester students (3rd Year) to visit the Rihan Power Enterprises on 06/03/2025 to 08/03/2025 between 08:30AM to 5:00PM.

List of students is enclosed for your kind permission to visit your Rihan Power Enterprises

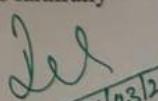
SL NO	SRN	STUDENT NAME
1	R22EM022	DISHA K PRABHU
2	R22EM026	GANGAMBIKA
3	R22EM051	NAGAMANI O
4	R22EM056	PALLAVI S N
5	R22EM032	HEMANTH H K
6	R22EM043	MANOJ T A
7	R22EM040	KUSHAL T A
8	R22EM027	GOWTHAM R N

We hope you will do the needful.

Note: We the School of Electrical & Electronics Engineering, REVA University, will be responsible for the participants during the above visit with respect to their safety and security.

Thanking you

Yours faithfully


4/03/25
Director
School of Electrical &
Electronics Engineering
REVA University, Rukmini Knowledge Park
Kattigenahalli, Yelahanka, Bengaluru-560 06

ABSTRACT

Electrical panel boards are a vital component of industrial electrical systems, serving as the central hub for power distribution, control, and monitoring. These panels house circuit breakers, fuses, and other protective devices that safeguard equipment from electrical faults, overloads, and short circuits, ensuring uninterrupted power supply and minimizing downtime. The significance of electrical panel boards in industries cannot be overstated, as they play a crucial role in enhancing safety, efficiency, and reliability. This report presents an overview of the industrial visit to Rihan Power Enterprises, focusing on high-voltage control panels and their applications in testing. High-voltage control panels are critical in power systems, ensuring safe and efficient operation by regulating, monitoring, and protecting electrical networks.

The report explores the components, layout, and applications of high-voltage control panels, emphasizing their role in high-voltage testing. Various testing methods, including dielectric strength tests, high-potential (Hi-Pot) tests, partial discharge tests, and surge impulse testing, are discussed. These tests validate the insulation integrity, fault resistance, and operational reliability of electrical equipment such as transformers, circuit breakers, HV motors, and switchgear.

Additionally, the key components of a high-voltage testing control panel, such as high-voltage transformers, voltage regulators, protection relays, measuring instruments, and data logging systems, are examined. The report highlights the significance of these panels in ensuring compliance with industry standards (IEC, IEEE) and preventing failures in power networks.

The visit provided valuable insights into advanced high-voltage technologies, automation in testing, and future trends such as eco-friendly insulation and AI-based predictive maintenance. The report concludes by emphasizing the importance of high-voltage testing in enhancing the safety, efficiency, and reliability of power systems in industrial and commercial sectors.

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CHAPTER 1

INTRODUCTION AND COMPONENTS OF ELECTRICAL PANEL BOARDS

1.1 Introduction to Electrical Panel Boards.

Electrical panel boards originated from simple fuse boxes and switchboards used in the 1800s, when simple fuse boxes and switchboards were used to manage electrical distribution. As alternating current (AC) systems replaced direct current (DC) systems in the late 1800s and early 1900s, electrical panel boards evolved to accommodate AC systems with the addition of circuit breakers and switches. The 1920s to 1950s saw the introduction of standardization and safety features, including grounding systems, arc fault protection, and thermal overload protection, as mandated by the National Electric Code (NEC) standards. The 1960s to 1980s brought advancements in materials and design, such as insulating materials, compact circuit breakers, and modular design concepts, making electrical panel boards more compact, efficient, and reliable. In recent decades, modern developments have led to intelligent electrical panel boards with monitoring and control capabilities, integration with building management systems (BMS) and supervisory control and data acquisition (SCADA) systems, and a focus on energy efficiency and sustainability. Today, electrical panel boards prioritize safety, energy efficiency, and flexibility, with future directions including integration with smart grid technologies, IoT devices, and renewable energy sources.

1.2 Types of Electrical Panel Boards (main, distribution, sub-panels)

1.2.1 Main Electrical Panel Board



Fig 1.2.1 Main Electrical Panel Board

- Primary electrical panel board in a building or facility.
- Receives incoming electrical power from the utility company or generator.
- Distributes power to various branch circuits and sub-panels.
- Typically houses main circuit breakers, fuses, or switches.
- Usually located in a central location, such as a basement or electrical room

1.2.2. Distribution Panel Boards.



Fig 1.2.2 Distribution panel board

- Receives power from the main electrical panel board
- Distributes power to specific areas or loads, such as lighting, HVAC, or equipment
- May house circuit breakers, fuses, or switches for branch circuits
- Often located in closer proximity to the loads they serve
- May be used to segment electrical systems for easier maintenance or upgrade

1.2.3. Sub-Panel Boards



Fig 1.2.3 Sub-Panel Board

- Receives power from a distribution panel board or main electrical panel board.
- Serves a specific area or load, such as a room, floor, or piece of equipment.
- Typically houses circuit breakers or fuses for branch circuits.
- Often used to provide additional circuit capacity or to serve remote areas.
- May be used to isolate electrical systems for safety or maintenance purposes.

1.3 Surge Protectors and Arresters



Fig 1.3(a) Surge protector

Surge protectors are devices designed to protect electrical equipment from voltage surges and spikes, such as those caused by lightning strikes, switching surges, or grid fluctuations. They absorb or divert surge energy to prevent damage to equipment.

- Devices that protect electrical systems from voltage surges and spikes.
- Absorb or divert surge energy to prevent damage to equipment.
- Typically installed in electrical panel boards to protect branch circuits.
- May be used to protect specific equipment or entire electrical systems.



Fig 1.3(b) Surge Arresters

Surge arresters are devices designed to protect electrical systems from voltage surges and spikes, such as those caused by lightning strikes or switching surges. They direct surge energy to ground, preventing damage to equipment and ensuring electrical system reliability.

- Devices that protect electrical systems from lightning strikes and switching surges.
- Direct surge energy to ground, preventing damage to equipment.
- Typically installed in electrical panel boards to protect main electrical circuits.
- May be used to protect entire electrical systems or specific equipment

1.4 Grounding and Bonding Systems.

Grounding systems and bonding are essential components of electrical installations, ensuring safety, reliability, and noise reduction. A grounding system is a network of conductors and electrodes that provide a safe path to ground for electrical currents, preventing electrical shock and equipment damage. Bonding, on the other hand, is the process of connecting metal parts and equipment to the grounding system, ensuring electrical continuity and safety. Effective grounding and bonding designs follow standards such as IEEE Standard 80 and NEC Article 250, and involve regular testing, including visual inspections, megohmmeter testing, and ground resistance testing. Proper grounding and bonding ensure electrical safety, minimize downtime and maintenance costs, reduce noise and interference, and guarantee compliance with electrical codes and standards. By connecting equipment and systems to a grounding point, such as a grounding electrode, electrical currents are safely directed to the earth, preventing damage and ensuring continuous operation.



Fig 1.4 Door Earthing

1.5 Electrical Panel Board Control Systems.

Electrical Panel Board Control Systems are advanced solutions that monitor and control electrical power distribution, ensuring safe and reliable operation. These systems consist of components such as Programmable Logic Controllers (PLCs), Remote Terminal Units (RTUs), Intelligent Electronic Devices (IEDs), and Supervisory Control and Data Acquisition (SCADA) Systems, which work together to provide real-time monitoring and

alerts. They perform various functions including monitoring voltage, current, and power, controlling switching and tripping, and providing protection against overcurrent and overvoltage. Additionally, they enable automation of tasks such as automatic transfer switching and load shedding, and facilitate data acquisition for logging, trending, and analysis. By implementing Electrical Panel Board Control Systems, operators can improve safety and reliability, increase efficiency and productivity, and make data-driven decisions to ensure optimal operation of electrical power distribution systems.

CHAPTER 2

DESIGN AND CONSTRUCTION OF PANNEL BOARD

2.1 Design Considerations:

In modern electrical systems, panel boards play a vital role in ensuring safe and efficient power distribution. A well-designed panel board is essential for preventing electrical shocks, equipment damage, and downtime. As electrical systems become increasingly complex, the importance of proper panel board design cannot be overstated.

The key design considerations for panel boards are:

2.1.1 Electrical Considerations:

- 1. Voltage and current ratings:** Ensure the panel board can handle the maximum voltage and current requirements of the connected equipment.
- 2. Short circuit and fault current calculations:** Calculate the short circuit and fault current to determine the required breaking capacity of the circuit breakers.
- 3. Overcurrent protection:** Select circuit breakers or fuses that provide adequate overcurrent protection for the connected equipment.
- 4. Grounding and bonding:** Ensure proper grounding and bonding to prevent electrical shocks and equipment damage.
- 5. Arc flash and arc blast:** Consider arc flash and arc blast protection measures, such as arc-rated enclosures and PPE.

2.1.2 Physical Considerations:

- 1. Size and layout constraints:** Ensure the panel board fits within the allocated space and allows for easy maintenance.
- 2. Mounting options:** Choose from wall, floor, or wall-mounted options, considering accessibility and space constraints.
- 3. Environmental conditions:** Select materials and designs suitable for the operating environment (e.g., temperature, humidity, exposure to chemicals).
- 4. Material selection:** Choose materials that meet electrical, mechanical, and environmental requirements (e.g., metal, plastic, fiber-reinforced polymer).

5. Sealing and gasketing: Ensure proper sealing and gasketing to prevent moisture and contaminants from entering the panel.

2.1.3 Safety Considerations:

1. Compliance with safety standards: Adhere to national and international safety standards (e.g., NEC, IEC).

2. Lockout/tagout procedures: Develop procedures for safe lockout/tagout during maintenance and repair.

3. Warning labels and signage: Install warning labels and signage to alert personnel of potential hazards.

4. Surge protection: Install surge arresters or suppressors to protect equipment from voltage spikes.

5. Emergency shutdown and isolation: Design for rapid shutdown and isolation in case of emergencies.

2.1.4 Functional Considerations:

1. Control and monitoring requirements: Determine the need for control and monitoring devices (e.g., switches, meters, indicators).

2. Communication protocols: Select communication protocols for integration with other systems (e.g., Modbus, Ethernet).

3. Display and user interface: Choose a user-friendly display and interface for monitoring and control.

4. Alarm and notification systems: Design alarm and notification systems for alerts and warnings.

5. Integration with other systems: Ensure compatibility with other systems (e.g., SCADA, DCS).

2.1.5 Compliance and Standards:

1. National Electric Code (NEC): Comply with NEC requirements for electrical installations.

2. International Electrotechnical Commission (IEC) standards: Adhere to IEC standards for electrical equipment and systems.

3. UL (Underwriters Laboratories) and ETL (Intertek) certifications: Obtain certifications from UL or ETL for electrical equipment and systems.

4. Industry-specific standards: Comply with industry-specific standards (e.g., IEEE, ASME).

2.1.6 Other Considerations:

- 1. Cost and budget constraints:** Balance design requirements with budget constraints.
- 2. Aesthetics and appearance:** Consider the visual appeal of the panel board and its components.
- 3. Future expansion and upgradeability:** Design for future expansion and upgradeability.
- 4. Supply chain and logistics:** Ensure availability and accessibility of components and materials.
- 5. Warranty and support:** Provide adequate warranty and support for the panel board and its components.

2.2 Component Selection:

An electrical panel consists of several key components that work together to regulate and protect the electrical system like Main breaker, Circuit breakers, Bus bars, Transformers, Relays etc.

2.2.1. Main breakers:



Fig 2.2.1 Main Breaker

Main breakers in electrical panel boards are the primary switches that control the flow of electricity to the entire electrical system. They are typically located at the top or bottom of the panel board and are used to shut off the power to the entire system in case of an emergency or for maintenance purposes.

- 1. Primary power shut-off:** Main breakers provide a single point of control to shut off the power to the entire electrical system.
- 2. High current rating:** Main breakers have a high current rating to handle the total load of the

electrical system.

3. Manual operation: Main breakers are typically manually operated, allowing users to switch the power on or off.

4. Lockout/tagout capability: Main breakers often have provisions for lockout/tagout procedures to prevent accidental power restoration during maintenance.

5. Arc fault protection: Some main breakers come with arc fault protection, which detects and interrupts arcing faults to prevent electrical fires.

6. Ground fault protection: Main breakers may also have ground fault protection, which detects and interrupts ground faults to prevent electrical shocks.

2.2.2 Bus bars



Fig 2.2.2 Bus bars

Bus bars are metal bars that distribute electrical power from the main breaker to the circuit breakers. They provide a pathway for the electricity to travel throughout the panel.

An electrical bus bar is instrumental in simplifying complex power distribution networks, making them more cost-effective and adaptable. Essentially, it is a conductor, typically a metallic strip or bar, securely enclosed within switchgear, panel boards, and busway casings for localized, high-current power distribution. It forms a pivotal junction where electric power is amassed from incoming feeders and is then distributed to outgoing feeders.

Electrical bus bars are characterized by the harmonious operation of multiple lines, which function at identical voltage levels and frequencies. Often, copper or aluminum, known for their excellent conductivity, are the chosen materials for constructing these integral components.

Depending on the specific requirements, they are fashioned into pipes or thin-walled tubes to facilitate effective power transmission.

2.2.3 Transformers:

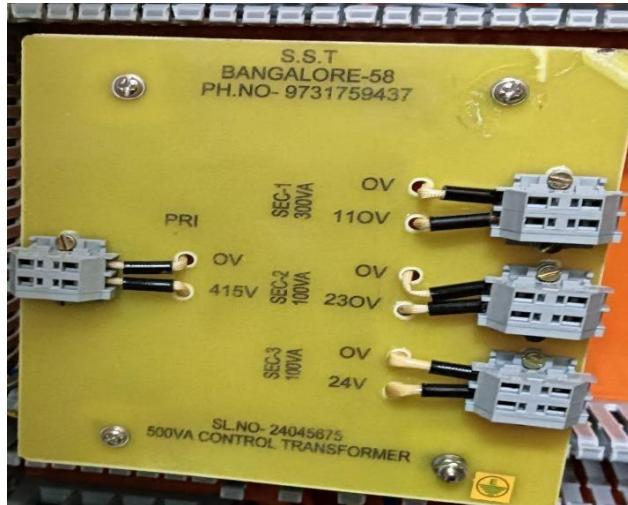


Fig 2.2.3 Transformer

A control transformer, also known as an instrument transformer, is a type of transformer specifically designed to regulate voltage levels in control circuits. It is primarily used to step down high voltage to a lower, more manageable voltage suitable for powering control devices. Control transformers are commonly found in industrial machinery, HVAC systems, motor control centers, and other applications where precise voltage control is necessary.

1. **Voltage Regulation:** Control transformers ensure that control devices receive a consistent and stable voltage, regardless of fluctuations in the input voltage. This helps maintain the accuracy and reliability of control systems.
2. **Isolation:** The electrical isolation provided by control transformers protects control devices and operators from high voltages on the primary side. It reduces the risk of electrical shocks and prevents damage to sensitive equipment.
3. **Compact Size:** Control transformers are compact and designed to fit into limited spaces. Their small size makes them ideal for applications where space is a constraint.
4. **Versatility:** Control transformers can be customized to meet specific voltage and power requirements. They can be designed for different input and output voltages, ensuring compatibility with various control devices.

2.2.4 Relay:

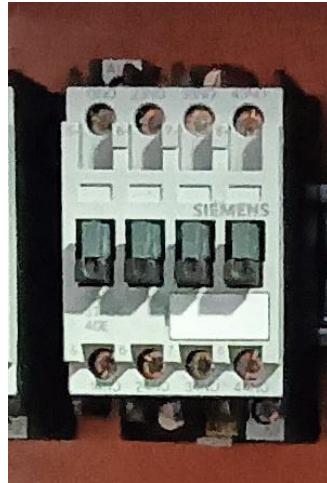


Fig 2.2.4 Relay

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations.

Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal. Relays were first used in long-distance telegraph circuits as signal repeaters: they refresh the signal coming in from one circuit by transmitting it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

2.2.5 Circuit Breaker:



Fig 2.2.5 Circuit Breaker

Circuit breaker is an electrical safety device designed to protect an electrical circuit from damage caused by current in excess of that which the equipment can safely carry (overcurrent). Its basic

function is to interrupt current flow to protect equipment and to prevent fire. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation.

Circuit breakers are commonly installed in distribution boards. Apart from its safety purpose, a circuit breaker is also often used as a main switch to manually disconnect ("rack out") and connect ("rack in") electrical power to a whole electrical sub-network.

2.2.6 Contactor:



Fig 2.2.6 Contactor

A contactor is an electrically controlled switch used for switching an electrical power circuit. A contactor is typically controlled by a circuit which has a much lower power level than the switched circuit, such as a 24-volt coil electromagnet controlling a 230-volt motor switch.

contactors are designed to be directly connected to high-current load devices. Devices switching more than 15 amperes or in circuits rated more than a few kilowatts are usually called contactors. Apart from optional auxiliary low-current contacts, contactors are almost exclusively fitted with normally open ("form A") contacts.

2.2.7 Timer:



Fig 2.2.7 Timer

A timer in a panel board is a device that controls the operation of electrical circuits or devices for a specific period. It is a type of control device that allows for automated switching of electrical circuits, turning them on or off at set times or intervals.

Timers in panel boards serve various functions, including on/off control, delayed on/off, pulse generation, repeat function, alarm function, scheduling, energy monitoring, remote control, automatic switching, and time-setting. These functions enable timers to automate tasks, optimize energy consumption, ensure equipment shutdown in case of an emergency, reduce wear and tear on equipment, and provide flexibility and adjustability. By automating electrical circuits and devices, timers enhance safety and efficiency, while also improving monitoring and control capabilities. Additionally, timers allow for adjustable time settings and functions, making them a versatile and essential component in panel boards. Overall, the functions of timers in panel boards contribute to increased efficiency, energy savings, improved safety, reduced maintenance, and flexibility.

2.3 Panel Board Layout and Wiring:

2.3.1 Component Plate Layout:

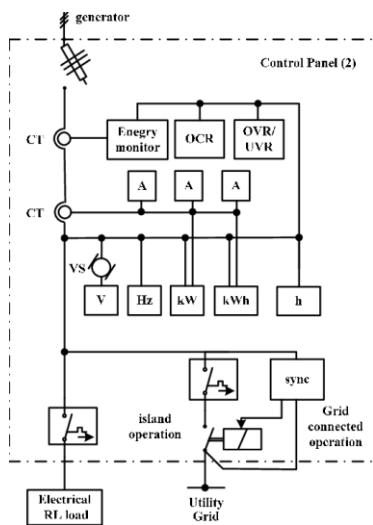


Fig 2.3.1 Component plate layout

Arranging components on a plate requires careful planning and consideration of several factors.

Step 1: Identify the Components

1. List all the components that need to be mounted on the plate, including their dimensions, mounting requirements, and electrical connections.
2. Categorize components into groups, such as:
 - Power components (e.g., transformers, capacitors)
 - Control components (e.g., relays, switches)
 - Sensing components (e.g., temperature sensors, pressure sensors)
 - Display components (e.g., LEDs, LCDs)

Step 2: Determine the Plate Layout

1. Decide on the plate size and shape based on the components' dimensions and the available space.
2. Consider the plate material, thickness, and strength to ensure it can support the components' weight and withstand environmental factors.
3. Use a grid system or grid paper to sketch the plate layout, taking into account the components'

mounting requirements and electrical connections.

Step 3: Arrange Components

1. Start with the largest components: Place the largest components, such as transformers or capacitors, first, as they require the most space.
2. Group similar components together: Group components of the same type, such as relays or switches, to simplify wiring and maintenance.
3. Place components in a logical order: Arrange components in a logical order, such as from input to output, to simplify signal flow and reduce wire runs.
4. Consider component orientation: Orient components to minimize wire runs and connections, while ensuring proper spacing and alignment.
5. Leave space for cable management: Allocate space for cable entry and exit points, and plan cable routing and management to prevent damage and ensure easy maintenance.

Step 4: Check for Interference and Clearance

1. Verify that components do not interfere with each other, either mechanically or electrically.
2. Ensure adequate clearance between components for heat dissipation, electrical safety, and maintenance.
3. Check for any mechanical or electrical conflicts, such as overlapping components or conflicting electrical connections.

Step 5: Refine the Layout

1. Review the layout to ensure it meets all requirements and specifications.
2. Check for any errors or conflicts.
3. Refine the layout as needed to optimize performance, safety, and maintainability.

2.3.1 Components Wiring:

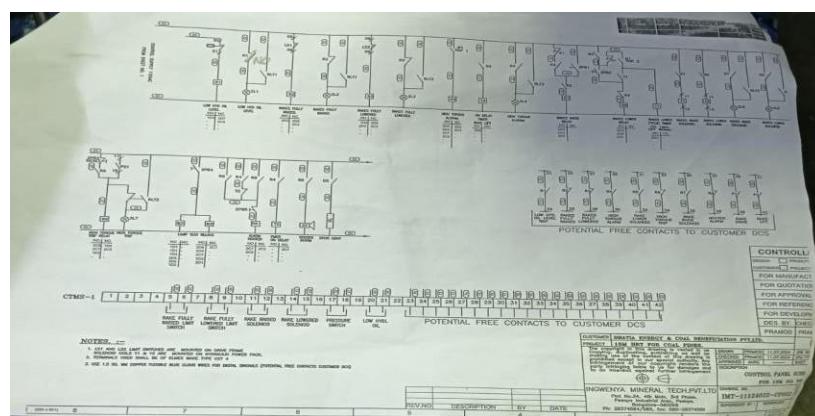


Fig 2.3.2 Wiring SLD

Wiring refers to the process of connecting electrical components, such as devices, circuits, and systems, using insulated conductors, like wires or cables. The primary purpose of wiring is to transmit electrical energy, signals, or data between components, ensuring safe and efficient operation.

Methods of wiring:

Conventional Wiring Methods:

1. Point-to-Point Wiring:

- Connects components directly with wires.
- Advantages: Simple, cost-effective.
 - Disadvantages: Difficult to maintain, prone to errors.

2. Bus Wiring:

- Uses a common bus for multiple connections.
- Advantages: Efficient, scalable.
 - Disadvantages: Complex, requires careful planning.

3. Wiring Cables:

- Uses cables to connect components.
- Advantages: Flexible, easy to install.
 - Disadvantages: Prone to damage, limited durability.

Modular Wiring Methods:

1. Modular Busbar Trunking:

- Pre-assembled modules for easy installation.
- Advantages: Quick installation, easy maintenance.
 - Disadvantages: Limited flexibility, higher cost.

2. Modular Wiring Systems:

- Interconnected modules for flexible design.
- Advantages: Flexible, scalable, easy to maintain.
 - Disadvantages: Higher cost, complex design.

Flexible Wiring Methods:

1. Flexible Busbar Trunking:

- Flexible cables for easy routing.
- Advantages: Easy to install, flexible.
 - Disadvantages: Prone to damage, limited durability.

2. Flexible Wiring Cables:

- Flexible cables for easy installation.
- Advantages: Flexible, easy to install.
 - Disadvantages: Prone to damage, limited durability.

Rigid Wiring Methods:

1. Rigid Busbar Trunking:

- Rigid cables for high-reliability applications.
-

Disadvantages: Difficult to install, inflexible.

2. Rigid Wiring Cables: Rigid cables for durable and reliable connections.

- Advantages: Durable, reliable.
- Disadvantages: Difficult to install, inflexible.

Wiring Techniques:

1. Strain Relief: Prevents cable damage with strain relief devices.

- Advantages: Prevents cable damage, ensures reliability.
- Disadvantages: Additional cost, complex installation.

2. Cable Management: Manages cables with cable ties, clips, and organizers.

- Advantages: Organizes cables, prevents damage.
- Disadvantages: Additional cost, complex installation.

3. Wire Wrapping: Secures connections with wire wrapping.

- Advantages: Secure connections, easy to install.
- Disadvantages: Prone to errors, limited durability.

4. Soldering: Creates permanent connections with soldering.

- Advantages: Permanent connections, reliable.
- Disadvantages: Complex installation, prone to errors.

2.4 Materials Selection for Harsh Environments.

Enclosure:

Enclosure materials are used to construct the outer casing of an electrical or electronic device, protecting its internal components from environmental factors, mechanical damage, and electrical shock. Electrical enclosure manufacturers use different materials to construct their products. These materials offer varying degrees of resistance to factors such as impact, corrosion, heat, and other conditions. The most common materials used in electrical enclosures are metal, plastic, and fiber glasses.



Fig 2.4 Enclosure

Types:

1. Steel Electrical Enclosures:

Steel is a strong and durable material that offers excellent protection against impact, vibration, and corrosion. Steel electrical enclosures are typically used in harsh industrial environments where the enclosure is subject to high levels of wear and tear.

2. Carbon Steel Enclosures:

Carbon steel is a strong and durable material that can withstand high temperatures and harsh environments. Carbon steel enclosures are also less expensive than most other metal enclosures, which makes them budget-friendly options.

3. Stainless Steel Enclosures:

Stainless steel enclosure offers better resistance to corrosion. This makes it a good choice for environments where the enclosure is exposed to chemicals or salt water. Stainless steel electrical enclosures also have a clean, polished look that makes them suitable for applications where aesthetics is an important factor. These include offices, food processing plants, and healthcare facilities.

4. Galvanized Steel Enclosures:

Galvanized steel enclosures have a coating that protects against corrosion. This makes them a good choice for outdoor applications or environments where the enclosure is exposed to chemicals.

5. Aluminium Electrical Enclosures:

Aluminium enclosures are lighter than steel enclosures and offer good protection against corrosion. However, they are not as strong as steel enclosures and are more susceptible to damage from impact.

In addition to corrosion withstand, aluminium electrical enclosures provide a natural shield to EMI or RFI. That makes them ideal for use in electronic enclosures that must be protected from electromagnetic interference.

6. Plastic Electrical Enclosures:

Plastic enclosures are lightweight and offer good resistance to impact, chemicals, and corrosion. They are typically less expensive than steel or aluminium enclosures. As such, a plastic enclosure box provides a cost-effective option for many applications.

7. Polycarbonate Enclosures:

Polycarbonate is a strong and durable material that offers good resistance to impact and other causes of damage. It's a good choice for environments where the enclosure is subject to high levels of wear and tear and can be used for both indoor and outdoor enclosures.

8. ABS Enclosures:

ABS plastic is a lightweight material that offers a good choice for applications where weight is a concern. However, ABS enclosures do not offer the durability and sturdiness of polycarbonate. This enclosure material is, therefore, mostly used in situations where only basic protection is required.

9. PVC Enclosures:

Just like ABS, PVC is a lightweight and inexpensive enclosure material that can be used for a range of applications. PVC enclosures do not offer good durability and are best used in environments that do not subject the housing to extreme conditions. As such, these enclosures are not very popular.

10. Fiberglass Electrical Enclosures:

Fiberglass enclosures are strong and durable, and offer good resistance to impact, chemicals, and heat. They are typically more expensive than plastic enclosures.

Fiberglass enclosures are a good choice for environments where the enclosure is subject to high levels of wear and tear. They are also a good choice for applications where the enclosure needs to withstand high temperatures.

CHAPTER 3

INSTALLATION AND COMMISSIONING OF ELECTRICAL PANEL BOARDS

3.1 Pre-installation Checks and Site Surveys.



Fig 3.1 Pre-installation checks and site surveys

Before installing a panel board, a comprehensive pre-installation check and site survey are essential to guarantee a safe, successful, and compliant installation. This includes:

1. Verifying the panel board's compatibility with the existing electrical system, including voltage, current, and frequency requirements.
2. Assessing the site's electrical infrastructure, such as the condition and capacity of the electrical supply, distribution equipment, and grounding systems.
3. Ensuring compliance with relevant codes, regulations, and standards, including National Electric Code (NEC), Occupational Safety and Health Administration (OSHA), and International Electrotechnical Commission (IEC) requirements.
4. Evaluating the physical installation space, considering factors such as:
 - Accessibility for maintenance and operation.
 - Ventilation and cooling requirements.
 - Proximity to water sources, hazardous materials, or explosive environments.
 - Exposure to environmental stressors like temperature, humidity, or vibration.

5. Identifying potential sources of electrical interference or harmonics, such as:

- Electromagnetic interference (EMI) from nearby equipment.
- Harmonic distortion from non-linear loads.
- Radio-frequency interference (RFI) from communication systems.

6. Reviewing electrical load requirements, including:

- Calculating the total connected load and starting currents.
- Assessing the load's power factor and harmonic content.
- Ensuring the panel board is properly sized and rated for the expected load.

By conducting a thorough pre-installation check and site survey, installers can:

1. Identify and address potential issues before they become major problems.
2. Ensure a smooth and successful installation process.
3. Guarantee compliance with relevant codes and regulations.
4. Optimize the panel board's performance and reliability.
5. Minimize downtime and maintenance requirements.

3.2 Electrical Panel Board Mounting and Anchoring:

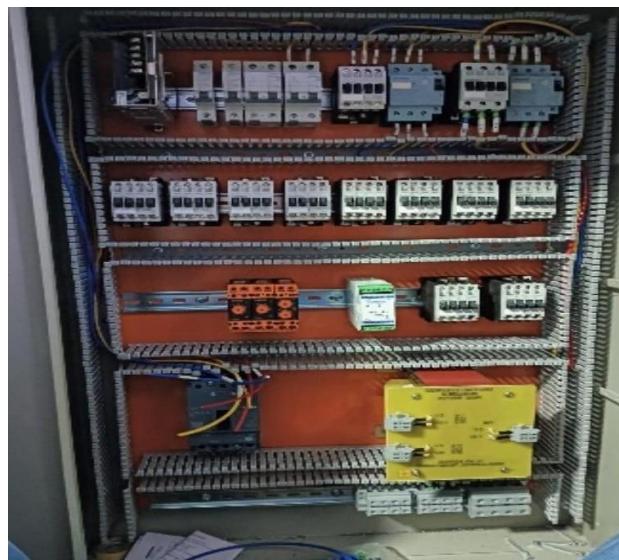


Fig 3.2 Mounting and Anchoring

3.2.1 Mounting:

Mounting is the process of securely attaching electrical devices, components, or instruments to the panel board's surface or frame.

1. Panel board orientation: Mount the panel board with the operating handle or switches facing the accessible side.

2. Mounting hardware: Use compatible mounting hardware, such as screws, nuts, or clips, to secure the panel board.

3. Leveling: Ensure the panel board is properly leveled to prevent uneven weight distribution.

3.2.2 Anchoring:

Anchoring is the process of securing devices, components, or instruments to the panel board's surface or frame using various fastening methods. This ensures that the mounted items remain stable, safe, and easily accessible for maintenance.

1. Anchor material: Choose anchors made from corrosion-resistant materials, such as stainless steel or zinc-plated steel.

2. Anchor depth: Ensure the anchors are embedded at the recommended depth to provide sufficient holding power.

3. Torque specification: Tighten anchors according to the manufacturer's recommended torque specification.

3.2.3 Additional considerations:

1. Seismic requirements: Ensure the panel board is mounted and anchored to withstand seismic activity, if applicable.

2. Environmental factors: Consider environmental factors, such as temperature, humidity, and exposure to chemicals or moisture.

3. Accessibility: Ensure the panel board is mounted in an accessible location for maintenance and operation.

4. Electrical codes and standards: Comply with relevant electrical codes, standards, and regulations, such as NEC, IEC, or local authorities.

5. Manufacturer instructions: Follow the manufacturer's instructions for specific mounting and anchoring requirements.

3.3 Wiring and Cabling Best Practices:

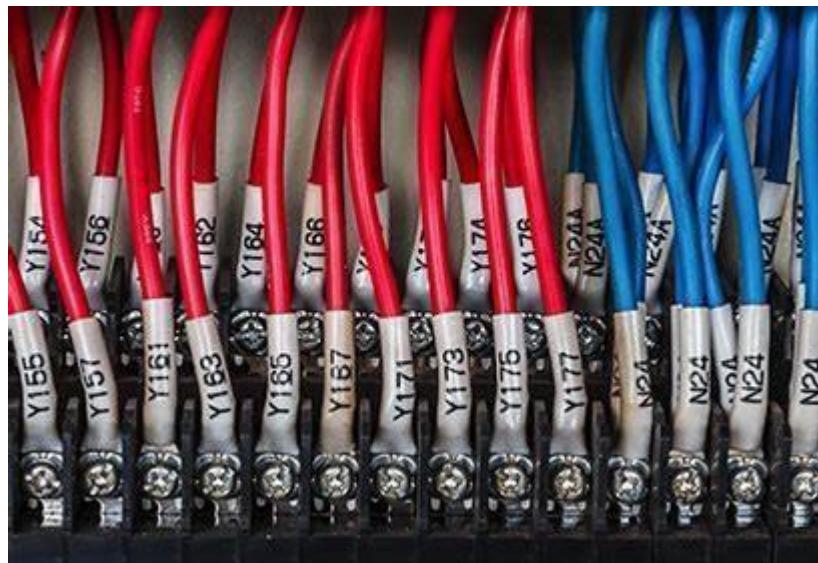


Fig 3.3 Wiring and Cabling

Best practices of Wiring and Cabling:

- 1. Labeling:** Label all wires and cables clearly and consistently for easy identification.
- 2. Color-coding:** Use standardized color-coding for wires and cables to indicate voltage, phase, or function.
- 3. Cable management:** Use cable ties, clips, or baskets to keep cables organized and secure.
- 4. Wire sizing:** Ensure wires are properly sized for the intended load and voltage drop.
- 5. Insulation and protection:** Use appropriate insulation and protection for wires and cables from environmental factors.
- 6. Termination:** Ensure secure and proper termination of wires and cables to prevent loose connections.
- 7. Testing:** Test all wiring and cabling before energizing the system.
- 8. Documentation:** Maintain accurate documentation of wiring and cabling layouts and configurations.
- 9. Compliance:** Ensure compliance with relevant electrical codes, standards, and regulations.

10. Regular inspection: Regularly inspect wiring and cabling for signs of wear, damage, or deterioration.

3.4 Commissioning Tests and Acceptance Criteria:



Fig 3.4 Commission Test

3.4.1 Commissioning Test:

A commissioning test is a series of evaluations and checks performed on a newly installed or upgraded electrical panel board or system to ensure it meets the design specifications, is installed correctly, and functions as intended. The goal of commissioning is to identify and resolve any issues before the system is put into operation.

Test procedure:

1. Visual Inspection: Verify panel board assembly, wiring, and component installation.

2. Electrical Tests:

- Voltage and current measurements
- Insulation resistance testing
- Grounding system testing
- Circuit breaker and fuse testing

3. Functional Tests:

- Control circuit testing
- Motor control testing
- Alarm and monitoring system testing

4. Performance Tests:

- Load testing
- Efficiency testing
- Harmonic distortion testing

3.4.2 Acceptance Criteria:

Acceptance criteria are the specific conditions or requirements that must be met for a product, system, or service to be considered acceptable and ready for deployment or use. In the context of commissioning tests, acceptance criteria are the standards against which the results of the tests are evaluated.

1. Compliance with design specifications and relevant standards
2. Successful completion of commissioning tests
3. No electrical shocks or safety hazards
4. Proper operation of control and monitoring systems
5. No excessive heat, noise, or vibration
6. Meets efficiency and performance requirements
7. No visible signs of damage or wear
8. All components and wiring properly labeled and documented
9. Meets environmental and seismic requirements (if applicable)
10. Obtains necessary certifications and approvals

CHAPTER 4

OPERATION AND MAINTENANCE OF ELECTRICAL PANEL BOARDS

4.1 Energy Efficiency Optimization Techniques:

1. Voltage Optimization:

Voltage optimization is a technique that regulates voltage levels to minimize energy waste and reduce voltage-related losses. By using voltage regulation devices, dynamic voltage optimization systems, or smart voltage management systems, panel boards can reduce energy consumption by up to 5% and extend equipment life.

2. Power Factor Correction:

Power factor correction improves the power factor to reduce energy losses and improve system efficiency. This can be achieved through the use of capacitor banks, power factor correction units, or active power factor correction systems. By improving the power factor, panel boards can reduce energy consumption by up to 10% and improve system efficiency.

3. Harmonic Filtering:

Harmonic filtering reduces harmonic distortion to minimize energy waste and prevent equipment damage. Passive harmonic filters, active harmonic filters, or hybrid harmonic filters can be used to achieve this. By reducing harmonic distortion, panel boards can reduce energy consumption by up to 5% and improve system efficiency.

4. Load Management:

Load management optimizes load distribution to reduce energy consumption and prevent overloading. This can be achieved through load shedding systems, load management software, or demand response systems. By optimizing load distribution, panel boards can reduce energy consumption by up to 20% and improve system efficiency.

5. Energy Monitoring:

Energy monitoring tracks energy usage to identify areas for improvement and optimize energy efficiency. Energy management systems, advanced metering infrastructure, or energy monitoring software can be used to achieve this. By tracking energy usage, panel boards can

improve energy efficiency by up to 10% and reduce energy consumption.

6. Efficient Transformer Selection:

Efficient transformer selection involves choosing transformers with high efficiency ratings to minimize energy losses. High-efficiency transformer designs, transformer selection software, or energy-efficient transformer standards can be used to achieve this. By selecting efficient transformers, panel boards can reduce energy consumption by up to 5% and improve system efficiency.

7. Cable Size Optimization:

Cable size optimization involves selecting optimal cable sizes to minimize energy losses and reduce heat generation. Cable sizing software, energy-efficient cable designs, or cable insulation optimization can be used to achieve this. By optimizing cable sizes, panel boards can reduce energy consumption by up to 5% and improve system efficiency.

8. Switchgear and Circuit Breaker Optimization:

Switchgear and circuit breaker optimization involves selecting and configuring switchgear and circuit breakers for optimal energy efficiency. High-efficiency switchgear designs, circuit breaker selection software, or energy-efficient switchgear standards can be used to achieve this. By optimizing switchgear and circuit breakers, panel boards can reduce energy consumption by up to 5% and improve system efficiency.

9. Motor Control and Optimization:

Motor control and optimization involves optimizing motor control systems to reduce energy consumption and improve efficiency. Variable frequency drives, soft starters, or motor efficiency optimization software can be used to achieve this. By optimizing motor control systems, panel boards can reduce energy consumption by up to 30% and improve system efficiency.

10. Lighting Control and Optimization:

Lighting control and optimization involves optimizing lighting systems to reduce energy consumption and improve efficiency. LED lighting systems, lighting control systems, or energy-efficient lighting standards can be used to achieve this. By optimizing lighting systems, panel boards can reduce energy consumption by up to 50% and improve system efficiency

4.2 .High Voltage Applications :

High voltage plays a crucial role in testing applications to ensure the reliability, insulation strength, and performance of electrical equipment. Control panels used in high-voltage testing help regulate, monitor, and analyze test conditions in various industries.

4.2.1. High-Voltage Testing in Control Panels

Control panels are used to apply, measure, and control high-voltage levels for testing electrical insulation, performance, and safety compliance. These panels are equipped with:

- Voltage regulators for precise control.
 - Meters and indicators to monitor voltage, current, and resistance.
 - Safety interlocks to protect equipment and personnel.
 - Relay-based protection circuits to prevent overvoltage damage.
-

4.2.2. Major Applications of High Voltage Testing

1. Dielectric Strength Testing (Insulation Testing)

- Purpose: To test the insulation capability of cables, transformers, switchgear, and circuit breakers.
- Method: A high voltage (AC or DC) is applied to check for insulation breakdown.
- Example: HV cables (33kV and above) undergo dielectric testing to verify their insulation integrity before installation.

2. High-Potential (Hi-Pot) Testing

- Purpose: Ensures no leakage current passes through insulation.
- Method: A voltage higher than normal operating voltage is applied to the equipment to check for weak insulation points.
- Example: Hi-Pot tests are done on motors, transformers, and circuit boards.

3. Partial Discharge (PD) Testing

- Purpose: Detects micro-level electrical discharges within insulation materials.
 - Method: High-voltage pulses are applied, and sensors detect PD activity in cables and insulation.
 - Example: Used in power transformers and HVGIS (Gas-Insulated Switchgear).
-

4. Transformer Testing

- Purpose: To verify insulation strength and performance under real operating conditions.
- Method: A high-voltage impulse test simulates power surges, and the transformer's response is analyzed.
- Example: 400kV power transformers undergo impulse testing before deployment.

5. Surge/Impulse Testing

- Purpose: To assess the ability of electrical equipment to withstand voltage surges (e.g., lightning strikes, switching surges).
- Method: A high-voltage impulse generator applies a surge, and the equipment's ability to handle it is measured.
- Example: Transmission line insulators and arresters are tested with 1.5x their rated voltage.

6. Circuit Breaker Testing

- Purpose: Ensures that circuit breakers trip correctly under high-voltage fault conditions.
- Method: A high-voltage test panel applies overvoltage, and response time is recorded.
- Example: SF₆ and vacuum circuit breakers are tested for correct operation under simulated short circuits.

7. Electrical Motor Testing

- Purpose: Tests insulation and winding strength in HV motors.
- Method: A high voltage is applied, and leakage current is measured.
- Example: Induction motors (6.6kV, 11kV, 33kV) undergo Hi-Pot testing before commissioning.

8. High-Voltage Testing in Research & Development

- Purpose: Testing new materials for HV insulation, semiconductors, and grid components.
- Method: High-voltage stress tests are performed on prototypes to validate design.
- Example: Power grid components (GIS, relays, isolators) undergo high-voltage stress testing.

4.2.3. Components of a High-Voltage Testing Control Panel

Component	Function
High-Voltage Transformer	Steps up voltage for testing
Voltage Regulator	Adjusts test voltage levels
Protection Relays	Prevents overvoltage and faults
Measuring Instruments (Voltmeters, Ammeters, Oscilloscopes)	Monitors test conditions
Insulation Monitoring Devices	Detects insulation failures
Data Logging System	Records test results for analysis
Emergency Stop & Safety Interlocks	Ensures operator safety

4.2.3. Importance of High-Voltage Testing in Control Panels

- Ensures equipment reliability and longevity by identifying weak points.
- Prevents electrical failures that could cause downtime or accidents.
- Verifies compliance with industry standards (IEC, IEEE, ASTM).
- Essential for safety-critical applications like power grids, substations.

4.3. Geo Tag Photos



Rihan Power Enterprises



CHAPTER 5

CONCLUSION

In conclusion, my internship experience in the electrical panel board industry has been highly rewarding and informative. Throughout my tenure, I had the opportunity to gain hands-on experience in the design, installation, commissioning, operation, and maintenance of electrical panel boards.

I learned about the importance of electrical panel boards in ensuring safe and efficient electrical distribution, and the various components that make up a panel board, including surge protectors, grounding systems, and control systems. I also gained knowledge about the different types of panel boards, including main, distribution, and sub-panels.

My internship experience also provided me with the opportunity to work with a team of experienced professionals, who shared their knowledge and expertise with me. I participated in design reviews, installation inspections, and commissioning tests, which helped me understand the practical aspects of electrical panel board design and operation.

Through this internship, I gained valuable skills and knowledge that will benefit me in my future career as an electrical engineer. I developed my problem-solving skills, analytical skills, and communication skills, which are essential for success in the electrical industry.

I would like to express my gratitude to RIHAN POWER ENTERPRISES for providing me with this industrial visit opportunity. I appreciate the support and guidance provided by my supervisors and colleagues, which made my industrial visit experience enjoyable and rewarding.

