Draft Study Material

Electric Vehicle Service Assistant

(Qualification Pack: Ref. Id. ASC/Q1435)

Sector: Automotive

(Grade X)

PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION,
(a constituent unit of NCERT, under MoE, Government of India)
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Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives.

The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material.

Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material.

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Module 1 Tools and Equipment Used for Maintenance of Electric Vehicles

Module Overview

Electric Vehicles (EVs) need different tools and equipment to keep them running smoothly. These include diagnostic tools for finding and fixing problems and special machines for tasks, like maintaining the batteries and servicing the motors. It is important to understand how each tool works so they can do good work of maintaining EVs. In this Module, we will discuss the right tools for the job tools used for maintaining EVs.

Learning Outcomes

After completing this module, you will be able to:

1. Understand the specific uses of insulated hand tools in the maintenance and repair of Electric Vehicles components.
2. Identify the diagnostic tools like OBD-II Scanners, Multimeters, insulation testers, Battery Load Testers, and programming interfaces.
3. Understand the functions of diagnostic tools like OBD-II Scanners, Multimeters, Insulation Testers, Battery Load Testers, and Programming Interfaces.

Module Structure

Session 1: Types of Tools

Session 1: Types of Tools

In our ninth-grade class, we have extensively studied the diverse range of tools essential for the maintenance and upkeep of electric vehicles. As part of our curriculum, we will now delve into a comprehensive introduction to these tools, aiming to provide a detailed understanding of their functions and applications.

1. Diagnostic Tools:

Diagnostic tools are essential for identifying and troubleshooting issues in EV systems. They help technicians pinpoint problems accurately, saving

time and effort. Here are some common diagnostic tools used in EV maintenance:

a) OBD-II Scanner
b) Multimeter
c) Infrared Thermometer
d) Battery Management System (BMS) Diagnostic Tools
e) High-Voltage Insulation Resistance Testers (Megohmmeters)
f) Battery Load Testers
g) Programming Interfaces

A. Onboard Diagnostics II (OBD-II) Scanners

This tool connects to the vehicle's onboard diagnostics (OBD) port to retrieve information about the vehicle's electronic systems. It can diagnose issues related to the battery management system, motor control, and other EV-specific components. OBD-II scanners are essential for accessing the vehicle's diagnostic information. They plug into the OBD-II port, a standardized connector in all modern vehicles, including EVs.

Functions

1. Reading Trouble Codes: OBD-II scanners read Diagnostic Trouble Codes (DTCs) stored by the vehicle's computer when it detects a problem.
2. Monitoring Live Data: Provides real-time data on various parameters such as battery state, motor performance, and sensor outputs.
3. Clearing Codes: After repairs, the scanner can clear DTCs to reset the system.

Fig. 1.1: OBD-II Scanner

B. Multimeters

A multimeter is used to measure voltage, current, and resistance in electrical circuits. It helps technicians check the integrity of electrical connections and diagnose problems in the vehicle's electrical system. Multimeters are versatile tools used to measure electrical properties such as voltage, current, and resistance. For EVs, high-accuracy, high-impedance digital multimeters are preferred.

Functions

1) Voltage Measurement: Check the voltage of the battery and other electrical components.
2) Current Measurement: Measure the current flow to diagnose charging and discharging issues.
3) Resistance Measurement: Assess the integrity of circuits and components.

Fig. 1.2: Multimeter

C. High-Voltage Insulation Resistance Testers (Megohmmeters)

These testers measure the insulation resistance of high-voltage components, ensuring they are not compromised.

Functions

a) Insulation Integrity: Check the insulation resistance of cables and components to prevent electrical leaks.
b) Safety Verification: Ensure that high-voltage systems are safe to operate and maintain.

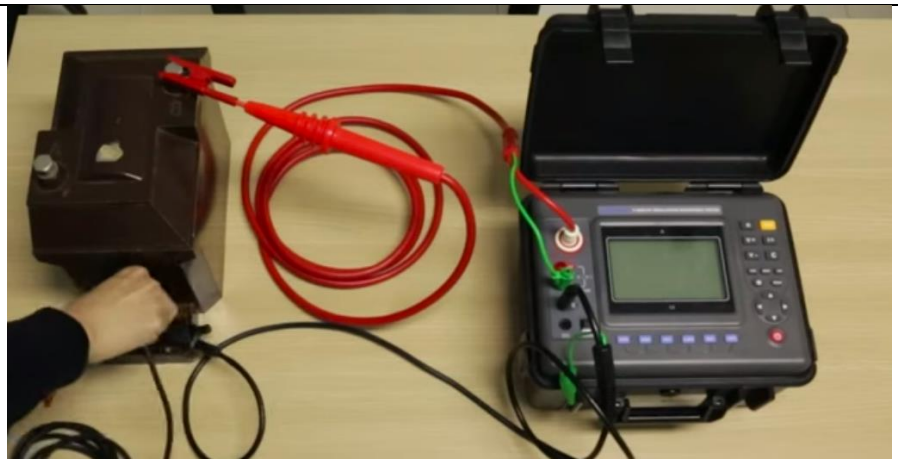


Fig. 1.3: Megohmmeter

c) Safe Disconnection: Isolate the high-voltage battery to prevent accidental electric shocks.
d) Maintenance Preparation: Prepare the vehicle for safe maintenance and repair work.

D. Battery Load Testers

Battery load testers simulate real-world load conditions to evaluate the battery's performance and capacity.

Functions

a) Performance Testing: Assess the battery's ability to deliver power under load.
b) Capacity Measurement: Determine the actual capacity of the battery compared to its rated capacity.
c) Health Monitoring: Identify weak or failing cells within the battery pack.

Fig. 1.4: Battery Load Tester

E. Programming Interfaces

Programming interfaces allow reprogramming of control units and modules within the EV's electrical system.

Functions

a) Module Reprogramming: Update or reconfigure control modules for optimal performance.
b) Parameter Adjustments: Adjust settings and parameters to suit specific requirements.
c) Troubleshooting: Identify and fix software-related issues.

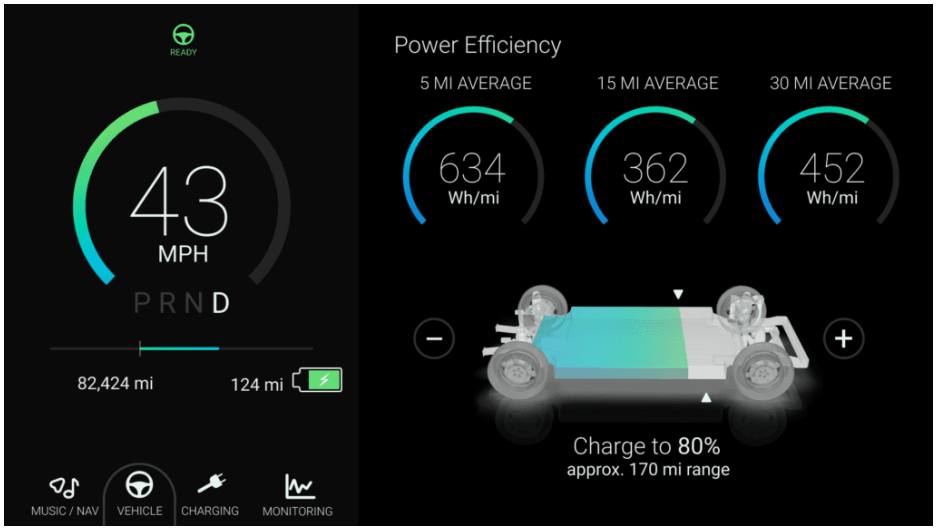


Fig. 1.5: Programming Interface

2. Insulated Hand Tools:

Insulated Hand tools are essential for performing various maintenance tasks on EVs. They allow technicians to dismantle, repair, and reassemble components efficiently. Here are some common hand tools used in EV maintenance:

a) Insulated Socket Set: An Insulated socket set is used for loosening and tightening bolts and nuts of different sizes. It's essential for working on the vehicle's chassis, suspension, and motor.
b) Insulated Screwdriver Set: Screwdrivers come in various types, including flathead, Phillips, and Torx. They are used for removing and installing screws in different parts of the vehicle.

a. Insulated Pliers: Insulated Pliers are versatile tools used for gripping, cutting, and bending wires and cables. They are essential for electrical repairs and installations.
b. Insulated Wrench Set: Insulated Wrenches are used for turning nuts and bolts. A combination of open-end and box-end wrenches is commonly used in EV maintenance.

Fig. 1.6: Insulated Hand Tools

4. Safety Equipment:

Safety should always be a top priority when working on EVs, as they involve high-voltage systems that can be dangerous if mishandled. Here are some essential safety equipment for EV maintenance:

a) Insulated Gloves and Mats: Insulated gloves and mats protect technicians from electric shock when working on high-voltage systems such as battery packs and motor controllers.
b) Safety Goggles: Safety goggles protect the eyes from potential hazards such as sparks, chemicals, and debris during maintenance tasks.
c) Fire Extinguisher: A fire extinguisher is essential for quickly extinguishing electrical fires that may occur during maintenance operations.

Fig. 1.7: Safety Equipment

5. Specialised Equipment:

Some maintenance tasks require specialised equipment to be performed effectively. Here are some examples of specialised equipment used in Two and Three-Wheeler EV maintenance:

a) Electric Vehicle Lift: An Electric Vehicle lift allows technicians to raise the vehicle off the ground, providing easier access to the underside for inspection and servicing of components like the battery pack and motor.
b) Torque Wrench: A torque wrench is used to tighten bolts and nuts to a specific torque value. It ensures that fasteners are tightened correctly, preventing damage to components.
c) Wheel Balancer: A wheel balancer is used to ensure that the wheels are balanced correctly, reducing vibrations and extending the life of the tyres.

Fig. 1.8: Electric Vehicle Lift

Know Your Progress

A. Multiple Choice Questions (MCQs)

1. Which tool connects to the vehicle's onboard diagnostics port to retrieve information about the vehicle's electronic systems?
   A. Multimeter
   B. OBD-II Scanner
   C. Infrared Thermometer
   D. Battery Hydrometer

2. What is the primary function of a multimeter in EV maintenance?
   A. Measuring surface temperature
   B. Charging batteries
   C. Measuring voltage, current, and resistance
   D. Balancing wheels

3. Why are insulated gloves and mats important in EV maintenance?
   A. For better grip
   B. For measuring voltage
   C. For protection from electric shock
   D. For cleaning components

4. Which tool is used to measure the specific gravity of the electrolyte in lead-acid batteries?
   A. Battery Load Tester
   B. Battery Charger/Discharger

C. Battery Hydrometer
D. Multimeter

5. What is the purpose of a torque wrench in EV maintenance?
   A. Measuring current
   B. Tightening bolts to a specific torque value
   C. Cutting wires
   D. Charging the battery

B. Fill in the Blanks

1. A _____ is used to measure surface temperatures without making direct contact and is useful for detecting overheating components in the EV.
2. The _____ set is essential for loosening and tightening bolts and nuts of different sizes on the vehicle's chassis, suspension, and motor.
3. A _____ is used to apply a load to the battery and measure its voltage and current response to assess battery performance.
4. _____ protect the eyes from potential hazards such as sparks, chemicals, and debris during maintenance tasks.
5. A _____ allows technicians to raise the vehicle off the ground for easier access to the underside for inspection and servicing.

C. Short Questions

1. What are some common diagnostic tools used in EV maintenance?
2. Describe the function of a battery charger/discharger in EV maintenance.
3. What safety equipment is necessary when working on high-voltage systems in EVs?

Activities

1. Identify the diagnostic tools and Demonstrate the troubleshooting issues in EVs.
2. Perform a practical with the help of a Multimeter to measure voltage, current, and resistance in various circuits.
3. Demonstrate how to use a battery hydrometer to measure the specific gravity of lead-acid batteries.
4. Learn and practice safety protocols for working on High-Voltage EV systems. Demonstrate the proper use of safety goggles to protect against potential hazards. Conduct a fire safety drill to practice the use of a fire extinguisher.

Module 2	Routine Service and Repair of Two and Three-Wheeler EVs

Module Overview

The global trend towards sustainability and environmental consciousness has caused a significant shift in the automotive industry in recent years. Electric Vehicles (EVs) have emerged as a major player in shaping the future of transportation due to their advanced technological features and zero-emission capabilities. As a result, EVs are becoming increasingly popular on our roads. However, regular service and repair are crucial to maintaining the optimal performance, longevity, and safety of these cutting-edge vehicles. This is especially important for Two-Wheeled and Three-Wheeled EVs, which comprise a significant portion of the electric mobility landscape.

To fully understand the care and maintenance required for Two and Three-Wheeled EVs, it is essential to explore the components of EVs, including batteries, motors, controllers, regenerative braking systems, and charging infrastructure. It is crucial to understand the intricacies of EV components to maintain their good health and durability.

In this Module, we will discuss the maintenance practices and troubleshooting common issues that can arise in Two and Three-Wheeled EVs. Proper maintenance includes regular battery checks, tyre rotations, brake inspections, and periodic software updates. To troubleshoot, it's essential to identify the root cause of any malfunction and take appropriate corrective measures.

Learning Outcomes

After completing this module, you will be able to:

1) Demonstrate preparatory activities for diagnosing faults and repairing Two and Three-Wheeler EV.
2) Demonstrate how to assist in the repair and maintenance of Two and Three-Wheeler EV-related tasks.

Module Structure

Session 1: Components of Two and Three-Wheeler EVs
Session 2: Reading of Owner's (Manufacturer) and Service Manual
Session 3: Types of Faults, Causes, And Rectification Procedures and Repair Work

Session 1: Components of Two and Three-Wheeler EVs

A two and three-wheeler Electric Vehicle (EV) typically consists of several key components, similar to traditional internal combustion engine vehicles but with modifications to accommodate electric propulsion. Here are the main components:

1 Battery Pack: It is the heart of the Electric Vehicle; the battery pack stores electrical energy and powers the electric motor. Lithium-ion batteries are commonly used due to their high energy density.

2 Electric Motor: Responsible for converting electrical energy from the battery into mechanical energy to drive the vehicle. Brushless DC motors or AC induction motors are commonly used in EVs.

3 Power Electronics: This includes the inverter and power control unit, which manage the flow of electricity between the battery and the electric motor. The inverter converts DC power from the battery into AC power for the motor.

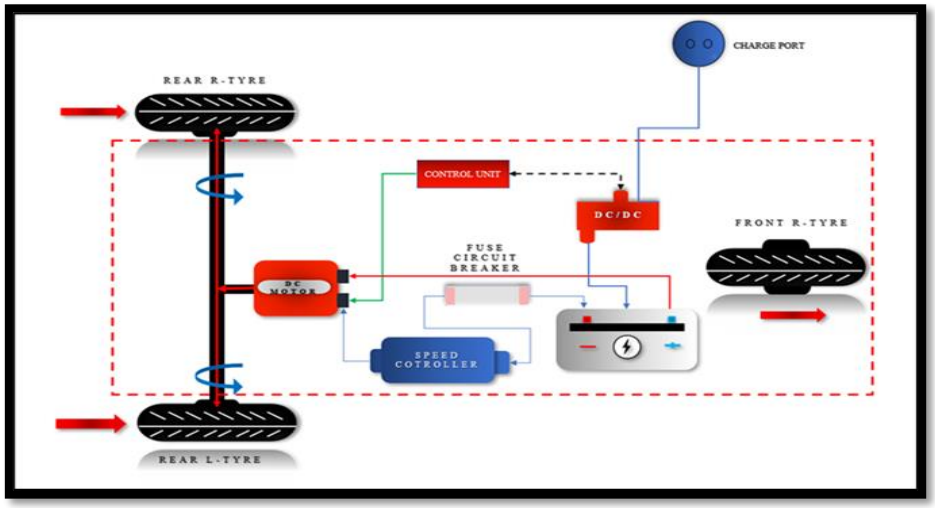


Fig. 2.1: Component of Three-Wheeler Electric Vehicle

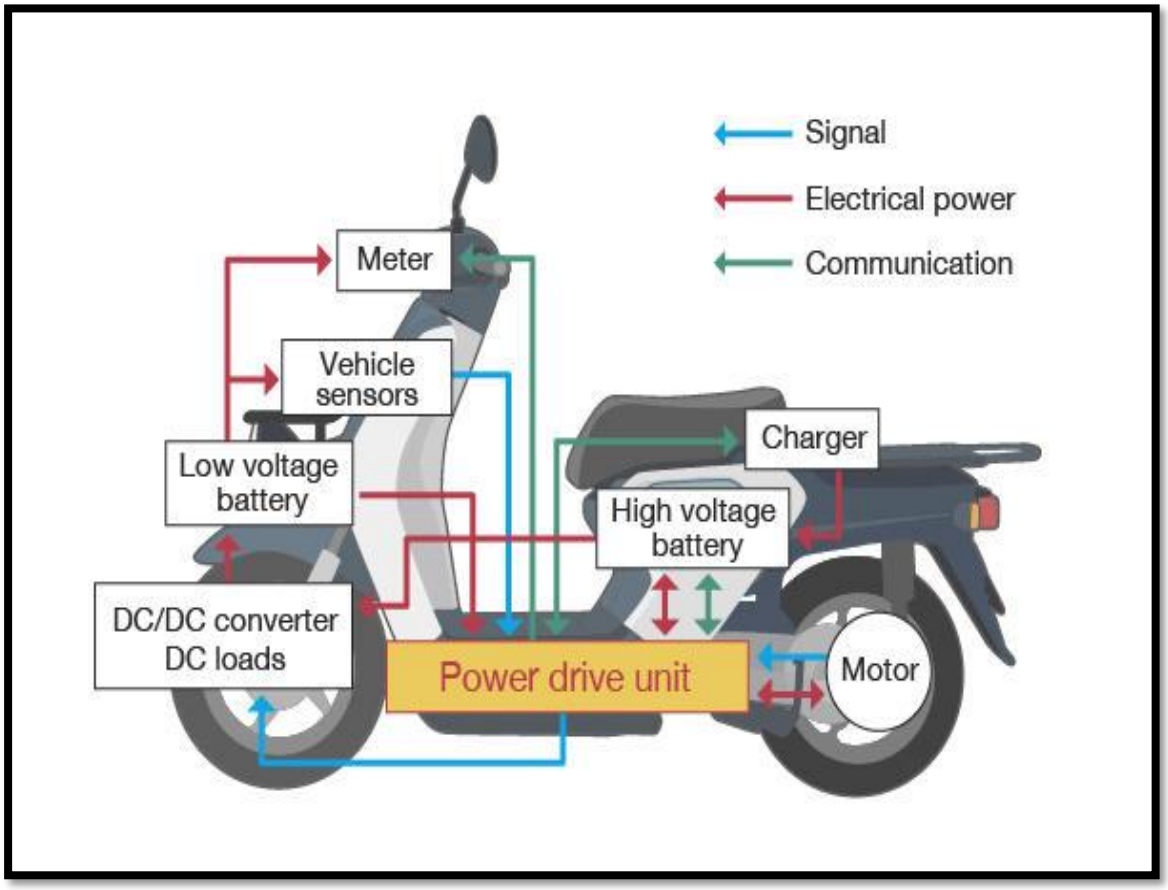


Fig. 2.2: Power Drive Unit of Two-Wheeler Electric Vehicle

4 Charging System: The components required for charging the battery pack, including the Onboard charger and charging port. Charging systems can vary, with options for AC charging (typically at home or public charging stations) and DC fast charging.

5 Controller: Manages the overall operation of the Electric Vehicle, including communication between various components and ensuring optimal performance and efficiency.

6 Throttle and Brake Systems: Similar to traditional vehicles, these systems control acceleration and deceleration. However, in Electric Vehicles, the throttle is often connected to a drive-by-wire system.

7 Transmission or Reduction Gear: Some electric two/three-wheelers use a single-speed transmission or reduction gear to optimize the power delivery from the motor to the wheels.

8 Regenerative Braking System: Recovers energy during braking and deceleration, converting kinetic energy back into electrical energy to recharge the battery.

9 Frame and Chassis: The structural framework that supports all the vehicle components. It is designed to be lightweight and sturdy to ensure the safety and performance of the Electric Vehicle.

10 Suspension System: Provides a smooth ride by absorbing shocks and vibrations from the road surface. This typically includes front forks and rear shock absorbers.

11 Wheels and tyres: Similar to conventional vehicles, these components are essential for movement and traction.

Interconnections of various systems and components of Two and Three-wheeler EVs.

The interconnections of various systems and components in a Two and Three-Wheeler Electric Vehicle (EV) are crucial for the seamless functioning of the vehicle. These interconnections involve a network of electrical and electronic systems that work together to ensure optimal performance, efficiency, and safety. Let's delve into the key interconnections within a Two and Three-Wheeler EV:

1. **Powertrain Integration:** The electric motor is connected to the motor controller, which regulates the power supplied to the motor based on inputs from the rider, sensors, and the vehicle's control systems. The motor controller is intricately linked to the battery management system (BMS) to ensure that the electric motor receives the appropriate power without exceeding the battery's safety limits.

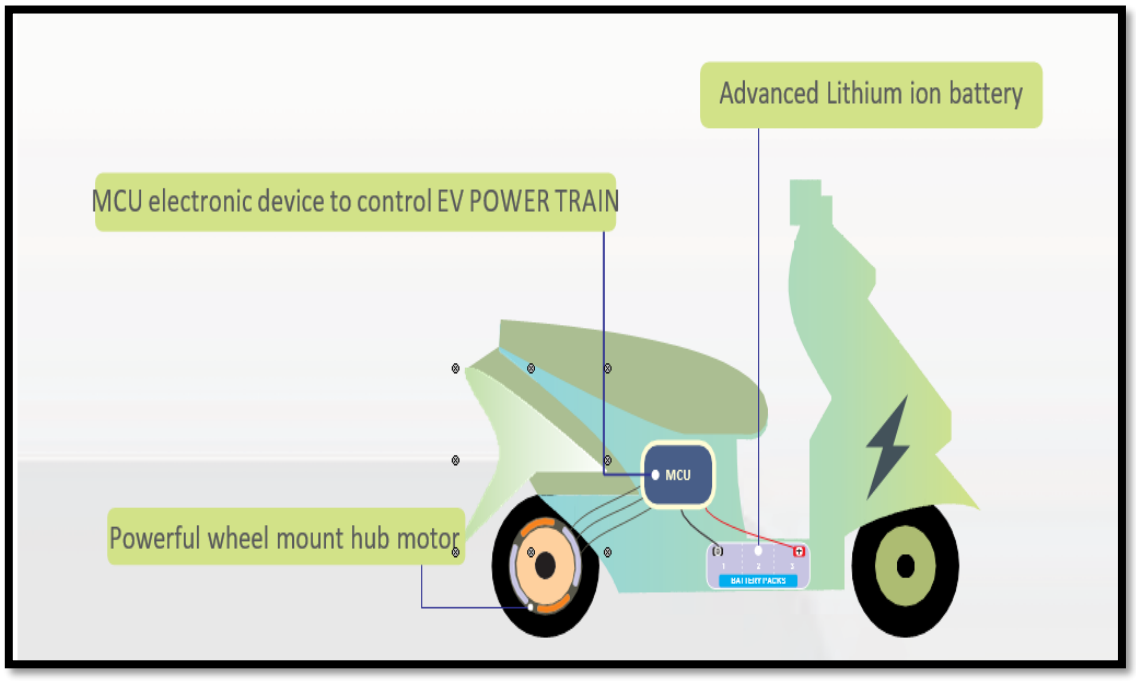


Fig. 2.3: Component of Two-Wheeler Electric Vehicle

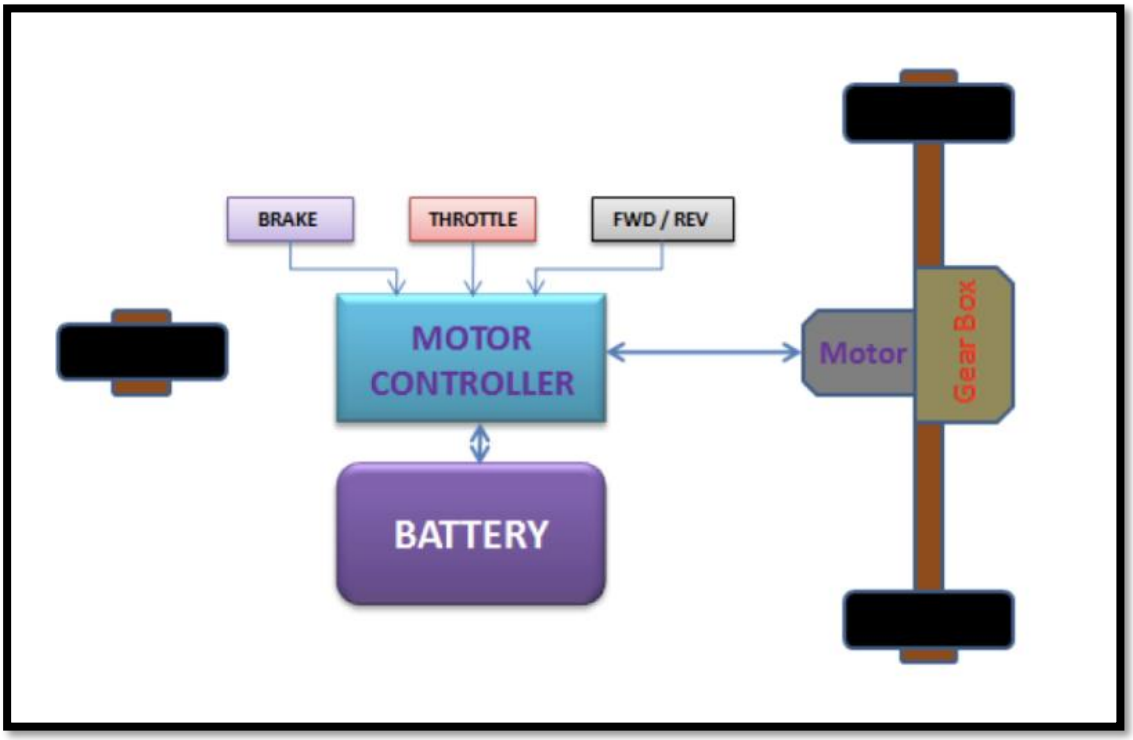


Fig. 2.4: Component of Three-Wheeler Electric Vehicle

2. **Battery Management System (BMS):** The BMS is a central component that communicates with individual battery cells to monitor their voltage, temperature, and state of charge.
   It provides feedback to the motor controller, allowing it to adjust power delivery to the electric motor based on real-time battery conditions.

3. **Charging System:** The onboard charger is connected to the battery and the charging port. It manages the charging process, converting alternating current (AC) from the charging port to direct current (DC) for the battery. The charging port is integrated into the vehicle's electrical system, enabling the user to connect an external power source for recharging.

4. **Regenerative Braking System:** The regenerative braking controller is linked to both the motor controller and the braking system. It captures energy during braking and converts it into electrical energy for recharging the battery. The controller coordinates with the vehicle's brake system to seamlessly transition between regenerative and friction braking based on driving conditions.

5. **User Interface and Connectivity:** The dashboard and display are connected to various sensors and control units. They provide real-time information to the rider, such as speed, battery status, and range.

Connectivity features, like smartphone apps, communicate with the vehicle's electronic systems, allowing users to monitor the EV remotely, access diagnostic information, and perform functions like locking/unlocking.

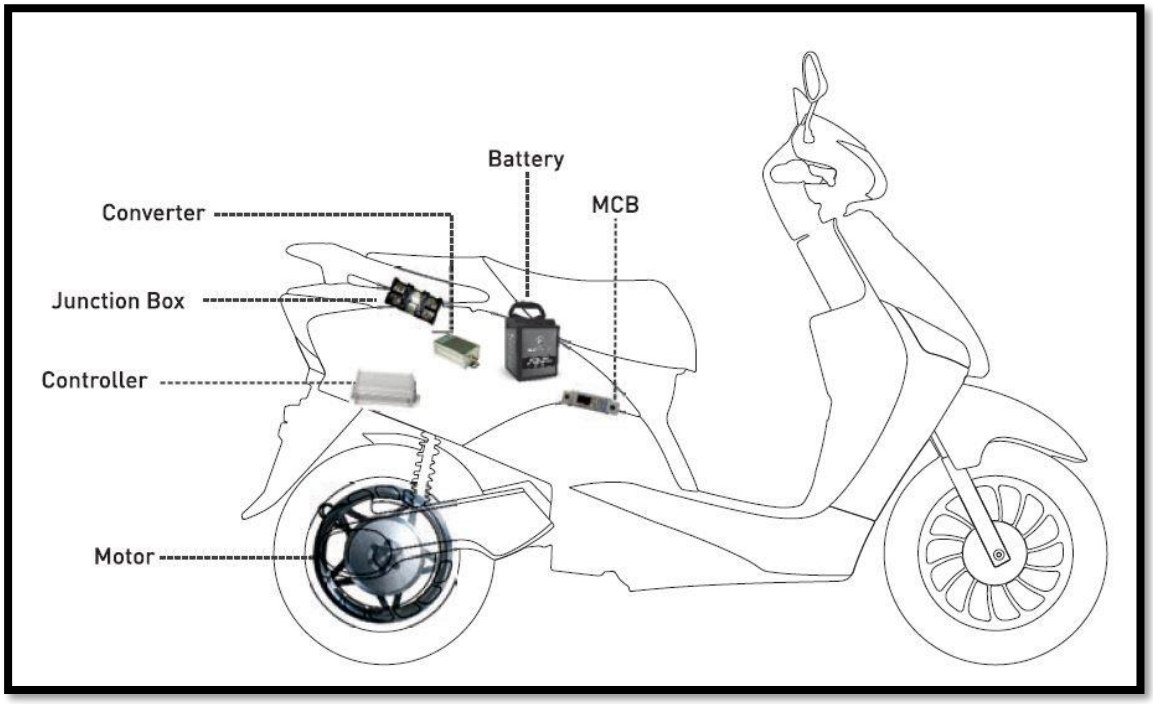


Fig. 2.5: Connections of Two-Wheeler Electric Vehicle

6. **Safety Systems:** The BMS communicates with the thermal management system to monitor and control the temperature of the battery cells, preventing overheating and ensuring safe operation. In case of abnormalities, such as overcharging or a malfunction in the powertrain, the safety systems can communicate with the motor controller to implement protective measures, including reducing power or initiating a safe shutdown.

7. **Controller Area Network (CAN):** The CAN bus is a communication network that links different electronic control units (ECUs) and sensors within an automobile. These ECUs, such as the motor controller, BMS, and regenerative braking controller, communicate with each other via the CAN bus to ensure that they work together in a coordinated and synchronized manner.

8. **Wiring Harness:** The wiring harness is a complicated system of wires that connects all electrical components of an Electric Vehicle, such as lights, sensors, controllers, and actuators. It's important to properly

insulate and organize the wiring harness to prevent interference, ensure reliability, and simplify maintenance and repairs.

9. **Mechanical Components:** Mechanical systems, such as suspension and braking systems, may have electronic components that communicate with the overall vehicle control system through the CAN bus. Ensuring the proper functioning of mechanical and electronic components results in a smooth and responsive ride.

Electric Two-Wheeler Manufacturers in India

Electric bikes and scooters nowadays typically use a lithium-ion battery pack to power the electric motor. The Electric Two-Wheeler market (E2W) is becoming more competitive, offering consumers better options in terms of pricing, vehicle type, features, and more. Here are the Electric Two-Wheeler companies in India

1. Ola Electric

Ola Electric accounted for the largest number of EV sales. The EV manufacturer set up the world's largest Two-Wheeler factory in Tamil Nadu (a state in South India) with an annual production capacity of 10 million units.

2. Hero Electric

Hero Electric is one of India's leading electric scooter companies with a wide range of electric scooters and bikes.

The company's product line-up includes:

1. City Speed variant with the speed of more than 45 km/hr (CX): Hero Electric Photon LP, Hero Electric Optima CX-Dual Battery, Hero Electric Optima CX-Single Battery, and Hero Electric NYX HS500 ER

2. Comfort Speed variant with a max speed of 25 km/hr (LX): Hero Eddy, Hero Electric NYX E5, and Hero Electric Atria LX

3. Ampere Vehicles

The country's fourth biggest 2W seller—Ampere—is owned by Greaves Cotton, which is an Indian engineering company specializing in engine and heavy equipment manufacturing. As part of its plan to increase market share in the Indian EV space, Greaves Electric Mobility (Greaves Cotton's e-

mobility wing) launched its largest EV plant in Tamil Nadu, with an initial capacity to produce 1.20 lakh units annually.

4. **Ather Energy**

Ather Energy occupied the fifth position on the list of India's top-rated electric 2W companies. Ather Energy is known for building fast and intelligent electric scooters, including the Ather 450X and the Ather 450 Plus. Moreover, the company has established the Ather Grid—the electric vehicle charging infrastructure across the country.

India offers a range of powerful electric bikes and scooters, including Oben Rorr by Oben Electric, Revolt RV400 by Revolt Motors, Tork Kratos R by Tork Motors, Simple One by Simple Energy, and TVS iQube Electric by TVS Motor Company.

Electric Three-Wheeler Manufacturers in India

Traditionally, autos and rickshaws have been the most commonly used passenger carriers and road transport vehicles for carrying passengers and goods from one location to another. Over the years, EV makers have come up with a broad range of electric three-wheelers that are easy to buy, operate, and maintain, while reducing harmful emissions. Now, let us see the top electric Three-wheeler companies in India:

1. **Mahindra Electric**

In 2010, Mahindra & Mahindra partnered with the Reva Electric Car Company to create Mahindra Reva Electric Vehicles, which was later rebranded as Mahindra Electric Mobility Limited. Apart from electric cars, the pioneer of EV technology in the country offers electric 3-wheelers, including:

- Mahindra Alpha Mini
- Mahindra Treo
- Mahindra Treo Zor

Mahindra Treo is the company's first low-maintenance three-wheeler powered by advanced lithium-ion technology, which offers best-in-class interior space and superior ride quality.

On the other hand, Mahindra Treo Zor is one of the highest-selling EVs in India, with the highest-in-class payload, optimum driving range, and superior fuel savings.

2. **Piaggio Vehicles**

Piaggio Vehicles Pvt. Ltd. (PVPL) offers a wide range of vehicles in last-mile transportation, including electric 3-wheeler cargo vehicles:

- Piaggio Ape E-city
- Piaggio Ape E-Xtra

3. Atul Auto

Atul Auto Limited is India's leading electric vehicle manufacturer and is among the world's top 5 three-wheeler brands. The company offers a variety of three-wheelers in the cargo and passenger vehicle segments, including the electric 3-wheeler termed "Elite" (Atul Elite Cargo).

4. Lohia Auto

Lohia Auto is a major electric three-wheeler company in India, with an impressive portfolio of electric 2- and 3-wheelers, and diesel 3-wheelers. It is also one of the founding members of SMEV (Society of Manufacturers of Electric Vehicles).

5. Kinetic Green

Kinetic Safar Jumbo is stated to be India's first high-performance electric cargo three-wheeler. Electric autos and rickshaws are cheaper, cleaner, faster, and quieter contrary to ICE vehicles running on CNG, diesel, and petrol. Furthermore, these electric vehicles have a lower total cost of ownership.

6. Bajaj Auto

Bajaj Auto's electric three-wheeler is a zero-emission vehicle designed for efficient urban transport. It offers a sustainable solution with low running costs and reliable performance for commercial use.

Know Your Progress

Multiple Choice Questions (MCQs)

1. What is the primary function of the Battery Management System (BMS) in a two/three-wheeler EV?
   A. To provide mechanical support
   B. To monitor and manage battery conditions
   C. To convert AC power to DC power
   D. To control the vehicle's acceleration

2. Which type of motor is commonly used in two/three-wheeled EVs?
   A. Internal combustion engine
   B. Brushless DC motor

C. Steam engine
D. Jet engine

3. What does the regenerative braking system do in an EV?
   A. Provides additional acceleration
   B. Recovers energy during braking
   C. Powers the onboard charger
   D. Controls the vehicle's speed

4. Which component converts DC power from the battery to AC power for the motor in an EV?
   A. Inverter
   B. Throttle system
   C. Suspension system
   D. Transmission

5. What is the main advantage of using lithium-ion batteries in EVs?
   A. Low cost
   B. Heavy weight
   C. Limited lifespan
   D. High energy density

Fill in the Blanks

1. The _____ is the structural framework that supports all the vehicle components in an EV.
2. The _____ system in an EV manages the charging process and converts AC power to DC power for the battery.
3. _____ braking system converts kinetic energy back into electrical energy to recharge the battery during deceleration.
4. The electric motor in an EV converts _____ energy from the battery into mechanical energy to drive the vehicle.
5. A _____ is a communication network that links different electronic control units and sensors within an EV.

Short Questions

1. What are the main components of a two/three-wheeler electric vehicle (EV)?
2. How does the Battery Management System (BMS) contribute to the safety and efficiency of an EV?
3. Describe the role of the power electronics in an EV.
4. What maintenance practices are essential for ensuring the longevity of two/three-wheeled EVs?

5. Explain how regenerative braking benefits the overall efficiency of an EV.

Activities

1. Learn how to properly check and maintain the battery pack of a two/three-wheeled EV and Demonstrate how to measure the voltage and state of charge of the battery.
2. Demonstration showing the transition between regenerative and friction braking. Analyse the amount of energy recovered during braking in different driving conditions.
3. Learn how to use diagnostic tools to troubleshoot common issues in two/three-wheeled EVs.

Session 2: Reading the Owner's (Manufacturer) Manual and Service Manual

Understanding how to effectively use owner's manuals and service manuals is important for both vehicle owners and service professionals. These manuals provide detailed information on vehicle operation, maintenance, and troubleshooting. In this guide, we'll explore the steps for effectively reading and using owner's manuals and service manuals with the help of the Vehicle Service Assistant. Let's start with the Owner's manual.

Owner's Manual

The Owner's Manual is a crucial document provided by vehicle manufacturers to guide owners on the proper operation, maintenance, and care of their vehicles. This guide serves as a reference point for understanding the features, controls, and maintenance requirements specific to a particular vehicle model. In this detailed exploration of the owner's manual, we will study its structure, contents, and significance in empowering vehicle owners with the knowledge needed to ensure the optimal performance and longevity of their vehicles.

Importance of the Owner's Manual

The owner's manual is a vital resource for vehicle owners. It provides essential information about their vehicles' features, functions, and maintenance requirements. By following the maintenance recommendations outlined in the manual, owners can operate their vehicles safely, prolong their lifespan, and reduce repair costs.

Structure of the Owner's Manual:

The user manual begins with an introduction that gives an overview of the vehicle and is then divided into chapters or sections covering various aspects of the vehicle, such as controls, maintenance, troubleshooting, and specifications. It includes a detailed table of contents and an index for easy reference.

Key Information in the Owner's Manual:

- Vehicle Features and Controls: Detailed descriptions of the vehicle's features, controls, and instrumentation help owners understand how to operate and customize their vehicles according to their preferences.
- Maintenance Schedule: The owner's manual typically includes a maintenance schedule outlining recommended service intervals for routine tasks such as oil changes, fluid checks, tyre rotations, and filter replacements.
- Fluid Capacities and Specifications: Information regarding fluid capacities, recommended fluids, and technical specifications for various components helps owners perform maintenance tasks accurately and safely.
- Warranty Information: Details about the vehicle's warranty coverage, including terms and conditions, provide owners with valuable insights into their rights and responsibilities regarding warranty claims and service.

Visual Aids and Diagrams:

- Illustrations and Photographs: Visual aids such as illustrations, diagrams, and photographs enhance the clarity of instructions and help owners identify vehicle components and systems.
- Schematic Diagrams: Schematic diagrams depicting the layout and interconnections of electrical and mechanical systems aid owners in troubleshooting and understanding their vehicles' architecture.

Maintenance and Care Instructions:

- Routine Maintenance: Step-by-step instructions for routine maintenance tasks enable owners to perform basic service procedures themselves or communicate effectively with service professionals.
- Care and Cleaning: Guidance on proper care and cleaning procedures for both the vehicle's exterior and interior surfaces helps owners maintain their vehicles' aesthetic appeal and resale value.

- Storage and Towing: Recommendations for vehicle storage and towing procedures ensure owners take appropriate precautions to safeguard their vehicles during periods of inactivity or transportation.

Troubleshooting and Problem Resolution:

- Common Issues and Solutions: The owner's manual often includes troubleshooting guides for common vehicle issues, along with recommended solutions or diagnostic procedures.
- Warning Lights and Indicators: Descriptions of warning lights and indicators, along with their meanings and recommended actions, help owners identify and address potential problems promptly.

Safety Precautions and Recommendations:

- Safe Operating Practices: The owner's manual emphasizes the importance of safe driving practices and provides guidelines for operating the vehicle responsibly and defensively.
- Child Safety: Information on child safety features and recommendations for installing and using child seats ensure owners prioritize the safety of younger passengers.
- Emergency Procedures: Instructions for responding to emergencies such as accidents, breakdowns, or adverse weather conditions equip owners with the knowledge needed to handle unexpected situations effectively.

Fig. 2.6: Owner's Manual of Two-wheeler Electric Vehicle

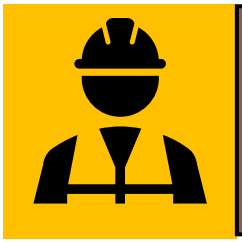
The owner's manual is an indispensable tool for vehicle owners, providing them with essential information and guidance on operating, maintaining, and caring for their vehicles. By familiarizing themselves with the contents of the owner's manual, owners can optimize their driving experience, minimize maintenance costs, and ensure the safety and longevity of their vehicles. As technology continues to advance, the owner's manual remains a timeless resource, empowering owners with the knowledge and confidence needed to navigate the complexities of vehicle ownership.

Fig. 2.7: Owner's Manual of Three-wheeler Electric Vehicle

SERVICE MANUAL

The Service Manual is significant for Electric Vehicle Assistants, Technicians and Service Professionals. Service Manual also consist of

detailed instructions and technical specifications for diagnosing, repairing, and maintaining vehicles. Unlike the Owner's Manual, which is tailored for vehicle owners, the Service Manual is designed to assist skilled professionals in performing complex repair procedures and ensuring the optimal functioning of automotive systems. In this session, we will explore the structure, contents, and significance of the service manual in Two and Three-Wheeler Electric Vehicle service and maintenance activities.



The **Service Manual** is essential for automotive technicians, providing them with comprehensive guidance and technical information for diagnosing, repairing, and maintaining vehicles.

Importance of the Service Manual:

- Technical Guidance: The Service Manual serves as a comprehensive technical guide, providing detailed instructions and specifications for diagnosing and repairing vehicle components and systems.
- Standardized Procedures: By following standardized repair procedures outlined in the service manual, technicians can ensure consistent and accurate repairs, minimizing the risk of errors or complications.
- Efficiency and Effectiveness: Access to detailed diagnostic and repair information helps technicians streamline their workflow and efficiently address vehicle issues, ultimately enhancing customer satisfaction and service quality.

Structure of the Service Manual:

- Introduction: The manual typically begins with an introduction section that provides an overview of the vehicle model, including technical specifications and special features.
- Table of Contents: A detailed table of contents organizes the manual's contents into chapters, sections, and subsections for easy navigation.
- Chapters and Sections: The manual is divided into chapters or sections covering various vehicle systems and components, such as transmission, suspension, and electrical.
- Index: An index at the end of the manual allows technicians to quickly locate specific topics, procedures, or components within the document.

Key Information in the Service Manual:

- Diagnostic Procedures: Detailed diagnostic procedures guide technicians through the process of identifying and isolating vehicle problems, often including flowcharts, diagnostic trouble code (DTC) charts, and testing procedures.
- Repair Instructions: Step-by-step repair instructions provide technicians with detailed guidance on disassembly, assembly, adjustment, and replacement procedures for vehicle components and systems.
- Technical Specifications: Comprehensive technical specifications, including torque values, fluid capacities, wiring diagrams, and component locations, ensure technicians have the necessary information to perform repairs accurately and efficiently.
- Special Tools and Equipment: Information regarding specialized tools, equipment, and diagnostic devices required for specific repair procedures helps technicians ensure they have the necessary resources to complete their work.

Visual Aids and Diagrams:

- Schematic Diagrams: Detailed schematic diagrams illustrate the layout, configuration, and interconnections of vehicle systems and components, aiding technicians in understanding their operation and diagnosing problems.
- Exploded Views: Exploded views provide visual representations of complex assemblies, showing the individual components and their relationships within the assembly, facilitating disassembly and reassembly procedures.
- Photographs and Illustrations: High-quality photographs and illustrations enhance the clarity of repair instructions, helping technicians identify components, connectors, and reference points accurately.

Maintenance and Service Procedures:

- Scheduled Maintenance: Service manuals often include maintenance schedules outlining recommended service intervals for routine tasks such as fluid changes, filter replacements, and system inspections.
- Preventive Maintenance: Guidance on preventive maintenance procedures helps technicians identify and address potential issues before they escalate into major problems, prolonging vehicle lifespan and reliability.
- Service Bulletins and Updates: Service manuals may incorporate service bulletins or updates issued by the manufacturer, providing technicians

with information on known issues, software updates, or repair procedures.

Safety Precautions and Recommendations:

- Personal Protective Equipment (PPE): Emphasizing the importance of safety, service manuals include recommendations for using appropriate personal protective equipment (PPE) when performing repairs, such as gloves, safety glasses, and respirators.
- Hazardous Materials Handling: Instructions for handling hazardous materials, such as fuels, oils, and chemicals, ensure technicians follow proper safety protocols to minimize the risk of accidents or environmental contamination.
- Vehicle Lifting and Support: Guidelines for safely lifting and supporting vehicles during service procedures help technicians prevent accidents and injuries in the workshop environment.

Fig. 2.8: Service Manual of Two-Wheeler Electric Vehicle

Integration with Diagnostic Tools and Software:

- Compatibility with Diagnostic Tools: Service manuals are often designed to complement diagnostic tools and software, allowing technicians to interface with vehicle systems, retrieve diagnostic trouble codes (DTCs), and perform system tests and calibrations.
- Data Interpretation: Service manuals guide interpreting diagnostic data and test results obtained from diagnostic tools, helping technicians diagnose complex vehicle issues accurately.
- Software Updates and Calibration Procedures: Instructions for updating vehicle software and performing system calibrations ensure technicians maintain compatibility and functionality with the latest vehicle technologies and advancements.

WARNING

- Working on Electric Vehicles without following proper procedures and using proper lifting equipment may result in vehicle damage or personal injury.
- Always wear safety glasses or approved eye protection while servicing the vehicle. Wear a full-face shield when working with batteries.
- Failure to maintain the vehicle properly could result in decreased vehicle performance, and reliability or cause severe personal injury.
- Exceeding rated vehicle load capacities could result in possible severe injury or property damage.
- Always turn the Power key to OFF and the directional selector to NEUTRAL, remove the Power key and block tyres. Turn the master disconnect switch counterclockwise to OFF before servicing or repairing your vehicle.

VEHICLE IDENTIFICATION NUMBER (VIN)

Each vehicle is assigned a unique Vehicle Identification Number (VIN). The VIN describes the facts and features of the vehicle and contains 17 digits (NEV) or 13 digits (LSV). Refer to the charts on the right. The VIN can be found in four locations: in the glove box, on the front dash panel on the kick panel below the driver's seat and under the steering wheel cover. Record the VIN here and provide this number to the dealer when repairs or adjustments are required.

VIN MATRIX NEIGHBORHOOD ELECTRIC VEHICLE (NEV)

Digit 1 thru 3: 5FC = CPC	Manufacturer Identification
Digit 4: Line	L = Low-Speed Vehicle
Digit 5: Series	E = Eagle M = MEGA S = Summit U = Utility N = Earlier NEV Series
Digit 6: Body Type	2 = 2 Person 3 = Long Bed 4 = 4 Person 5 = Short Bed
Digit 7: Engine Type	48V AC Induction Drive
Digit 8: Restraint	A = Type 1 Seat Belt Assembly B = Type 2 Seat Belt Assembly (3 Point)
Digit 9: Check Digit	Calculated per 49 CFR 565.4
Digit 10: Model Year	A = 2010 B = 2011 C = 2012 D = 2013 etc.
Digit 11: Plant Location	1 = Reedsburg
Digit 12-17: Sequential Numbers	00019 - 000999

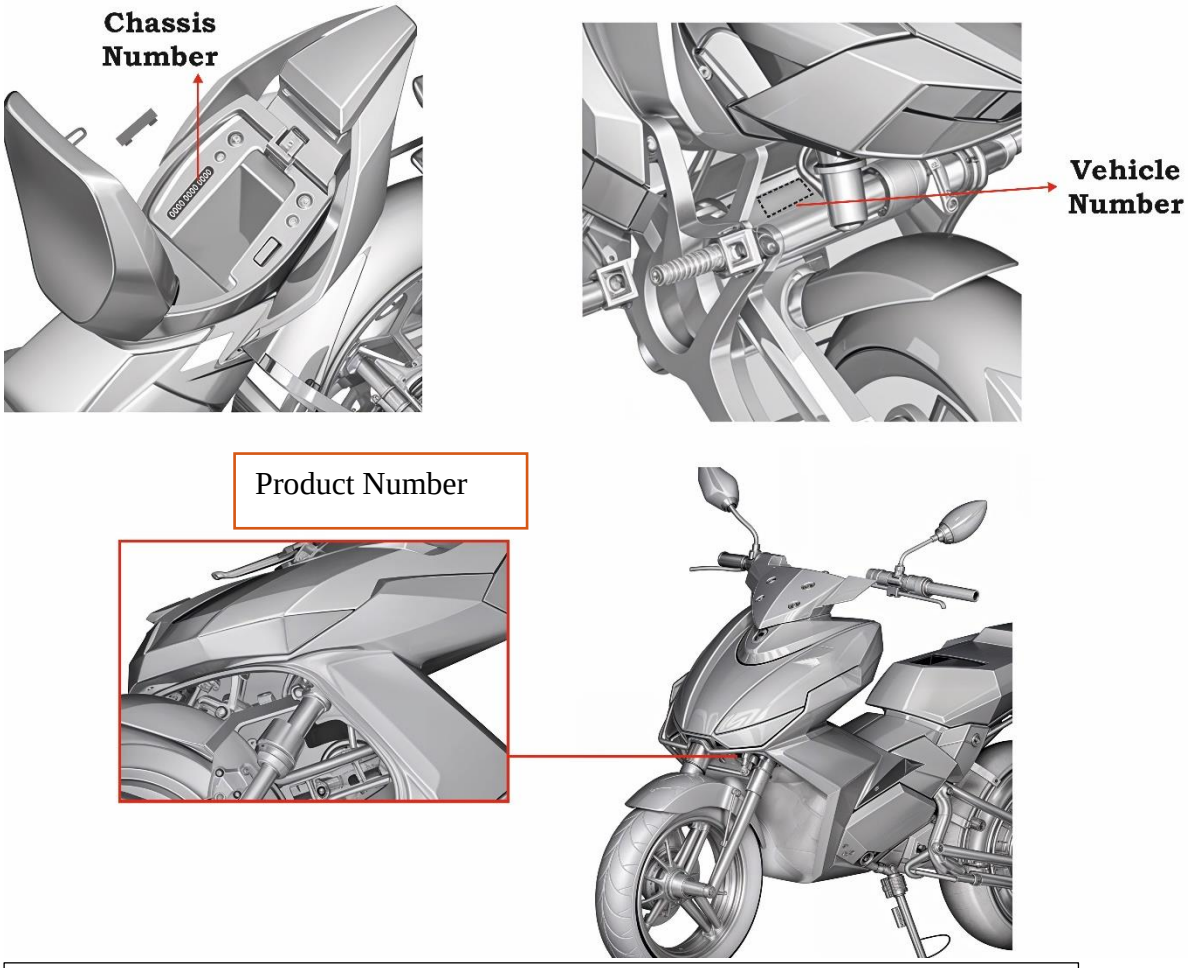


Fig 2.9: Location of Vehicle Identification Number (VIN)

Main Parameters of Two-Wheeler Electric Vehicle

The main parameters of a Two-Wheeler Electric Vehicle (EV) typically include Battery Capacity, Motor Power, Maximum Speed, Charging Time, Range, Weight, Dimensions, Connectivity and Safety Features (etc) shown in the given table. The parameters can vary depending on the specific model and manufacturer of the two-wheeler Electric Vehicle.

ITEMS		SPECIFICATION
Size	Total length	1800 mm
	Total width	750 mm
	Total height	1090 mm
	Wheel base	1250 mm
	Saddle height	790mm
	Ground clearance	160 mm

	Curb weight	130 kg
	Maximum load	160 kg
Chassis	Chassis type	Steel tube chassis
Front-wheel	Front tyre dimension	110/80-14
	Cold tyre pressure	200 kPa
Front shock absorber	Spring free length	438±3 mm
	Liquid volume	57- 59 mL
Rear wheel	Rear tyre dimension	140/70-14
	Cold tyre pressure	225 kPa
Rear shock absorber	Spring free length	275±3 mm
	Liquid volume	104-106 mL
Front brake system	Front brake	Hydraulic single-disc brake
	Brake fluid	DOT3
	Brake disc thickness	4±0.1 mm
Rear brake system	Rear brake	Hydraulic single-disc brake
	Brake fluid	DOT3
	Brake disc thickness	4±0.2 mm
Controller	Max input current	120 A
Converter	Type	DC-DC
	Output	13.8 V/7 A
Power Battery	Type	Lithium battery
	Voltage	96 V*/72 V* / 48V*
	Capacity	58 Ah
	Total mass	35±1 kg
	Single-cell configuration	26S1P
Battery	Voltage	12 V
	Capacity	4 Ah

*** The specifications of a Two-Wheeler Electric Vehicle may vary depending on the specific type of vehicle**

ITEMS		**SPECIFICATION**
Charger	Charging method	CC-CV
	Input	100-240 Vac
	Output	70-108 V/7.4 A
	Cooling method	Air cooling
Fuse	Power battery fuse	150 A
	DC input fuse	7 A
	USB charging fuse	5 A
Power-off switch	Power-off switch	63 A
	Motor installation position	Central installation

Motor	Type	Permanent magnet
	Rated power	5 kW
	Rated voltage	96 V
	Cooling method	Air cooling
	Maximum power	10 kW

Main Parameters of Three-Wheeler Electric Vehicle

ITEMS		**Specification**
Performance	Max Speed	≤ 22 Km/h
	Distance per charge	≥35Km
	Product Size (mm)	2520L × 850W × 1200H
	Max. Capacity	≤300kg
	Net Weight	179 Kg
	Max. Steering angle	≤45°
Battery	Type	Lead acid
	Voltage	48V (12v * 4)
	Capacity	84V 20Ah
Controller	Under Voltage Value	42 ±1V
	Current limit value	28 ±1A
Charger	Voltage	48V
	Output Voltage	59 ±0.2V
	Charge current	2.8A

Know Your Progress

Multiple Choice Questions (MCQs)

1. What is the primary purpose of the owner's manual?
   A. To provide detailed repair procedures
   B. To guide vehicle owners on proper operation, maintenance, and care
   C. To list vehicle recalls
   D. To offer advanced diagnostic tools for technicians

2. Which section of the owner's manual includes detailed descriptions of the vehicle's features and controls?
   A. Troubleshooting and Problem Resolution
   B. Maintenance Schedule
   C. Vehicle Features and Controls
   D. Warranty Information

3. What type of diagrams help owners understand the layout and interconnections of vehicle systems?

A. Photographs
B. Charts
C. Schematic Diagrams
D. Flowcharts

4. What information does the service manual provide that is not typically found in the owner's manual?
   A. Vehicle maintenance schedules
   B. Step-by-step repair instructions
   C. Warranty information
   D. Vehicle operating tips

5. What does the Vehicle Identification Number (VIN) identify?
   A. The owner's address
   B. The service manual reference
   C. The vehicle's maintenance history
   D. The vehicle's features and manufacturing details

Fill in the Blanks

1. The _____ manual serves as a comprehensive technical guide for diagnosing and repairing vehicle components and systems.
2. A _____ at the end of the service manual allows technicians to quickly locate specific topics, procedures, or components within the document.
3. The owner's manual typically includes a _____ outlining recommended service intervals for routine tasks such as oil changes, fluid checks, tyre rotations, and filter replacements.
4. _____ diagrams in the service manual illustrate the layout, configuration, and interconnections of vehicle systems and components.
5. Detailed descriptions of warning lights and indicators, along with their meanings and recommended actions, can be found in the _____ section of the owner's manual.

Short Questions

1. What is the significance of the owner's manual for vehicle owners?
2. How do visual aids and diagrams in the owner's manual benefit vehicle owners?
3. What are some key components covered in the service manual that support technicians in their work?
4. Describe the importance of the Vehicle Identification Number (VIN).
5. What type of maintenance tasks are typically outlined in the owner's manual?

Activities

1. Identify and read vehicle features and controls, maintenance schedules, and safety precautions through the Owner's Manual. Also, use visual aids and diagrams to understand the layout of vehicle systems.
2. Understand how to access and use the Service Manual for vehicle diagnostics and repairs.
3. Locate the introduction, table of contents, and index to navigate the manual. Identify and read sections on diagnostic procedures, repair instructions, and technical specifications.
4. Locate the Vehicle Identification Number (VIN) in Two and Three-Wheeler present near you and decode the Vehicle Identification Number (VIN). Decode a sample VIN to identify the manufacturer, series, body type, engine type, model year, plant location, and sequential numbers.

Session 3: Types of Faults, Causes, and Rectification Procedures and Repair Work

In this session, we are going to discuss the pre-driving checklist, starting and stopping your vehicle, and essential pre-operation inspections. But don't worry, we'll break it down into easy-to-understand steps, so you'll feel confident every time you take the wheel.

PRE-DRIVING CHECKLIST

Before you even think about turning "ON" the start switch (key), there are few things you need to check to ensure your safety and the proper functioning of your vehicle.

From adjusting the mirror to tyre pressure checking and making sure that the brakes are working correctly, this checklist covers all the basics as given below:

- Check the position of the rear-view mirror.
- Check and adjust the seat.
- Check battery level and make sure the vehicle is adequately charged to provide power while in operation.
- Check tyres for proper inflation.
- Check lights, horn and reverse buzzer for proper operation.
- Check that the brake throttle has firm pedal pressure with minimal travel.
- Check the parking brake for proper engagement and release.

- Check that all warning and operation labels are in place.
- Check for smooth accelerator operation (throttle).
- Make sure the AC charger cord is disconnected.
- Put on and adjust the seat belt.
- Check that payload limits and the total authorized weight (including weight of driver, passenger and cargo) have not been exceeded.

STARTING AND STOPPING

Once you're all set with your pre-driving checklist, it's time to start your vehicle. Learn how to release the handbrake and accelerate the throttle. When it's time to stop, know how to safely come to a complete halt and engage the handbrake. The process of starting and stopping of vehicle is given below:

- Release the handbrake.
- Set the key in the START/RUN position and wait for the contact sound.
- Select the direction of travel with the directional knob.
- Accelerate the Throttle.
- Place the key switch in the S (Anti-Theft Steering Lock) position.
- To stop, press the brake and come to a complete stop. Engage the handbrake.
- Set the key/switch in rest position.

PRE-OPERATION INSPECTIONS

Discover how to perform pre-operation inspections to ensure your vehicle is in tip-top shape before every journey. From checking the body for damage to testing the lights and batteries, these inspections are crucial for your safety and the longevity of your vehicle.

Each vehicle has been inspected and adjusted to factory specifications before delivery. Upon receipt, perform a pre-delivery inspection of the vehicle. Also, before using the vehicle, some checks must be performed to ensure that it is in safe working order.

Service Item	**Service Method/Check**
Vehicle Body	Visually, check for damaged or loose hardware.
Steering and Linkages	Test drive, check for free movement and proper operation.
Accelerator/Brake Operation	Test drive, check free travel and

	braking action.
Warning Labels	Visually inspect all labels for readability or missing.
Tyres	Visually check for wear or damage.
Reverse Warning Buzzer or In-Motion Beeper	Test drive, and check for proper operation.
Charger Plug	Check for damage and snug fit.
Head, Tail or Flasher, Lights	Check for proper operation
Batteries	Check the Multifunctional Display Indicator (MDI) for battery condition.
Horn	Check for proper operation.

DIFFERENTIAL

1. Check the differential oil only if signs of leakage are detected.
2. Change oil initially between 25-50 hours.
3. Capacity 34 ounces (1 L). SAE 30 weight.

To check/change differential oil, see Figure:

1. Raise the vehicle.
2. Remove the Level/Fill screw (1). The correct level of oil is level with this hole.

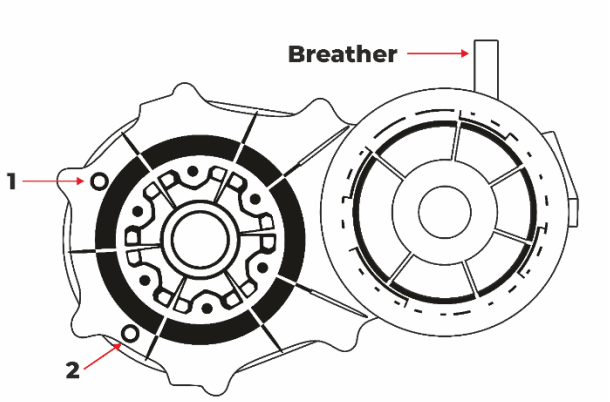


Fig. 2.10: Differential

3. Fill if necessary through the Level/Fill screw hole (1). Do not overfill.
4. Drain through the drain screw (2).

Troubleshooting Tips

Sometimes, things don't go as planned, and your vehicle might encounter some issues. But fear not! This session also includes troubleshooting tips

for common problems like slow operation or power cuts. With these tips, you'll be able to diagnose and fix minor issues with confidence.

PRE-TROUBLESHOOTING STEPS

Before troubleshooting a vehicle for any problem or symptoms, certain steps must be followed:

Inspect/Test	Corrective Action
• Ensure the vehicle is safe for service	• Visually inspect for any obvious signs of hazards such as sharp edges in the body or other parts, open wire insulation or wire connections, or discoloured parts of the vehicle indicating heat or chemical presence.
• Record the Vehicle Identification Number (VIN)	• This number is necessary to obtain technical help or support, and submit a warranty, and is essential to understand completely the vehicle that is being serviced. • The VIN, with the help of the correct VIN matrix, will denote specific information about each vehicle, such as operating power system and voltage, brake package options, speed operation settings, and other vehicle configuration options.

BATTERY

Batteries may be recharged if the vehicle has been driven 15 minutes or more since the previous charge. Before charging, be sure the master power key switch is Off and the key is removed from the switch.

BATTERY TESTING

Batteries are the heart of your vehicle, providing the power needed to get you where you need to go. Learn how to recharge your batteries and check their condition to keep your vehicle running smoothly.

The first step in servicing any Electric Vehicle that is not operating properly is to completely test the batteries. The batteries are the source of power for the vehicle drive and auxiliary systems, therefore are the most integral part of the Electric Vehicle troubleshooting. Battery testing should be done as follows and, in the order, as follows:

Inspect/Test Condition			Corrective Action
1.	Perform a visual examination of batteries and connections	Examine for signs of corrosion and clean/or replace any affected terminals or cables.	The batteries can be cleaned by hose washing with a standard garden hose or with a soft bristle brush (ensure battery caps are present and tight before washing batteries).
		Examine the battery hold-down. If the material from the hold-down has been dissolved by the sulphuric acid in the batteries, the hold-down can act as a drain on the battery pack.	Replace the hold-down if it appears damaged.
2.	Test each battery with a Multimeter	With a Multimeter set to a scale able to read DC volts at up to 100 volts (or greater), check each battery individually, and test the entyre pack together.	Place the Multimeter probes on the battery positive post and battery negative post of each battery. Record the reading from each battery. Each should contain at least 6.0 volts and no battery should be more than .5 volts lower than the highest reading. If any battery tests low on charge, charge the battery individually with an auxiliary charger or the entyre pack with the Delta Q charger (allow charging until the remote LED indicates a full charge).

			If one or more batteries still test low, the battery should be tested individually and replaced as necessary. *NOTE: It is recommended that all batteries in a system be changed together to ensure the batteries are the same brand, vintage, and service life.*
3.	Test each battery cell with a battery hydrometer.	Any battery or battery cell that tests low should be fully charged and then rechecked.	If the cell continues to test low with a hydrometer, the battery should be replaced
4.	A battery may test well with a voltage or hydro-meter test when no load is being drawn from it. Test using a battery load tester.	A battery must be able to produce 45 minutes of capacity when tested at a 55 amp draw after a complete recharge cycle.	A battery that is not able to produce this capacity should be replaced. See note above.

TROUBLESHOOTING SPECIFIC COMPLAINTS

Troubleshooting is a matter of investigation and deduction based on the symptoms and the possible causes. Recording every possible solution to every possible cause would be impossible, but this troubleshooting section is designed to assist in solving issues that may arise in the service life of an Electric Vehicle. Problems that could be encountered with the vehicle(s) are:

1. The vehicle operates slowly
2. Vehicle drives in forward or reverse only
3. Vehicle drives but operation is jerky or inconsistent
4. Vehicle power cuts out

5. Less mileage

VEHICLE WILL NOT OPERATE OR POOR PERFORMANCE

See **Fig. 2.11,** Set the vehicle power switch to "ON". The Multifunctional Digital Indicator (MDI) will indicate an alarm. The alarm is displayed by a code; the first two digits inform about the electronic module in the alarm (16 = MDI; 02 = Traction controller; 05 = Pump controller). The last two digits give the alarm code. See the AC Power System Manual for decoding the displayed alarms and use of the troubleshooting handset.

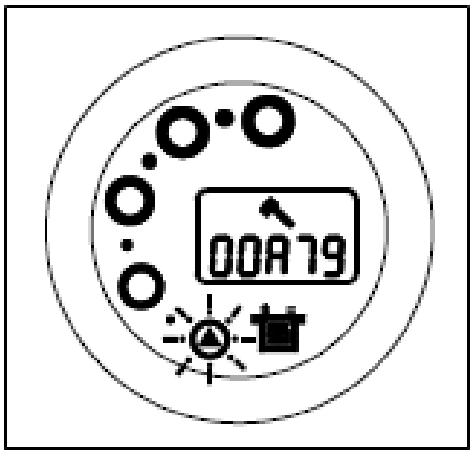


Fig. 2.11: Multifunctional Digital Indicator (MDI)

COMPONENTS TROUBLESHOOTING

In addition to the problems/causes/solutions listed in this section, individual sections also contain some testing and problem solutions for individual components. Check the appropriate section first, and if the information is not found, check the following when a component is causing a problem:

A. MULTIFUNCTIONAL DIGITAL INDICATOR (MDI):

Inspect/Test Condition	Corrective Action
Fuse failed	*Check the fuse and replace it if failed.*
Open wiring or failed connection.	*Check wiring and connections*
Inoperable MDI gauge	*Replace gauge.*
Weak or failed batteries	*Test batteries and charge as necessary.*

B. REVERSE BEEPER

Inspect/Test Condition		Corrective Action
a)	The fuse or relay failed	*Replace the fuse or relay.*
b)	Open wiring or failed connection	*Check wiring and connections*
c)	Inoperable reverse beeper	*Replace beeper.*
d)	Weak or failed batteries	*Test batteries and charge as necessary.*
e)	Controller set wrong	Check the controller setting using a handheld. Reset if necessary.
f)	Inoperable directional switch	Test the switch and replace it if necessary.

C. BRAKE LIGHTS

	Inspect/Test Condition	Corrective Action
a)	Fuse failed	*Check the fuse and replace it if failed.*
b)	Open wiring or failed connection	*Check wiring and connections*
c)	Bulb failed	*Replace bulb.*
d)	Misadjusted or inoperable brake light switch	*Check the switch adjustment, and replace the switch if necessary.*

D. HEADLIGHTS

	Inspect/Test Condition	Corrective Action
a.	Fuse failed.	*Check the fuse and replace it if failed.*
b.	Open wiring or failed connection.	*Check wiring and connections*
c.	The bulb burnt out.	*Replace bulb.*
d.	Failed power key switch.	*Test and replace the contactor as necessary.*
e.	Inoperable switch.	*Replace switch.*

E. POWER OUTLET

	Inspect/Test Condition	Corrective Action
a.	Fuse failed.	*Check the fuse and replace it if failed.*
b.	Open wiring or failed connection.	*Check wiring and connections*
c.	Inoperable power outlet.	*Replace the power outlet.*

F. TAIL LIGHT

	Inspect/Test Condition	**Corrective Action**
a)	Fuse failed.	*Check the fuse and replace it if failed.*
b)	Open wiring or if failed connection.	*Check wiring and connections*
c)	The bulb burnt out.	*Replace bulb.*
d)	Failed power key switch.	*Test and replace as necessary.*

G. BACKUP LIGHT

	Inspect/Test Condition	**Corrective Action**
a)	Fuse or relay failed.	*Replace the fuse or relay.*
b)	Open wiring or if failed connection.	*Check wiring and connections*
c)	Light burnt out.	*Replace light.*
d)	Failed power key switch.	*Test and replace as necessary.*

H. BRAKES

1) Slow or incomplete release of brakes.

1. Shoes and linings: - *Shoes were improperly adjusted. Shoes are self-adjusting; check parts for wear. Shoes distorted or incorrect. Replace with new parts*
2. Mechanical parts: - *Damaged or weak return springs-replace. Cables and linkage sticking, dirty or corroded. Lubricate with a commercial solvent like WD40, PB Blaster, etc. Make sure not to contaminate brake pads with solvent.*
3. Wheel bearings: - *Damaged or contaminated-replace. Grabbing or pulling- replace.*
4. Air in hydraulic lines (hydraulic brakes): - *Bleed hydraulic lines.*

2) Severe reaction to throttle and uneven stopping.

1. Shoes and linings: - *Shoes were improperly adjusted. Shoes are self-adjusting; check parts for wear. Shoes distorted or incorrect. Replace with new parts*
2. Mechanical parts: *Damaged or weak return springs-replace. Cables and linkage sticking, dirty or corroded. Lubricate with a commercial solvent like WD40, PB Blaster, etc.*

3. Drums: - *Drums are thin (expanding when hot); oversize (beyond .030") of original specification – replace. Scored, out-of-round – replace* Squealing, clicking or scraping noises upon application of brakes.

I. ACCELERATOR THROTTLE

Accelerator throttle maintenance consists of periodic inspections. No lubrication or adjustment is necessary. The accelerator throttle is a fully integrated device and you utilize the controller to adjust and control vehicle direction and speed. All adjustments are made using the handset.

J. HYDRAULIC BRAKE SYSTEM

- The hydraulic brake system utilizes a combination of mechanical and hydraulic components and is equipped with front disc and rear drum brakes.
- A mechanical brake throttle/linkage assembly is utilized to actuate a master cylinder. The master cylinder creates hydraulic pressure which operates the brakes.
- Hydraulic brake systems require a separate mechanical parking brake. A hand-operated parking brake, mechanical linkage and cables are utilized to mechanically lock the rear brakes for parking.

PERIODIC BRAKE INSPECTION

Intervals between brake service and inspection may vary depending on driving habits, type of driving, road and climate conditions, and vehicle load. Periodic inspection should always include the following:

1. With the vehicle stationary, depress the brake handle. The Brake handle should not travel more than 2-1/2" as measured from the floorboard. If the throttle/pedal travels more than 2-1/2" before resistance is felt, or if the throttle /pedal feels spongy and soft, repair or maintenance is required.
2. Inspect the brake master cylinder and adjoining brake lines for signs of fluid leakage. Remove the master cylinder cover (Fig. 2.12). Fluid must be clear and fluid level should be within 1/4" of the cylinder top (with the vehicle on level ground).

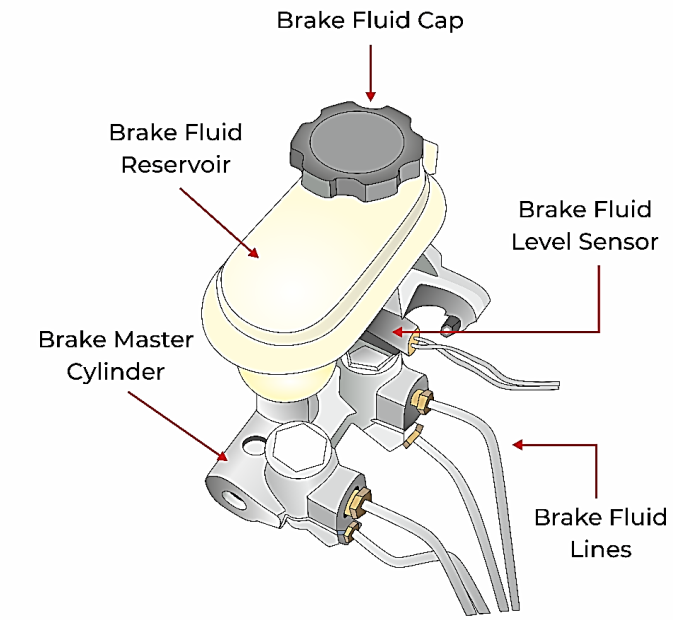


Fig. 2.12: Master cylinder

3. Check parking brake operation. The parking brake hand lever should travel no more than 3-1/2" upward when engaged. Check that the ratchet mechanism automatically holds the parking brake handle in the up position. Make sure the release button on the handle frees the parking brake lever and that lever returns to the full down (released) position.
4. Operate vehicle on level ground, applying brakes to ensure that both rear brakes apply equally. Check that excessive force is not required to apply brakes. Excessive force required to apply brakes could indicate a malfunctioning brake system or excessive wear to brake shoes.

ANNUAL BRAKE INSPECTION

5. Perform steps 1 & 2 under *Rear Drum Brake Disassembly*.
6. Inspect the drum for excessive or uneven wear. Refer to Brake Drum Service. Look for cracks radiating from stud holes.
7. Inspect brake shoes for thickness, uneven wear or physical damage. If brake shoe lining at any point is measured to be less than 1/16" (1.6 mm), brake shoes must be replaced.
8. Inspect for oil or grease contamination. Replace brake shoes that are contaminated.
9. Inspect the wheel cylinder area for fluid leakage. Inspect axle and axle tube area for leakage from axle bearing.
10. Wash mud, brake shoe debris, and dirt from brake assemblies and drums. Apply white lithium grease to the contact points between the

brake shoe and the brake back plate. Remove excess grease to prevent brake shoe contamination.

11. Perform steps 5-8 under Rear Drum Brake Reassembly.

REAR DRUM BRAKE DISASSEMBLY

1. Engage the parking brake. Remove nuts and remove the rear wheel/tyre assembly.
2. Release the parking brake. Remove the Torx screw as shown in Fig. 2.13(a) and brake drum.
3. Remove the axle nut as shown in Fig. 2.13 (b) and wheel hub.
4. Use a brake spring tool and remove the shoe return springs (short and long). Unhook each spring from the brake shoes and set it aside.
5. Remove the spring clips and remove the brake shoes.
6. Clean the brake assembly to remove brake debris, dust, dirt and mud.
7. See the Wheel Cylinder and replace it as necessary.

Fig. 2.13 (a): Torx screw

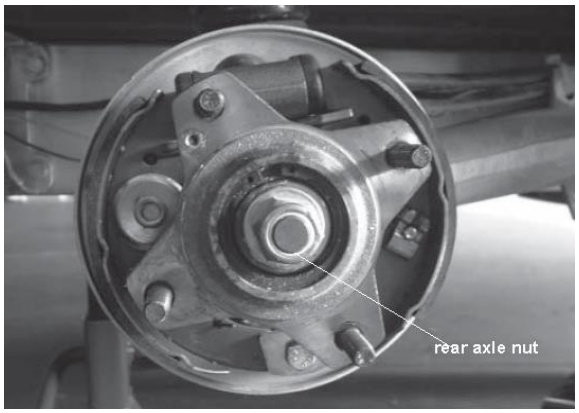
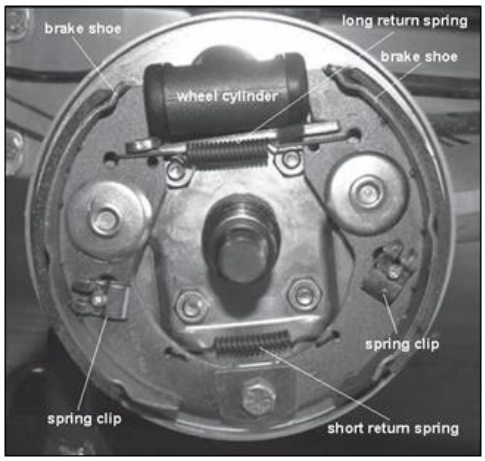


Fig. 2.13 (b): Rear Axle Nut



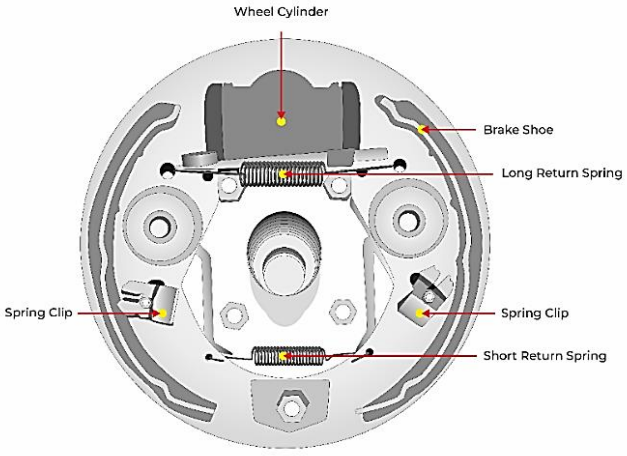


Fig. 2.13 (c): Rear Drum Brake Disassembly

BRAKE DRUM SERVICE

1. Skinning or replace drum:
   a) If the rubbing surface is rough or ragged, or if the depth of scoring exceeds 0.010".
   b) If the inside diameter of the drum at the open end exceeds the inside diameter at the closed end by more than 0.010".
   c) If the surface variance exceeds 0.005" on the side.
   d) If hard spots cause noticeable effects such as brake roughness. If spots are severe, replace the drum.
   e) If heat checking is visible or can be felt with a fingernail.
   f) If checks are severe, replace the drum.
   g) if out-of-round condition exceeds .006" total indicator reading or if brake roughness is noticeable.

2. To measure a drum diameter, place a gauge in the drum so the contact points are at the greatest diameter. Be careful to hold both contact points at the same depth (distance from the outside edge of the drum).
   a) The difference in diameter of drums on opposite ends of the same axle must not exceed 0.010", or when turning drums turn them in pairs to the same oversize (within 0.010") to ensure equal braking effort on all wheels.
   b) When skimming a drum, remove only enough metal to obtain a smooth braking surface. If the drum does not clean up when turned to maximum skimming diameter, replace it. Removal of more metal will affect the ability of the drum to dissipate heat and may cause drum distortion.

REAR DRUM BRAKE REASSEMBLY

   a) Place brake shoes into position on retaining pins. Install spring clips. Make sure shoes are positioned properly on the cylinder. Check that brake shoes are correctly positioned into the slots provided in each master cylinder piston.
   b) Install a long return spring (top) and a short return spring (bottom).
   c) Install the brake drum fully onto the brake assembly and install four new nuts.
   d) Reinstall the rear wheel/tyre assembly and four lug nuts. Engage the brake and tighten lug nuts in a crisscross pattern to a maximum of 65 ft. lbs. Repeat for other rear wheel/tyre assembly. Recheck lug nut torque with the vehicle on the ground.

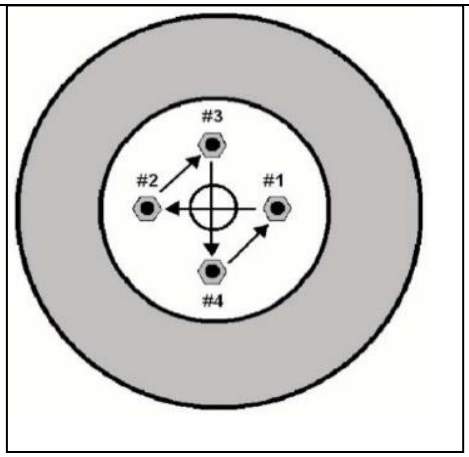


Fig. 2.14: Rear Drum Brake Reassembly

BRAKE FLUID MAINTENANCE

Maintain fluid level within 1/4" of the master cylinder filler opening.

1. Changing brake fluid:

   - As a result of use, brake fluid loses some of its original qualities and may become contaminated. When performing major brake work to the hydraulic system, remove old fluid and replace it with clean brake fluid.
   - Brake fluid must be changed following extended usage or contamination. Anytime fluid looks milky or dark, there are contaminants in the fluid.
   - If any of the hydraulic system parts are corroded, or the fluid is discoloured, flush the hydraulic system to remove old fluid, then fill it with clean brake fluid.

2. Soft or swollen rubber parts or milky or discoloured fluid indicate the brake fluid is contaminated.

   - Drain the old fluid from the system. Replace cups and seals.
   - Flush the hydraulic system with clean brake fluid. Refill system with clean brake fluid.

3. Handling and storing brake fluid:

   - Keep brake fluid clean. Do not allow any foreign material in the fluid.
   - Prevent any petroleum product (gasoline, kerosene, oil, grease, etc.) from contaminating the brake fluid.

- Use only clean containers for dispensing brake fluid. Do not use containers contaminated with dirt, grease, etc.
- Always cover or cap brake fluid containers when not dispensing the fluid. If containers are left open or uncovered, the fluid absorbs moisture from the air.
- Never reuse old brake fluid drained from the system. Used brake fluid is contaminated to some extent.
- Store brake fluid containers in a clean, dry place.

CONTROLLER

REMOVING THE CONTROLLER

The controller is located under the hood. To access the controller, remove the thumb screws securing the cover, and remove the cover.

Troubleshooting for controller.

1. Turn the main switch Anti-clockwise to disconnect the power supply (OFF position).
2. Label/mark controller cables while connecting and disconnecting for terminal identification, if not labelled/ marked.
3. Remove the bolts, lock washers, plain washers, and all the cables and wires connected to the controller.
4. Remove the 32-pin connector and the 8-pin MDI connector from the controller.
5. The controller is secured with mounting plates, nuts, washers and bolts. This plate is secured with the vehicle with additional bolts.
6. Remove these bolts first which will allow the controller and mounting plate to be removed. Remove the mounting plates bolts, washers and nuts to release the controller.

NOTICE: Do not attempt to disassemble the controller. There are no repairable parts inside.

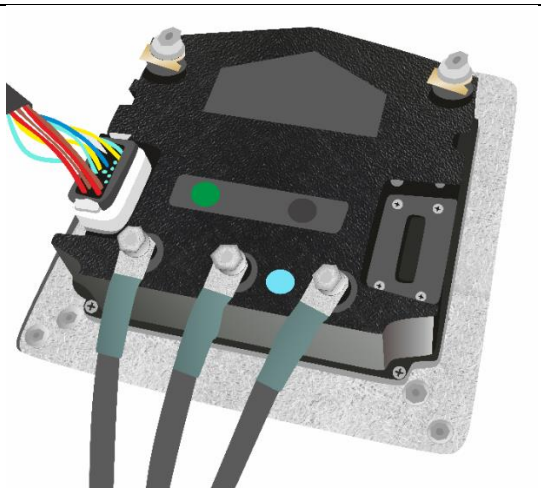


Fig. 2.15: Controller

INSTALLING THE CONTROLLER

- Position the new controller to the mounting bracket and secure it with bolts, washers and nuts. Install assembly in the vehicle with bolts.
- Install cables to controller terminals and cable identification labels. Make sure there is a flat washer under the terminal ends of the cables. This will spread the load and help prevent the terminal ends from folding over.
- Use dielectric grease in both multi-pin harness connections.
- Torque controller cable attaching bolts as shown in Fig. 2.16.
- Reconnect the battery negative cable. Turn the main disconnect switch clockwise to the ON position.

Fig. 2.16: Torque controller cable attaching bolts

REMOVING THE MAIN CONTACTOR

- The contactor is located under the hood. To access the controller, remove the thumb screws securing the cover, and remove the cover.
- Turn the main disconnect switch counterclockwise to the OFF position.
- Label contactor cables with terminal identification. Remove two nuts, washers and cables from stud terminals (Figure 8-15).
- Remove control circuit wires from spade terminals.
- Remove two nuts, washers, bolts and contactors.

INSTALLING THE MAIN CONTACTOR

- Position the new contactor to the mounting bracket.
- Secure the contactor to the mounting plate with two bolts, nuts and washers.
- Install heavy cables to stud terminals. Install control circuit wires to the spade terminal. Double-check the wiring diagram to ensure connections are correct.
- Turn the main disconnect switch clockwise to the ON position.
- Operational Check: The contactor should emit an audible click when the power key switch is set to the ON position.

MOTOR MAINTENANCE

A well-planned maintenance program can save time and prevent major components from failing. Maintenance schedules include regular checks of motors, batteries, and wiring. The following recommendations are suggested for periodic maintenance inspection:

i. Normal service – 8 hours per day operation
   a) Routine inspection every 1,000 hours
ii. Severe service – as stated in the below
   b) Routine inspection every 500 hours (vary from company to company)

EXTERNAL MOTOR INSPECTION

1. Check for clean, tight terminal studs and mounting bolts.
2. Internal and external spline drives, between the motor and final drive axle, must be periodically lubricated with a thin layer of quality, anti-seize compound.
3. Check for any signs of oil leaks from the final drive axle, which might cause oil to enter the traction motor.

REMOVING THE MOTOR

- Place the vehicle on the ground to remove the motor.
- Remove the front, right-hand wheel assembly, the lower panel and the inspection plate.
- Mark traction motor cables (if not already marked), with motor terminal identification.
- Use wrenches to remove cables hex nuts and washers.
- Remove hardware securing motor to frame.
- Carefully support the motor to prevent it from falling, and loosen and remove bolts, lock washers and flat washers securing the motor to axle/differential housing. Pull the motor away from the rear axle housing and lift it clear of the vehicle

INSTALLING THE MOTOR

- Coat the open end of the spline and rear axle input shaft with an anti-size compound. Place the motor into a vehicle and onto the input shaft.
- Rotate the motor to align mounting bolt holes to the axle/differential housing. Install the bolts lock and flat washer securing the motor to axle/differential housing, while carefully supporting the motor to prevent it from falling.
- Secure motor to frame with hardware.
- Inspect electrical system cables for terminal identification. Position cables to traction motor, double checking wiring to ensure connections are correct.
- Install inspection plate, lower panel and front, right-hand wheel assembly.
- Attach motor cables with flat washers and hex nuts. A torque motor cable attaches nuts while holding the bottom nut with a thin open-end wrench.

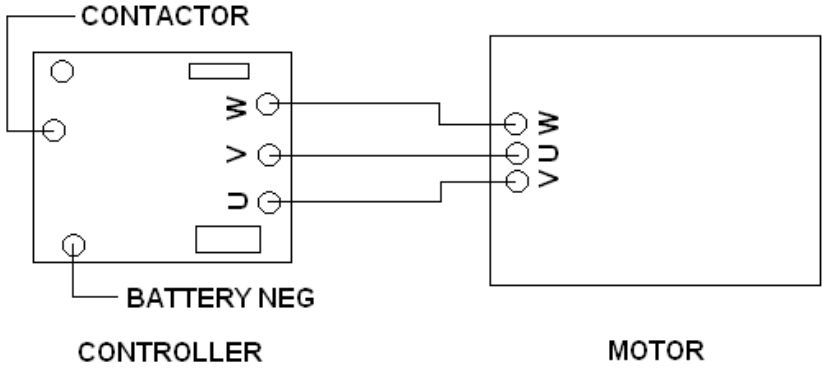


Fig. 2.18: Motor Wiring

Factory Reset EV's Software and Information Display

EV technology continues to advance, so it is necessary to stay informed on maintaining their vehicles. One important aspect that often requires attention is resetting the EV's software and information display. Let's explore the steps to identify and execute a factory reset of the EV, ensuring a smooth experience for years.

1 Understanding the Need for a Factory Reset

Before resetting EV's software, let's discuss why this procedure is sometimes necessary. Over time, software glitches or malfunctions may occur, affecting the performance and display of critical information. A factory reset serves as a powerful tool to address these issues, restoring EVs to their optimal state.

2 Identifying EV Model and Software Version

The first step in the factory reset process is to identify the specific EV model and the version of the software it is running. Each manufacturer may have unique steps for resetting, so it's crucial to consult the vehicle's manual or online resources provided by the manufacturer. Look for the "Settings" or "System Information" menu on the EV's display to find details about the software version.

3 Backing Up Important Data

Before starting the factory reset, please take a moment to back up any important data stored in the EV's system. It is important to back up your data before resetting to avoid losing valuable information. Common data to backup includes navigation history, personal settings, and stored preferences.

4 Step-by-Step Guide to Factory Resetting EV

Now that you've laid the groundwork, let's dive into the step-by-step process of resetting EV's software and information display:

A. Navigate to Settings

Access EV's main menu and locate the "Settings" or "System" option. This is usually represented by a gear icon.

B. Select System Information

Within the Settings menu, find the "System Information" tab. Here, you'll discover details about EV's software version and related information.

C. Choose Factory Reset

Once in the System Information section, look for the "Factory Reset" option. Selecting this will prompt a confirmation screen.

D. Confirm Reset

Carefully review the information on the confirmation screen. Confirm the decision to proceed with the factory reset. Some EVs may require a PIN or password verification at this stage.

E. Wait for the Reset Process

After confirming, patiently wait for the factory reset process to complete. This may take a few minutes, during which EV's display may go blank or show a progress indicator.

F. Restart EV

Once the reset is complete, restart the EV as per the manufacturer's instructions. This step ensures that the changes take effect.

Tips for a Successful Factory Reset

To maximize the effectiveness of the factory reset and minimize potential issues, consider the following tips:

- Ensure the EV is fully charged before initiating the reset.
- Disconnect any external devices or accessories during the reset process.
- Consult the manufacturer's website or customer support for model-specific guidance.

Know Your Progress

Multiple Choice Questions (MCQs)

1. **What is the first step in the pre-driving checklist?**
   A. Check tyre pressure
   B. Adjust the seat
   C. Check the position of the rear-view mirror
   D. Put on and adjust the seat belt
2. **Which of the following is NOT part of the pre-operation inspection?**
   A. Check the vehicle body for damage
   B. Check the fuel level
   C. Test the accelerator and brake operation
   D. Inspect the warning labels
3. **What should you do if the differential oil level is low?**
   A. Fill it through the Level/Fill screw hole

B. Fill it through the drain screw
C. Leave it as it is
D. Overfill the oil

4. **What is the correct procedure to start the vehicle?**
   A. Engage the handbrake and turn the key in the ignition
   B. Turn the key in the ignition, release the handbrake, and press down on the accelerator
   C. Press down on the accelerator, release the handbrake, and turn the key in the ignition
   D. Release the handbrake, turn the key in the ignition, and press down on the accelerator
5. **How often should the differential oil be changed initially?**
   A. Every 10-20 hours
   B. Every 25-50 hours
   C. Every 50-75 hours
   D. Every 75-100 hours

Fill in the Blanks

1. Before starting the vehicle, you should always check and adjust the _____.
2. The _____ should be visually inspected for damage or loose hardware during the pre-operation inspection.
3. The brake throttle should not travel more than _____ as measured from the floorboard.
4. When testing batteries with a multimeter, each battery should contain at least _____ volts.
5. The hydraulic brake system is equipped with front _____ and rear drum brakes.

Short Questions

1. What are the steps to perform a pre-driving checklist?
2. Describe the procedure for stopping the vehicle safely.
3. Why is it important to check the vehicle body during pre-operation inspections?
4. How do you test the condition of the vehicle's batteries?
5. What is the role of the multifunctional digital indicator (MDI) in troubleshooting?

Activities

1. Create a detailed pre-driving checklist for their vehicle. They will include steps such as checking mirrors, seat adjustment, tyre pressure, and other essential items.
2. Perform a mock pre-operation inspection on a vehicle (real or simulated), checking the vehicle's body, steering, brakes, and tyres.

Module 3	Routine Service and Repair of Four-Wheeler EVs

Module Overview

This module will discuss the fundamental aspects of routine maintenance and repair of Four-Wheeler Electric Vehicles (EVs). We will cover topics such as understanding the distinct components of EVs, maintenance practices, and how to troubleshoot common issues.

Learning Outcomes

After the completion of this module, you will able to

1) Demonstrate preparatory activities for diagnosing faults and repairing a four-wheeler EV.
2) Demonstrate how to assist in the repair and maintenance of four-wheeler EV-related tasks.
3) Demonstrate the types of Faults, Causes, Rectification Procedures and Repair Work.

Module Structure

Session 1: Components of Four-Wheeler EVs and their Functions

Session 2: Reading of Owner's Manual (Manufacturer) and Service Manual

Session 3: The types of Faults, Causes, Rectification Procedures and Repair Work

Session 1: Components of Four-Wheeler EVs and their Functions

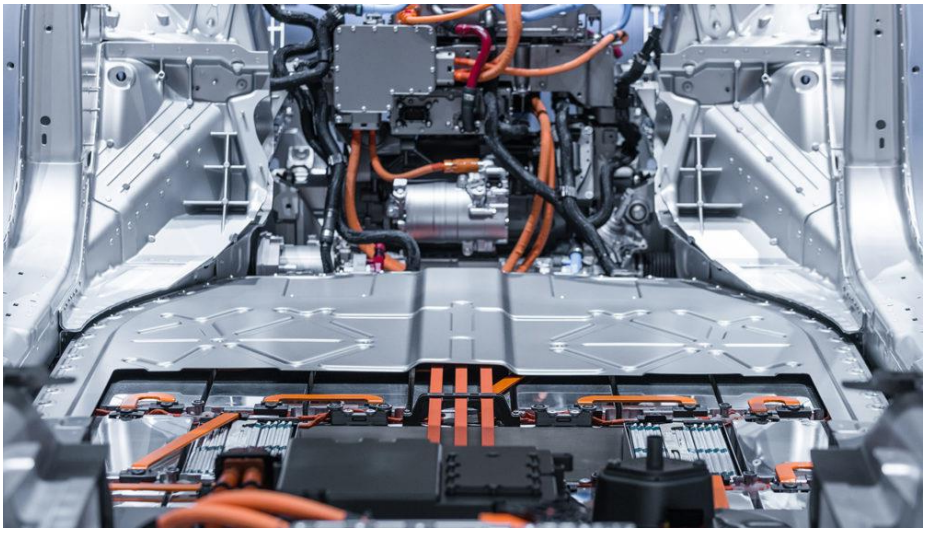


Fig. 3.1: An Inner view of Four-Wheeler Electric Vehicle

The electric vehicle's design and build can vary depending on the manufacturer and each component the Electric Vehicle uses. However, there are some common components found in most four-wheeled electric vehicles including:

- Traction Battery Pack
- Power Inverter
- Controller
- Traction motor
- Charger
- Transmission
- DC converter
- Auxiliary battery
- Charging port
- Thermal management system

1. Traction Battery Pack

The first component available in every electric car is a traction battery pack. The main function of this component is to store and supply Direct Current (DC) to the inverter. Furthermore, the power generated will be used to drive the traction motor.

When the controller sends a signal, the traction battery will immediately work by transferring electric current to drive the traction motor. This electric car component is made with a strong structure so the components are not easily damaged. Not only that, the traction battery is also designed to be recharged many times.

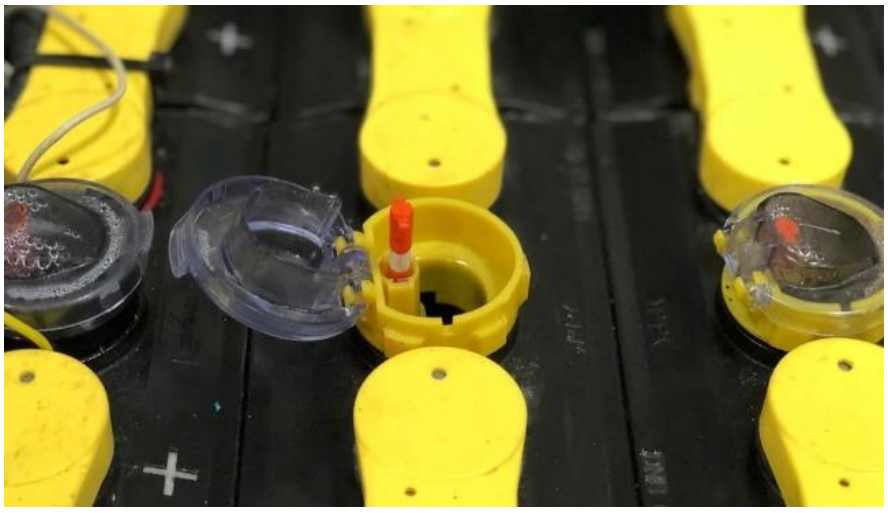


Fig. 3.2: Traction Battery Pack

2. Power Inverter

The inverter is a component that functions to convert DC (Direct Current) into AC (Alternating Current). The resulting current will then be used to drive or rotate the traction motor. This component is one part of the main driving component of an electric car. Not only that, this component also functions to convert AC during regenerative braking so that it becomes DC which can then be used to recharge the battery. For electric car battery components, the type of inverter used is usually a bi-directional inverter type.

Fig. 3.3: Power Inverter

3. Controller

This electric car component functions as a regulator of energy or electrical power in the battery pack to the inverter so that it can drive the traction motor. The way the controller works is to send a signal from the electric car pedal which is stepped on by the driver so that it affects the speed of the vehicle.

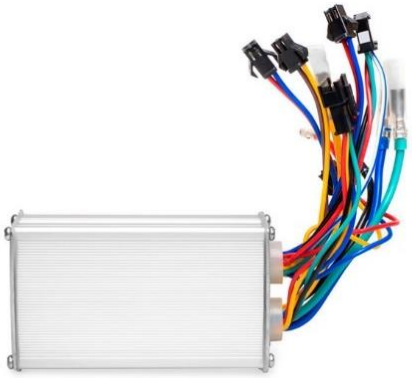


Fig. 3.4: Controller

4. Traction Motor

A traction motor is an electric car component in the form of an electric dynamo. This component functions to drive the transmission and wheels so it is called one of the most important components in supporting the electrical performance you use.

You need to know that the traction motor can rotate up to 18,000 rpm. Meanwhile, the type of traction motor that is most widely used in electric cars is the Brushless DC Traction Motor (BLDC). However, the BEV-type electric car uses a traction motor of the Internal Combustion Engine (ICE) type.

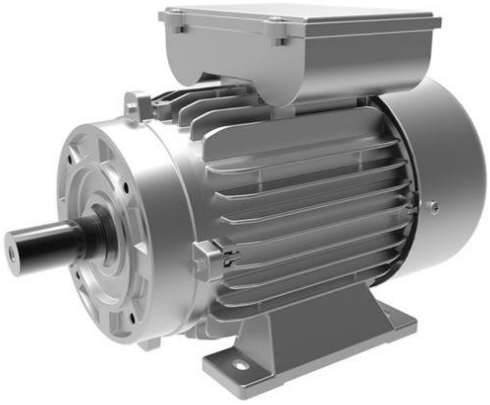


Fig. 3.5: Traction Motor

5. Charger

The charger is a supporting component as well as a complement in an electric car. The main function of this component is as a tool to recharge the battery pack in electric cars.

The way the charger works is to use AC PLN electricity and then convert it to DC electricity so that it can be stored in an electric car battery pack. Several types of electric car charger tips are usually used, namely On-board chargers and Off-board chargers.

Fig. 3.6: Charger

6. Transmission

Transmission is an electric car component that functions as a regulator of the mechanical power of the traction motor so that it can be used to drive the car's wheels. The way an electric car transmission works is not much different from a conventional car transmission.

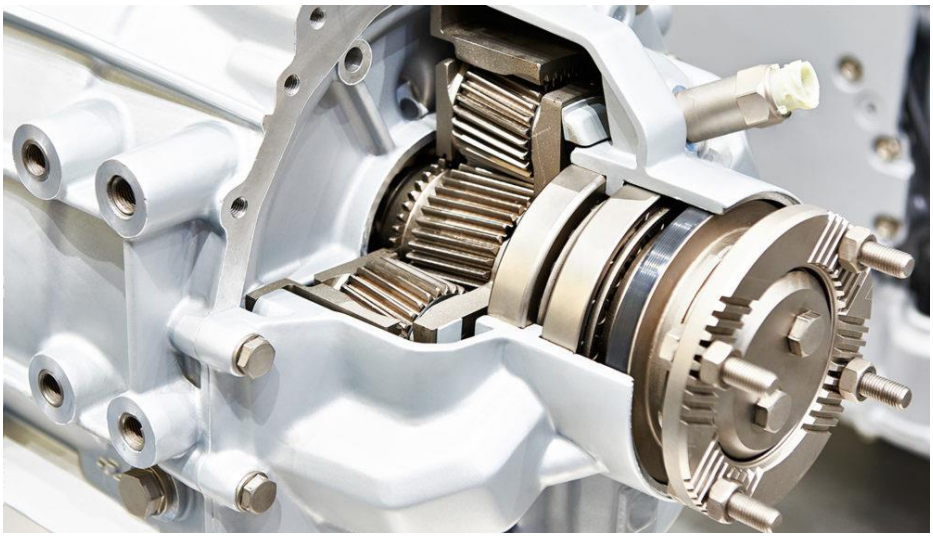


Fig. 3.7: A type of Transmission

7. DC Converter

The complementary component in the next electric car is the DC Converter. This component functions as a power converter or DC electric current from a high-voltage battery pack to be converted into a lower voltage.

The purpose of reducing the voltage is so that the components in the electric car with low power requirements can still be supplied properly. DC Converter also functions as a medium for battery chargers so that the current and voltage remain stable.

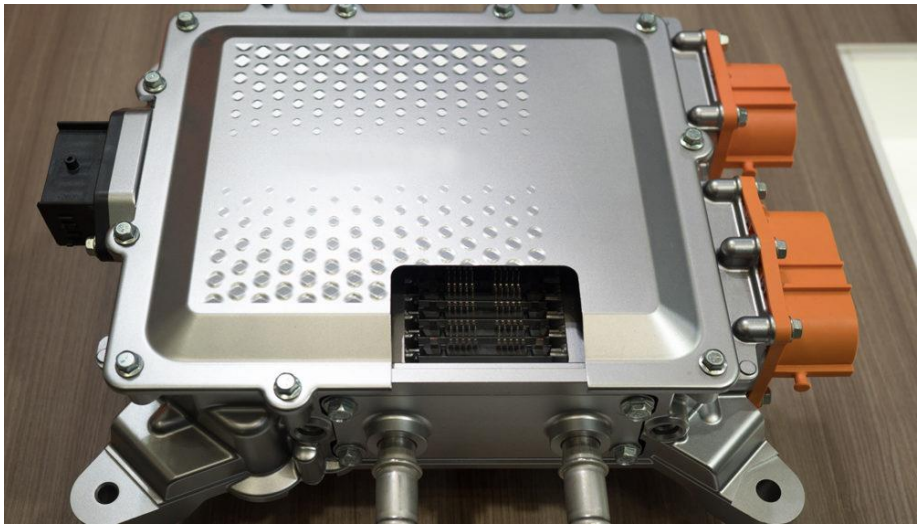


Fig. 3.8: DC Converter

8. Auxiliary Battery

Auxiliary batteries can also be referred to as additional batteries to be an auxiliary power source. The main function of this component is as a flow of electric current or a backup power provider that is used to turn on various accessories in electric cars such as wipers, car air conditioners to car alarms.

Fig. 3.9: Auxiliary battery

9. Thermal Cooling System

The component of an electric car and its next function is the thermal cooling system. This component functions as a temperature cooler and ensures operating temperature conditions always match the type of machine you are using.

Not only that, this component is also tasked with ensuring the condition of the traction motor and other electronic components is always at a normal temperature even if the electric car is used for a long time.

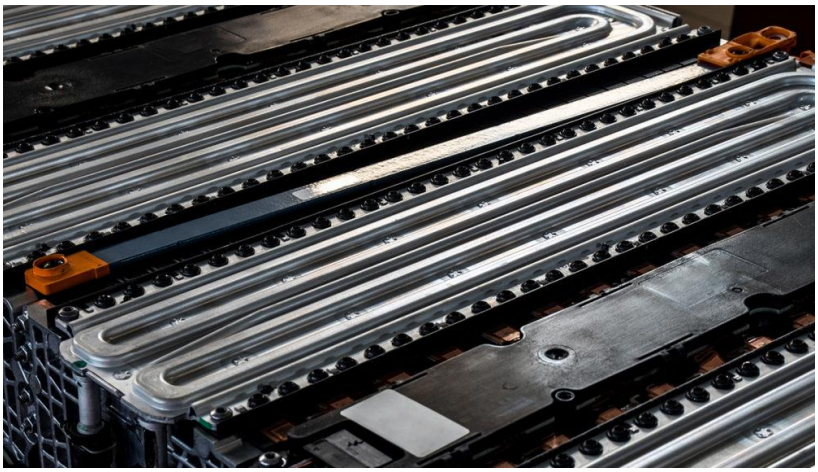


Fig. 3.10: Thermal Cooling System

10. Charging Port

Another important component of an electric car is the charging port. This is a useful part as a charging point for electric car batteries. The charging port will later be connected to an external power in the charging process for the battery pack.

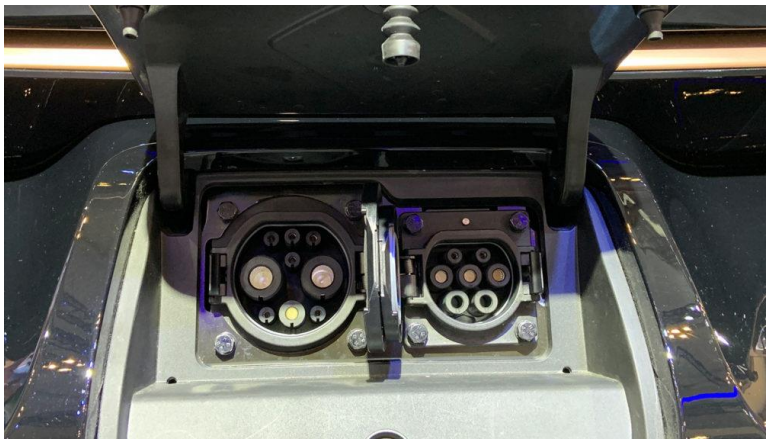


Fig. 3.11: Charging Port.

Four-Wheeler Electric Vehicle in India

Here is a list of the EV cars in India.

1. Tata Nexon EV: The Tata Nexon EV is popular in India. It can go more than 400 km on a single charge. It has a super-fast charger which charges from 10% to 80% in just one hour. The vehicle also has features like a big touchscreen and ventilated seats.
2. Mahindra XUV400 EV: This is one of the first electric SUVs from Mahindra. It has a strong battery and can go pretty far on a single charge. It looks stylish and has features like a big touchscreen and sunroof.
3. MG Comet: The MG Comet is a small electric car with a modern design. This is perfect for people who care about the environment. It can go up to 230 km on one charge and has technology like adaptive cruise control.
4. Tata Tiago EV: The Tata Tiago EV is like the regular Tiago but electric. It is affordable and has two options for battery size. Plus, it has got a touchscreen and auto AC. The Tigor EV can go around 306 km on one charge. It charges quickly from 0% to 80% in just 65 minutes. It is also super safe with a four-star rating.
5. Citroen eC3: It is a compact electric car with a unique design. It can go up to 320 km on one charge and has features like a touchscreen and automatic air conditioning.
6. MG ZS EV: This stylish British car has a long range of 460 km. It has got a big touchscreen and a panoramic sunroof.
7. Hyundai Kona Electric: Hyundai's first EV in India. This SUV has a huge range of 452 km and fast charges from 0% to 80% in just 60 minutes.
8. Kia EV6: The Kia EV6 is a crossover with a futuristic design. It can go up to 708 km on one charge and has superfast charging that charges from 10% to 80% in just 18 minutes.
9. Hyundai IONIQ 5: The IONIQ 5 is a brand-new electric crossover with a futuristic design with skateboard platform. It has a long range of 631 km and have ultrafast charging technology that charges from 0% to 80% in just 18 minutes.
10. Tata Punch EV: The range of up to 421 km and charges from 10% to 80% in just 55 minutes. Plus, it is packed with safety features like airbags, ADAS etc.

Know Your Process

Multiple Choice Questions (MCQs)

1. What is the main function of the traction battery pack in an electric vehicle?
   A. To store and supply direct current (DC) to the inverter
   B. To convert AC to DC
   C. To drive the transmission
   D. To cool the electric vehicle components
2. Which component in an electric vehicle converts DC to AC to drive the traction motor?
   A. Traction Battery Pack
   B. Power Inverter
   C. Controller
   D. Charger
3. What type of motor is most commonly used in electric vehicles?
   A. Brushless DC Traction Motor (BLDC)
   B. Internal Combustion Engine (ICE)
   C. Alternating Current (AC) Motor
   D. Synchronous Motor

4. Which component in an electric vehicle is responsible for converting AC to DC during regenerative braking?
   A. Controller
   B. Traction Battery Pack
   C. Power Inverter
   D. Charger
5. What is the purpose of the DC converter in an electric vehicle?
   A. To convert DC to AC for the traction motor
   B. To recharge the auxiliary battery
   C. To manage the thermal system
   D. To convert high-voltage DC to lower-voltage DC

Fill in the Blanks

1. The _____ stores and supplies direct current (DC) to the inverter.
2. The _____ converts DC into AC to drive the traction motor.
3. The _____ regulates the energy from the battery pack to the inverter.

4. The _____converts AC electricity to DC to recharge the battery pack.
5. The _____ ensures the components are kept at a normal operating temperature.

Short Questions

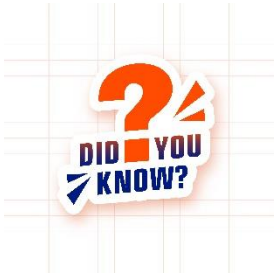
1. What is the function of the traction motor in an electric vehicle?
2. How does the power inverter contribute to regenerative braking in electric vehicles?
3. What role does the auxiliary battery play in an electric vehicle?
4. Why is the DC converter important in an electric vehicle?
5. How does the thermal management system benefit electric vehicle components?

Activities

1. Draw a diagram of electric vehicle components, label each component, and describe its function.
2. Create a maintenance schedule for an electric vehicle, including tasks such as checking the traction battery, inspecting the thermal management system, and verifying the functionality of the power inverter.

Session 2: Reading of Owner's (Manufacturer) Manual and Service Manual

OWNER'S MANUAL



The owner's manual is an incredibly helpful document provided by vehicle manufacturers? It's like your car's personal guidebook, full of information on how to operate, maintain, and care for your vehicle properly.

The manual is divided into chapters covering all sorts of topics, like controls, maintenance, troubleshooting, and specs. It even includes a table of contents and an index to make finding what you need super easy.

Fig. 3.12: Owner's Manual of Four-Wheeler Electric Vehicle

The manual includes details on your vehicle's features, maintenance schedule, fluid capacities, warranty information, visual aids, maintenance instructions, troubleshooting, and safety precautions. It also provides guidelines for safe driving practices and information on child safety features and using child seats.

WARNING

- Working on Electric Vehicles without following proper procedures and using proper lifting equipment may result in vehicle damage or personal injury.
- Always wear safety glasses or approved eye protection while servicing the vehicle. Wear a full-face shield when working with batteries.
- Failure to maintain the vehicle properly could result in decreased vehicle performance, and reliability or cause severe personal injury.
- Exceeding rated vehicle load capacities could result in possible severe injury or property damage.
- Always turn the Power key to OFF and the directional selector to NEUTRAL, remove the Power key and block tyres. Turn the master disconnect switch counterclockwise to the OFF position before servicing or repairing your vehicle.

SERVICE MANUAL

Service manuals are crucial for technicians and service professionals working on Electric Vehicles. Unlike owner's manuals, which are for vehicle owners, service manuals are designed to help skilled professionals diagnose, repair, and maintain vehicles. These manuals contain diagnostic procedures, repair instructions, technical specifications, special tools and equipment, visual aids and diagrams, maintenance and service procedures, as well as safety precautions and recommendations. Following the guidance in the manual helps technicians ensure consistent and accurate repairs, minimize the risk of errors or complications, and enhance customer satisfaction and service quality.

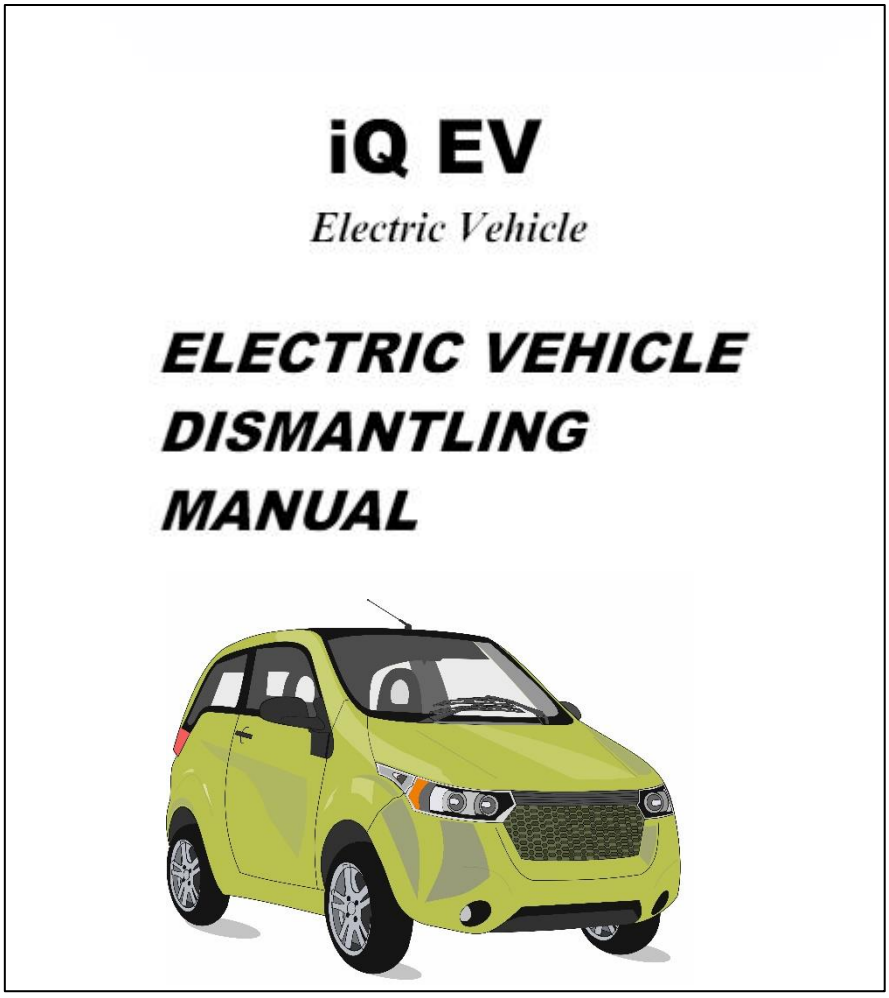


Fig. 3.13: Service manual of Four-Wheeler Electric Vehicle

FOUR-WHEELER VEHICLE SPECIFICATION

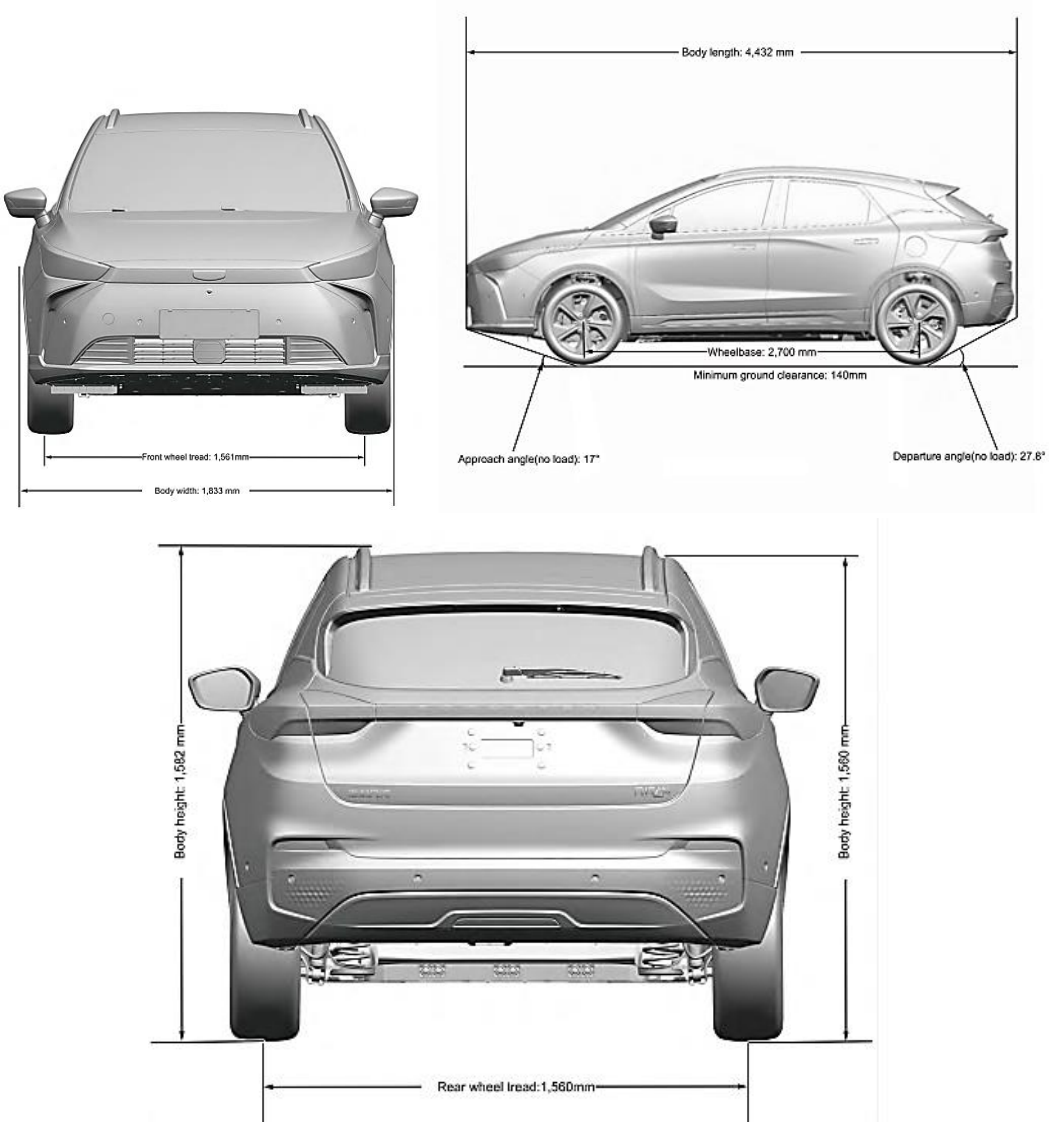


Fig. 3.14: Vehicle specifications of Four-Wheeler Electric Vehicle

VEHICLE IDENTIFICATION NUMBER (VIN)

The Vehicle Identification Number (VIN) is a unique identifier that is legally required for all vehicles. The VIN is usually engraved in several locations for safety and tracking purposes.

To find the VIN, you can look under the front passenger seat, where it is engraved on the beam. Simply move the seat back to its end and lift the protective cover to reveal the VIN.

Alternatively, the VIN can also be found in the following locations:

1. Inside the front compartment
2. On the VCU (Vehicle Control Unit)
3. On the upper part of the middle channel
4. Inside the left or right middle pillar
5. On the lower side of the right B-pillar
6. On the left side wall wheel pack
7. On the inner side of the tailgate.

The VIN is usually attached to the body bracket on the lower left corner of the windshield and is visible from the outside of the vehicle through the windshield. This ensures that the VIN can be easily checked and verified by law enforcement and other authorized personnel.

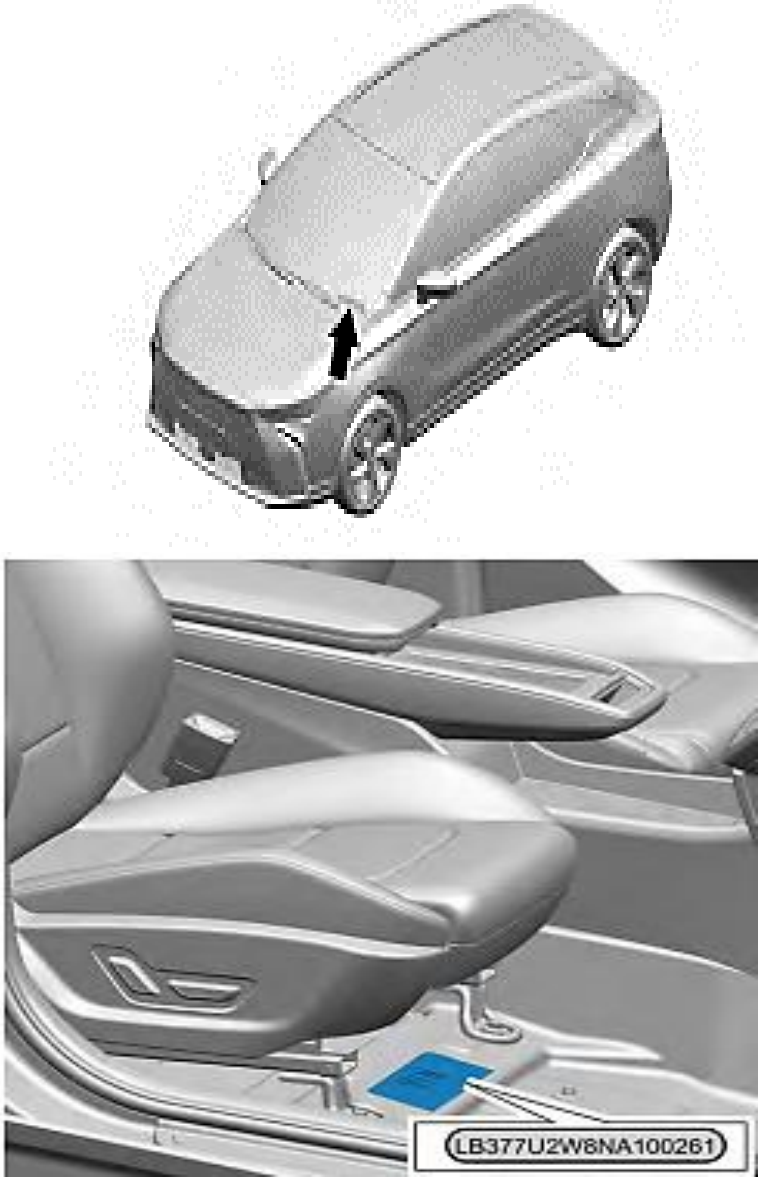


Fig. 3.15: Location of Vehicle Identification Number

Know Your Progress

Multiple Choice Questions (MCQs)

1. **What is the primary purpose of the owner's manual for a vehicle?**
   A. To provide detailed repair instructions
   B. To assist technicians in complex repair procedures
   C. To guide vehicle owners on operation, maintenance, and care
   D. To track vehicle identification numbers
2. **Which of the following is typically NOT found in an owner's manual?**
   A. Maintenance Schedule
   B. Troubleshooting guidelines
   C. Detailed diagnostic procedures
   D. Warranty information
3. **What is the key difference between an owner's manual and a service manual?**
   A. Owner's manuals are intended for vehicle owners; service manuals are for skilled professionals
   B. Service manuals are easier to understand
   C. Owner's manuals include technical specifications
   D. Service manuals are provided for free with the vehicle
4. **Where can you typically find the Vehicle Identification Number (VIN) on a vehicle?**
   A. Inside the fuel tank
   B. Under the front passenger seat
   C. Inside the glove compartment
   D. On the rear bumper
5. **What is the purpose of visual aids in an owner's manual?**
   A. To make the manual longer
   B. To provide entertainment while reading
   C. To clarify instructions and enhance understanding
   D. To fill space in the manual

Fill in the Blanks

1. Vehicle manufacturers provide the _____ and acts as a guidebook for proper operation, maintenance, and care of the vehicle.
2. _____ are designed to assist skilled professionals in diagnosing, repairing, and maintaining vehicles.

3. The _____ is a unique identifier legally required for all vehicles and is engraved in multiple locations for safety and tracking purposes.
4. _____ such as illustrations, diagrams, and photographs are included in the owner's manual to make the information clear and easy to understand.

Short Questions

1. What are some of the key topics covered in an owner's manual?
2. Why is the Vehicle Identification Number (VIN) important?
3. What type of information is typically found in a service manual?
4. How can visual aids in an owner's manual assist vehicle owners?
5. What steps should a vehicle owner take to find the VIN?

Activities

1. Provide students with sample owner's manuals and service manuals. Have them locate specific information, such as the maintenance schedule for a particular component or the procedure for checking fluid levels, using the table of contents and index.
2. Search and record the VINs from different locations on a vehicle.
3. Compare the structure and content of an owner's manual and a service manual for the same vehicle model.

Session 3: Types of Faults, Causes, Rectification Procedures and Repair Work

If you're driving an Electric Vehicle with four wheels and you notice anything strange, like decreased performance or odd sounds, it could be a sign of underlying issues that need to be addressed. Don't worry though, we can help!

To figure out what's going on, we'll need to do a thorough diagnosis. This just means we'll measure various aspects of your vehicle, like battery performance, motor function, and other relevant metrics. Once we know what's causing the problem, we can fix it to make sure your Electric Vehicle is running at its best and is safe for you to drive.

LIFT THE VEHICLE

Please ensure that the jack pads do not touch the brake hose or high-voltage wires when lifting the vehicle on the frame side rails or other designated lifting points. Touching the above-mentioned parts can cause damage to the vehicle or deterioration of vehicle performance.

Before starting any lifting procedures, make sure that the vehicle is on a clean, hard, and level surface. Also, ensure that all lifting devices meet the weight standard and are in good working condition.

Additionally, ensure that all vehicle loads are evenly distributed and stationary. If the vehicle is supported only by the frame rails, make sure that the lifting device does not exert excessive force on the frame rails or damage them.

- The rear-end lifting machine cushion block should not touch the rocker panel to the outside of the frame rail or the floor

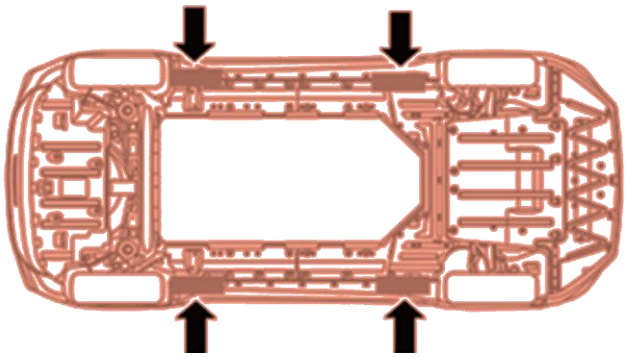
Place the rear-end cushion block for the lifting machine in the following position:

• Below the junction between the rear frame rails and the side frame rails

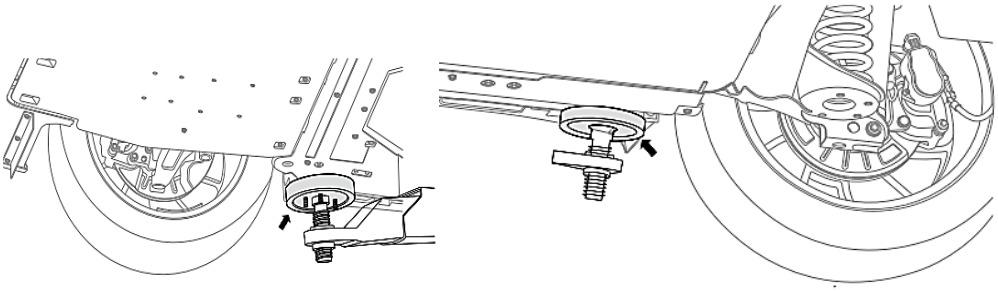
- The front-end lifting machine cushion block should not touch the rocker panel to the outside of the frame rail or the floor.

Place the front-end lifting machine cushion block in the following position:

• Below the junction between the front frame rails and the side frame rails.



a) Vehicle lifting points



B) Rear-End Lifting Machine Cushion Block

C) **Front-End Lifting Machine Cushion Block**

Fig 3.16: Location of Vehicle Lifting Points

ROUTINE INSPECTION

a) Power Battery System

- Check the after-sales installations that may affect the power battery system. Check system components that are easily accessible or can be seen to find out if there is any obvious damage or if there is a situation that may cause a malfunction.
- Check whether there is water or foreign matter outside the power battery.
- Check whether the high-voltage harness connector of the power battery is loose and whether there are signs of corrosion inside.
- Items to be checked while operating the vehicle

b) Horn Operation:

It is essential to press the horn periodically to ensure that it functions correctly. It is also important to check the positions of all buttons.

c) Brake System Operation:

When applying the brakes, it is crucial to remain alert for abnormal sounds or an increase in brake pedal travel. If there is repetitive brake running deviation, it is also necessary to take notice. Moreover, if the brake warning light is on or flashing, there may be a failure in some parts of the brake system.

d) Tyres, Vehicle, and Orientation Operation:

While driving on the highway, be alert to any vibrations in the steering wheel or seat, which may indicate that a wheel needs balancing. Additionally, if

the vehicle is running sideways on straight roads, it may be necessary to adjust the tyre pressure or wheel alignment.

e) Steering System Operation:

Pay attention to any changes in the steering action. If the steering wheel is difficult to turn or has too much free travel, or if there is an abnormal noise while turning or parking, it needs to be checked.

f) Lighting System Operation:

It is critical to observe the beam-focusing of the headlamp light occasionally. If the headlamp light's beam-focusing is incorrect, it needs to be adjusted.

✓ **Items should be inspected at least twice a year**

1. ***Brake master cylinder brake oil level***
   Check the fluid and keep it at the correct level, a low fluid level may indicate that the disc brake pads are worn and need repair. Check the vent hole on the reservoir cap to make sure there is no dirt and the airway is unobstructed.
2. ***Lubrication of doors and windows sealing strip***
   Use a clean rag to apply the sealing strip with silicone grease film.

✓ ***Items should be inspected during each replacement***

1. **Reducer (transmission) oil**
   Check the fluid level and add oil if necessary. Follow Reducer Oil Level Check Procedure, Reducer Oil Filling and Replacement

2. **Brake system inspection**
   Note: low brake fluid level may indicate that the disc brake pads are worn and need repair. Also, if the brake system warning lamp does not go out or turn on, the brake system may have faults. If the anti-lock brake system warning lamp does not go out or turn on, the anti-lock brake system may have faults. The check should be completed when the wheels are removed for transposition. Check whether the pipeline and hose connection are correct and whether there is catching, leakage, crack or scratch. Check the disc brake pads for wear. Check the surface condition of the brake disc and other brake parts, including the brake wheel cylinder, parking brake, etc. Check the adjustment of the parking brake, and shorten the interval between brake checks if driving habits or driving conditions require frequent braking

3. **Inspection of suspension and front drive axle shield and seals**

Check the front and rear suspension and steering system for damaged, misplace and signs of wear or insufficient lubrication. Clean and check the drive axle shield and seals for damage, cracking or leakage. If necessary, replace the seals.

✓ **Items to be checked during each filling**

4. **Check the coolant level and condition of the motor controller**
   - Check the liquid level in the expansion tank assembly and add integrated power controller coolant if necessary.
   - Check the motor controller coolant and replace the dirty integrated power controller coolant.
5. **Check the windshield washer fluid level**
   - Check the washer fluid level in the reservoir tank and add washer fluid if necessary.

✓ **CHECK THE ITEMS AT LEAST ONCE A MONTH.**

6. **Tyre and wheel and air pressure check**
   - **Check** tyres for abnormal wear or damage, check wheels for damage, check tyre pressure when it is cold, and also check spare tyre, keep the recommended pressure on the tyre label.
7. **Operation of the vehicle lamp**
   - Check the operations of license plate lamp, headlights (including high and low beam), parking lamps, fog lamps, tail lights, brake lamps, turn signals, reversing lamps and warning lamps.
8. **Oil and fluid leak check**
   - After the vehicle has been parked for some time, regularly check whether there is water or other liquids on the ground under the vehicle.
   - It is normal for the air conditioning system to drip water after use. If leakage is found, immediately find the cause and eliminate the fault.

Symptom	Possibility and cause	Measures
DC Charging Port Cannot Charge	1. The DC charging pile is faulty	Replace with normal charging pile.
	2. Low voltage communication circuit fault	Check DC Charging Port Fault Check Fast-charging Port Fault

	3. High voltage charging circuit failure	Check DC Charging Circuit Fault (Type l) Check DC Charging Circuit Fault (Type ll)
	4. BMS fault	Check the BMS module software version and update it. Replace the BMS if necessary
Battery temperature is too high or too low	1. BMS fault	Check the BMS module software version and update it. Replace the BMS if necessary
	2. Power battery circuit fault	Check the cell detection circuit and replace the harness if necessary (it is allowed to remove the power battery, otherwise the power battery should be replaced)
	3. Power battery fault	Check the internal circuits and contactors of the power battery, and replace **them** if necessary (it is allowed to remove the power battery, otherwise**,** the power battery should be replaced)
	4. Power battery cooling system fault	Check the power battery cooling system, coolant, water pump, fan, etc., and replace if necessary
Do not charge with a charger	1. AC charging pile or AC power supply failure	Replace with the normal charging pile or replace with the normal and stable power supply
	2. Charging connection circuit failure	Check and repair the charging connection circuit. Replace it if necessary
	3. Vehicle-mounted charger fault	Replace the vehicle-mounted charger
	4. BMS fault	Check the BMS module software version and update it. Replace the BMS if necessary
Charging status is abnormal	1. Charging connection circuit failure	Check and repair the charging connection circuit. Replace it if necessary
	2. Power supply fault	Replace with a normal and stable power supply
	3. Charger failure	Replace with normal charger.
	4. BMS fault	Check the BMS module software version and update it. Replace the BMS if necessary
The whole system does not work after the system is powered on	1. High-voltage circuit and low-voltage control circuit faults	Check the high-voltage lines and related low-voltage control lines, and replace the harness if necessary.

	2.BMS fault	Check the BMS module software version and update it. Replace the BMS if necessary
	3.VCU fault	Check the VCU module software version and update it, and replace the VCU if necessary
	4.Power battery fault	Check the internal circuits and contactors of the power battery, and replace if necessary (it is allowed to remove the power battery, otherwise the power battery should be replaced)

DIAGNOSIS

To diagnose a vehicle with complex communication on-board diagnostics (OBD), it is necessary to connect it to an intelligent detector. This will allow the user to read various data outputs from the control module. According to OBD specifications, the onboard computer will light up the fault lamp whenever it detects faults in parts or components of the system, and these fault Codes are recorded in the control module storage. If a fault does not reappear in three continuous cycles, the fault lamp will go out automatically, but the fault Codes will still be recorded in the control module storage.

To initiate the diagnostic process, the cable of the fault diagnostic instrument should be connected to the diagnostic interface. The key should then be turned to activate the vehicle power supply to the ON gear, thus enabling the diagnostic instrument. If there is a communication error on the display screen, there may be a problem either in the vehicle or in the diagnostic instrument.

Did you know that the **DC Bus,** also known as the DC Link, is a vital component in electric drives? It helps maintain a stable voltage across its terminals using a high-value capacitor. The DC Link acts as an interface between the rectifier and the DC/AC converter, and regulating its voltage is crucial for optimal motor performance. The voltage sensor measures the DC Bus voltage and passes this information to the controller. The DC Link capacitor isolates the input circuitry from the output circuitry to some extent, and it's important to choose the right capacitance value - not too small or too large. I hope this information helps!

REMOVING AND INSTALLING POWER BATTERY

Replacement of Power Battery

Removal procedure

1. Disconnect the negative cable of the battery. Disconnecting and connecting battery cable.
2. lift the vehicle. Lifting and jacking of vehicle as shown in Fig. 3.17.
3. Disconnect the DC BUS assembly. Replacement of DC Bus assembly as shown in Fig. 3.18 (1 and 2 indicate the DC BUS assembly).
4. Drain the power battery coolant. Follow the coolant replacement procedure.
5. Remove the power wire harness cover plate assembly. Replace the power wire harness cover plate assembly.
6. Remove the battery bottom shield Replace the battery bottom shield.
7. Place the flatbed under the vehicle and use the flatbed to support the power battery assembly.
8. Pull the snap ring 1 of the power battery water inlet pipe outward. as shown in Fig. 3.19.
9. Pull the snap ring 2 of the power battery water outlet pipe outward.
10. Unplug the water inlet and outlet pipes of the power battery.

Caution

Before pulling out the battery inlet and outlet pipes, prepare a container for waste liquid and

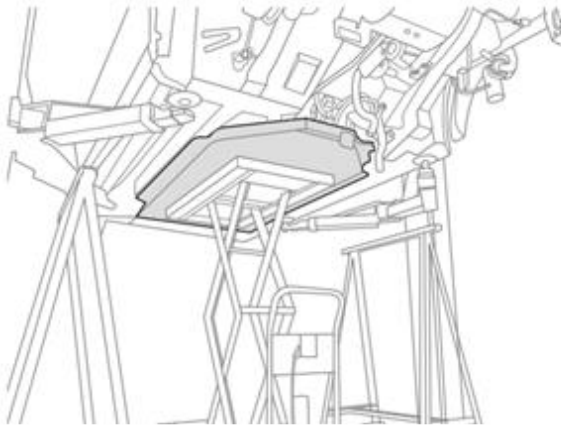


Fig 3.17: Lifting the vehicle

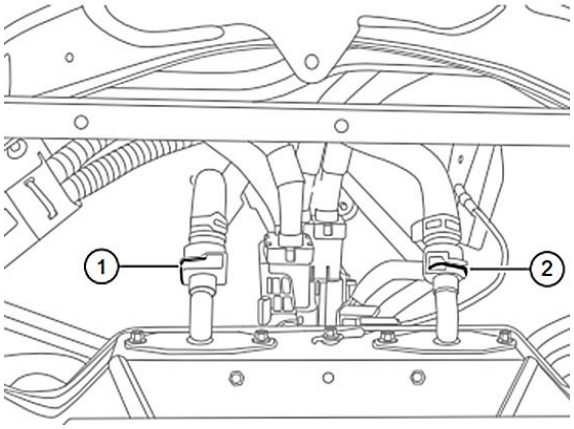


Fig 3.18: Disconnect the DC bus assembly

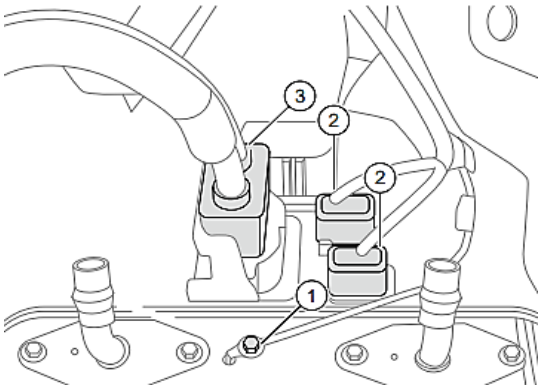


Fig 3.19: Pull the Snap Ring

place it at the connection between the battery inlet and outlet pipes to prevent the battery coolant from overflowing.

11. Remove the 1 fixing bolt 1 of the power battery ground wire.
12. Disconnect the front compartment harness connector 2.
13. Disconnect the power battery high-voltage harness connector 3.
14. Remove the 3 rear mounting bracket fixing bolts of the power battery pack as shown in Fig. 3.20.
15. Remove the fixing bolts at the bottom of the power battery as shown in Fig. 3.21.
16. Slowly lower the flatbed and take out the power battery.

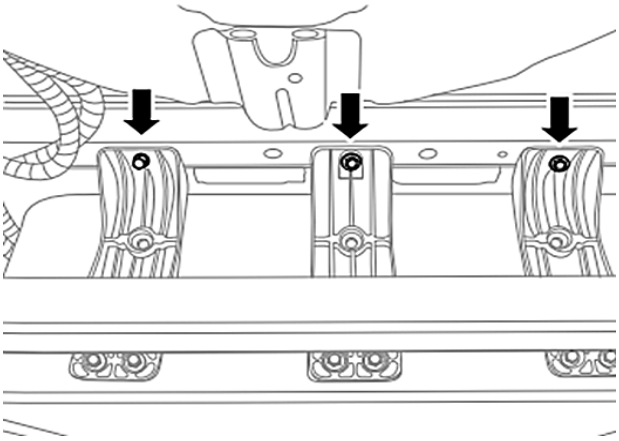


Fig 3.20: Remove the 3 rear mounting bracket fixing bolts

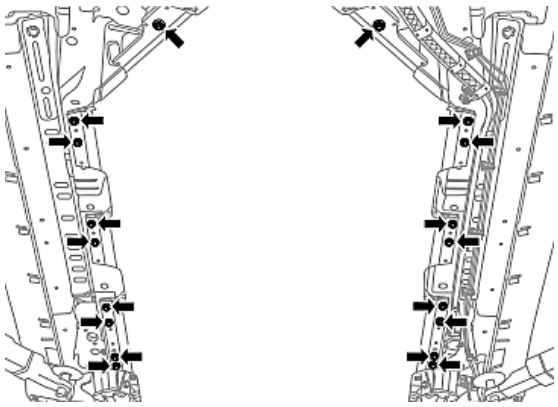


Fig 3.21: Remove the fixing bolts

Caution:
During the descent of the power battery, move the flatbed forward slowly to avoid interference between the power battery and the rear suspension.

Installation procedure

1. Move the power battery onto the flatbed, slowly lift the flatbed, and adjust the flatbed position to align the mounting hole on the power battery to align with the mounting nut on the vehicle body.

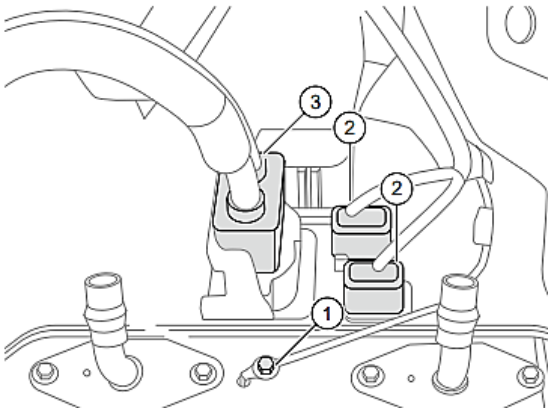


Fig 3.22: adjustment of the flatbed position

2. Install the fixing bolts at the bottom of the power battery.

Caution
During the ascent of the power battery, move the lifting platform backward slowly to avoid the interference by the power battery and the vehicle body.

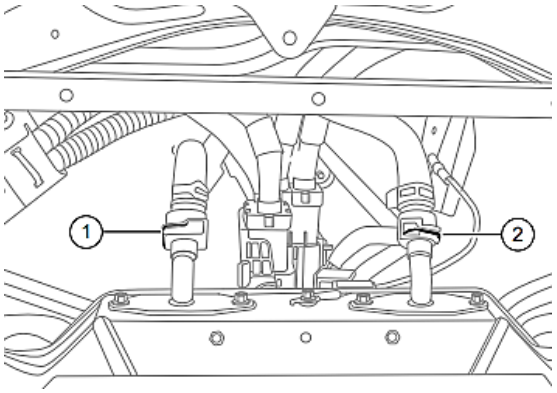


Fig 3.23: Installation of Rear Mounting

3. Install the 3 rear mounting bracket fixing bolts of the power battery pack.
4. Connect the power battery high-voltage harness connector 3.
5. Connect the harness connector 2 between the power battery and the front compartment harness.
6. Install the power battery ground wire fixing bolt 1.
7. Move the battery inlet pipe and battery outlet pipe to the installation positions.
8. Install the battery outlet pipe clamp 2.
9. Install the power battery inlet pipe clamp 1.
10. Install the battery bottom shield.
11. Install the power wire harness cover plate assembly.
12. Fill the power battery coolant.
13. Connect the DC bus assembly.
14. Lower the vehicle.
15. Connect the negative cable of the battery.

HIGH VOLTAGE DISTRIBUTION SYSTEM

Diagnostic information and procedures

1. Check the after-sales installations that may affect the operation of the high-voltage distribution system.
2. Check system components that are easily accessible or can be seen to find out if there is any obvious damage or if there is a situation that may cause a malfunction.
3. Check whether there is water or foreign matter outside the high-voltage distribution system.
4. Check whether the high-voltage harness connector of the high-voltage distribution is loose and whether there are signs of corrosion inside.

Fault symptom table

Symptom	Suspected parts	Measures
i. High voltage interlocking fault	1. VCU (Electric Vehicle Control Module), harness and connector	Check whether the VCU harness and connector are properly connected and repaired, and replace the VCU if necessary.
	2. Repair the isolating switch, harness and connector	Check and repair the disconnector switch harness and connector for normal connection and repair. Replace the disconnector switch if necessary.
	3. The high and low-voltage charging system, wiring harness and connector	Check whether the high- and low-voltage charging system harness and connectors are properly connected and repaired, and replace the high- and low-voltage charging system if necessary.
	4. Motor compressor, harness and connector	Check whether the motor compressor harness and connector are properly connected and repaired, and replace the motor compressor if necessary.
ii. Motor compressor failure	1. Motor compressor	Replace the motor compressor.
	2. Motor compressor high-voltage circuit	Motor compressor circuit fault

	3. High and low-voltage charging system	Check the software version of the high and low voltage charging system and update it. Replace the high and low voltage charging system if necessary.

REMOVING AND INSTALLING OF HIGH VOLTAGES DISTRIBUTION SYSTEM

High voltage maintenance power-on and power-off process

power-off process

1) Lift the vehicle.
2) Disconnect the negative cable of the battery. Disconnecting and Connecting Battery Cable.
3) Remove the power wire harness cover plate assembly. Replacement of Power Wire Harness Cover Plate Assembly if required.
4) Disconnect the 1 harness connector of the DC bus assembly connecting the power battery.

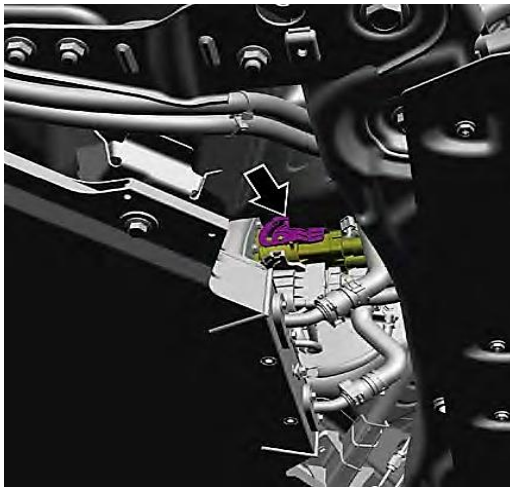


Fig 3.23: Removal of the power wire harness

5) Use a Multimeter to test the voltages between positive to ground, negative to ground, and positive and negative at both ends of the high-voltage connector plug socket, and confirm that the voltage value is ≤ 60V.

power-on process

1. Connect the 1 harness connector of the DC bus assembly connecting power battery.
2. Install the power wire harness cover plate assembly.
3. Connect the negative cable of battery.
4. Lower the vehicle.

Replacement of DC Bus Assembly

Removal procedure

- Disconnect the negative cable of the battery. Disconnecting and Connecting Battery Cable
- Remove the front compartment cover assembly. Replacement of Front Compartment Trim Cover Assembly
- Lift the vehicle.
- Remove the power wire harness cover plate assembly. Replace the Power Wire Harness Cover Plate Assembly
- Disconnect the DC bus assembly harness connector (HV/ LV charging system side).

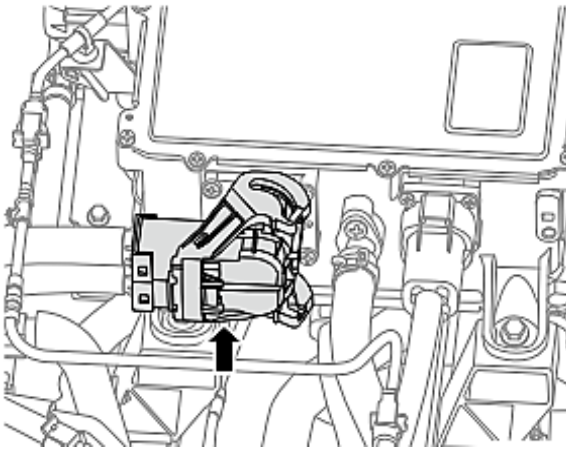


Fig 3.24: Disconnect the DC bus Assembly

Caution: Require insulation treatment; avoid coolant splashing on the plug.

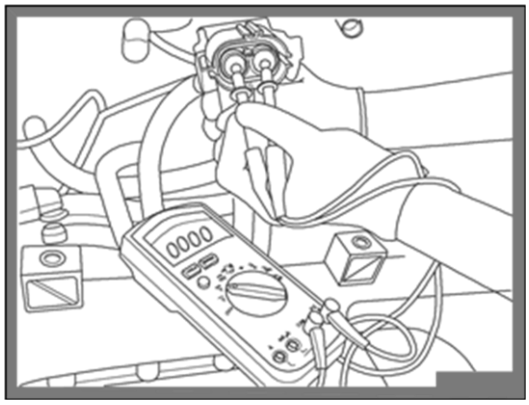


Fig 3.25: Measuring the Bus Voltage using a Multimeter

- Use a multimeter to measure the bus voltage after standing still for 5 minutes.
- Disconnect the negative cable of battery. Disconnecting and Connecting Battery Cable.
- Lift the vehicle.
- Remove the power wire harness cover plate assembly. Replacement of Power Wire Harness Cover Plate.

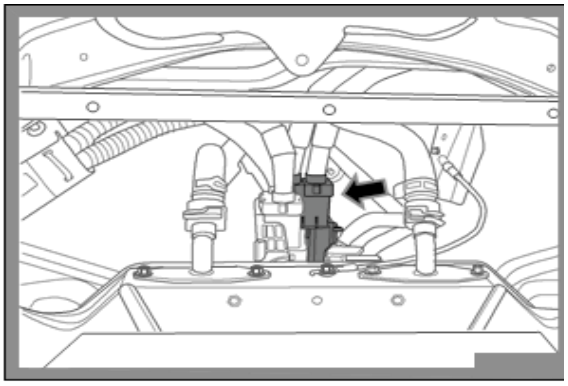


Fig 3.26: Replacement of the power harness cover plate

Installation procedure

1. Move the DC bus assembly to the mounting position and assembly wire harness clips.
2. Connect the DC bus assembly harness

connector (at the power battery side).

Caution: Pay attention to "one plug, two rings, three confirmations" when plugging.

3. Connect the DC bus assembly harness connector (at the high and low-voltage charging system side).
4. Install the power wire harness cover plate assembly.
5. Lower the vehicle.
6. Install the front compartment cover assembly.
7. Connect the negative cable of the battery.

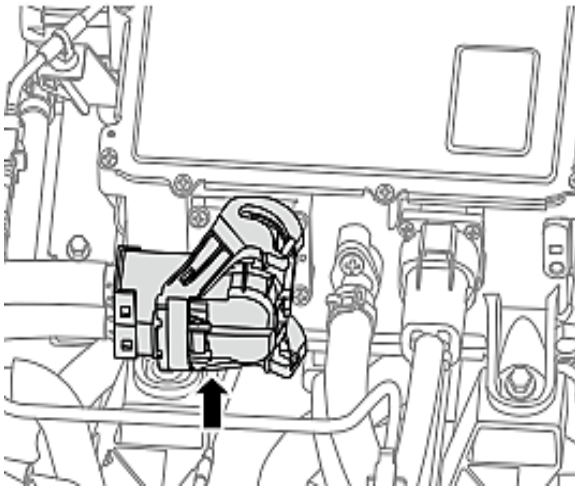


Fig 3.27: Connect the DC bus Assembly

Replacement of DC Bus Assembly (Low-configuration)

Removal procedure

1. Disconnect the negative cable of the battery. Disconnecting and Connecting Battery Cable
2. Lift the vehicle.
3. Remove the power wire harness cover plate assembly. Replace the Power Wire Harness Cover Plate Assembly
4. Disconnect the DC bus assembly harness connector (HV/ LV charging system side).
5. Use a multimeter to measure the bus voltage after standing still for 5 minutes.
6. Disconnect the DC bus assembly harness connector (the side of power battery).
7. Disconnect the DC bus assembly fixing clips and take off DC bus assembly.

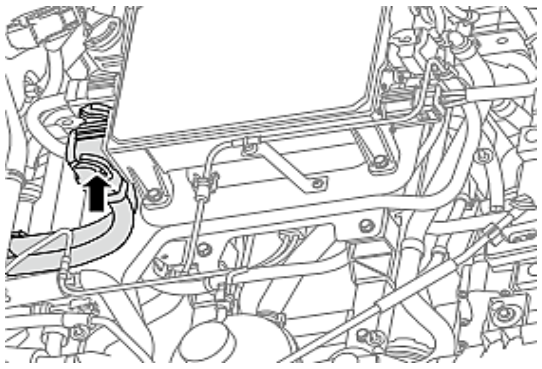


Fig 3.28: Disconnecting Battery Cable

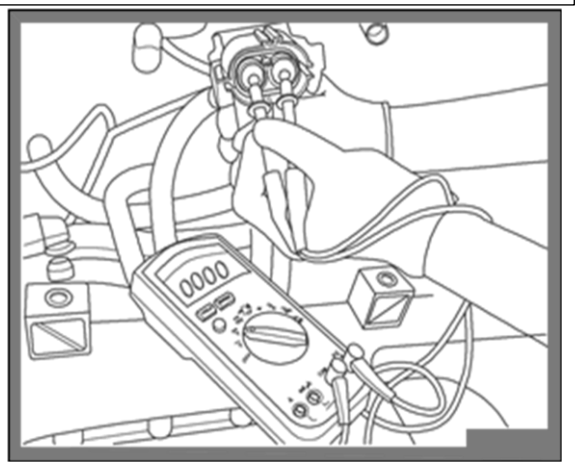


Fig 3.29: Multimeter to measure the bus voltage

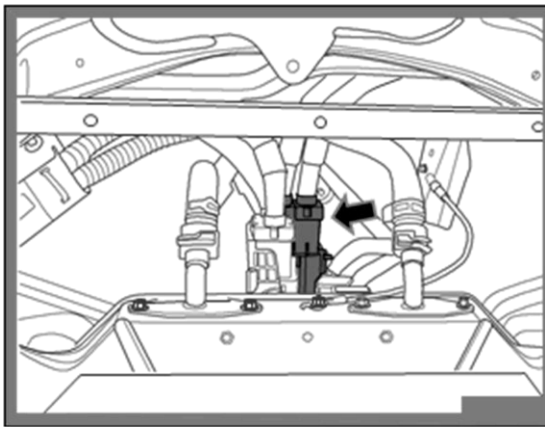


Fig 3.30: Disconnect the DC bus assembly fixing clips and take off DC bus assembly.

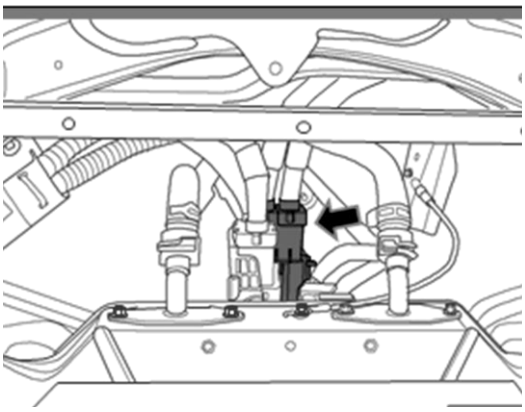


Fig 3.31: Move the DC bus assembly harness connector

Installation procedure

a. Move the DC bus assembly to the mounting position, and install wire harness clips.
b. Connect the DC bus assembly harness connector (at the power battery side).
c. Connect the DC bus assembly harness connector (at the high and low-voltage charging system side).
d. Install the power wire harness cover plate assembly.
e. Lower the vehicle.
f. Connect the negative cable of battery.
g.

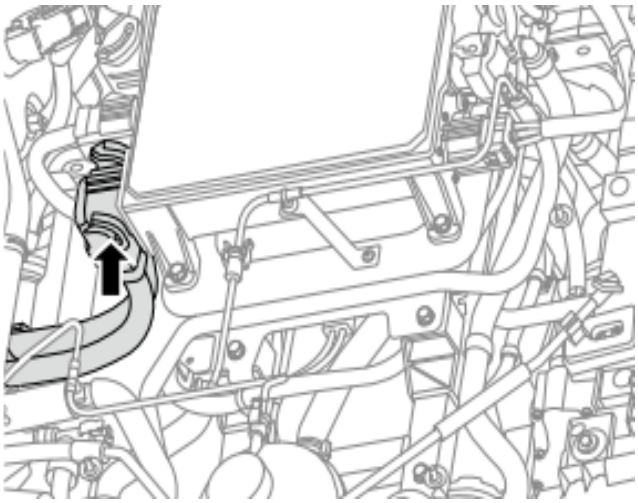


Fig 3.32: Installation the power harness cover and connect the negative cable of battery

Tyre s Diagnosis

Before we start diagnosing any issues with the wheel and tyre , let's make sure we understand how the system works and its operating procedures. This will help us take the right steps when a fault occurs. Also, it can help us figure out if the issue reported by the customer is just a normal part of the system's operation.

Routine inspection

- Check the after-sale installations to confirm that these installations will not influence the normal operation of the wheels and tyre s.
- Checking system parts that are easily accessible or can be seen to guarantee that there is no obvious damage or situation that may cause a fault.
- Check for the following conditions:
  – Obvious tyre and wheel run-out.
  – Obvious drive axle run-out.
  – Incorrect tyre pressure.
  – Incorrect vehicle front end height.
  – Wheel curve or damage.
  – Scarps on tyre s or wheels.
  – Abnormal or excessive tyre wear.
  – Defects in tyre s, including tread distortion and separation caused the collision and slight indentation of tyre side wall, are normal, which do not affect the driving quality.

In case of any of the above circumstances, please repair or replace the corresponding parts

Know Your Progress

Multiple Choice Questions (MCQs)

1. What is the primary purpose of a thorough diagnosis for an electric vehicle with noticeable issues?

   A. To upgrade the vehicle's software
   B. To change the vehicle's tyre s
   C. To install new high-voltage wires
   D. To measure various aspects like battery performance and motor function

2. When lifting an electric vehicle, why is it crucial to ensure the jack pads do not touch the brake hose or high-voltage wires?

   A. To prevent noise
   B. To avoid vehicle damage or deterioration of performance

C. To ensure the vehicle looks good
D. To avoid lifting the vehicle too high

3. What should be checked at least twice a year according to the routine inspection schedule?

   A. Brake master cylinder tank level
   B. Tyre pressure
   C. Battery charge level
   D. Headlight alignment

4. What might vibrations in the steering wheel or seat indicate while driving on the highway?

   A. The vehicle is running low on fuel
   B. The headlights are misaligned
   C. A wheel needs balancing
   D. The brake fluid is low

5. What action should be taken if the DC charging port cannot charge and the DC charging pile is faulty?

   A. Replace with normal charging pile
   B. Adjust the brake system
   C. Update the vehicle software
   D. Replace the windshield wiper fluid

Fill in the Blanks

1. If the brake warning light is on or flashing, there may be a failure in some part of the _____ system.
2. It is essential to check the positions of all buttons when ensuring correct _____ operation.
3. If the vehicle is supported only by the frame rails, make sure the lifting device does not exert excessive force on the _____ rails.
4. When checking the high-voltage harness connector of the power battery, it is crucial to check if it is _____ and if there are signs of corrosion inside.

Short Questions

1. Why is it important to ensure the vehicle is on a clean, hard, and level surface before lifting it?
2. What are some signs that the brake system might need inspection or repair?
3. What should be done if there is a communication error on the display screen during the OBD diagnostic process?

4. Why is it necessary to check the insulation resistances of charging ports and high-and-low-voltage systems?
5. What measures should be taken if the battery coolant starts to overflow during the removal of the power battery inlet and outlet pipes?

Activities

1. Visit the nearby service centre for Electric Vehicles and get a hands-on experience with an OBD diagnostic tool. Also, read fault codes, and interpret the data to diagnose potential issues by using the OBD diagnose tool.
2. Visit the nearby service centre for Electric Vehicles to understand the importance of safety inspections and proper procedures.

Module 4	Routine Service and Repair of Heavy Commercial EVs

Module Overview

This unit covers the basics of maintaining and repairing Heavy Commercial Electric Vehicles (HCEVs). We'll identify and understand different components, discuss maintenance best practices, and troubleshoot common issues like low battery life and charging problems. By the end of the unit, you will have the knowledge and skills to care for and maintain HCEVs effectively.

Learning Outcomes

After completion of this module, you will learn:

1) Demonstrate preparatory activities for diagnosing faults and repairing a Heavy Commercial Electric Vehicle.
2) Demonstrate how to assist in repairing and maintaining Heavy Commercial Electric Vehicle related tasks.

Module Structure

Session 1: Major Components of Heavy Commercial Electric Vehicles
Session 2: Reading of Owner's (Manufacturer) Manual and Service Manual
Session 3: Routine Inspection of Heavy Commercial Components Maintenance
Session 4: Troubleshooting of Components of Heavy Commercial EVs

Session 1: Major Components of Heavy Commercial Electric Vehicles

Fig. 4.1: Heavy Commercial Electric Vehicles (HCEVs)

Major Components of Power Train

1. Battery Pack
2. Battery Management System
3. Traction Motor
4. Motor Controller
5. HV Power Distribution Unit
6. LV Power Distribution Unit
7. DC-DC Converter
8. Vehicle Control Unit
9. Pneumatic System
10. Hydraulic System
11. Cooling System
12. Bus Aux unit
    a. Compressor motor -> Compressor
    b. Steering motor -> Steering
13. Lighting & Horn

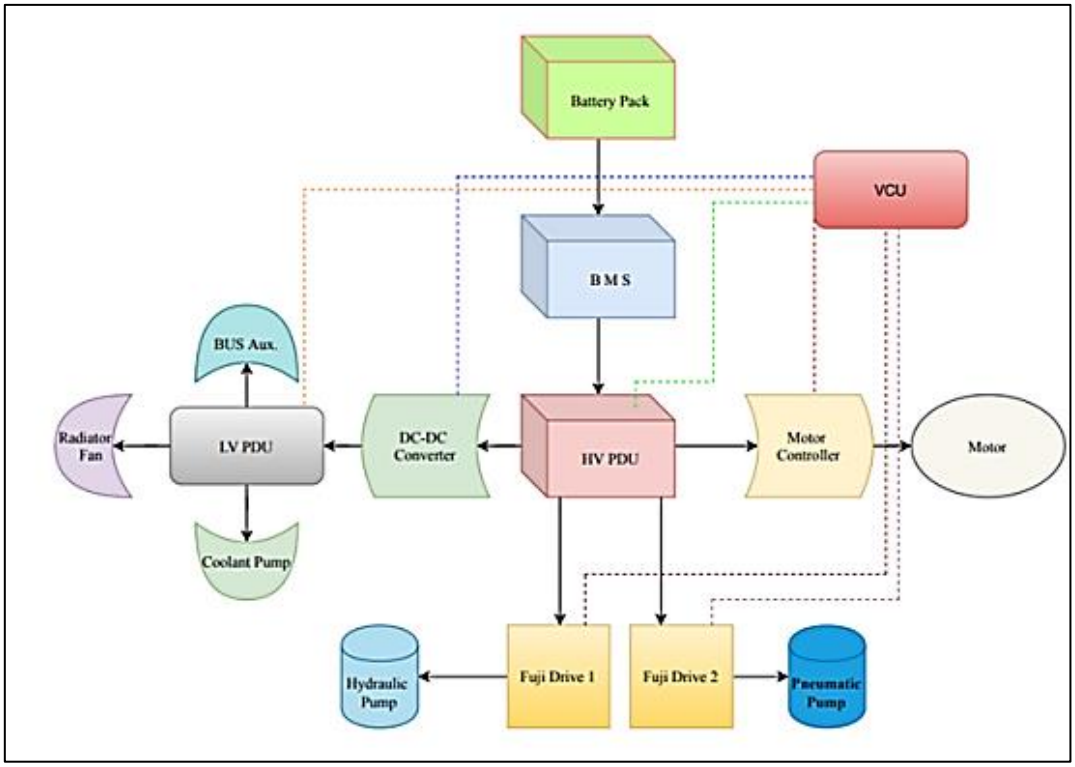


Fig 4.2: Flow Diagram of components of Heavy Commercial Electric Vehicles (HCEVs)

Powertrain of Electric bus

Powertrain refers to the set of components that generate the power required to move the vehicle and deliver it to the wheels. An EV powertrain has 60%

fewer components than the powertrain of an Internal Combustion Engine (ICE) vehicle. The components are described below:

- Battery Pack – The battery pack is made up of multiple Lithium-ion cells and stores the energy needed to run the vehicle. Battery packs provide direct current (DC) output.
- DC-AC Converter – The DC supplied by the battery pack is converted to Alternating current (AC) and supplied to the electric motor.
- This power transfer is managed by a sophisticated motor control mechanism (also referred to as a Powertrain Electronic Control Unit) that controls the frequency and magnitude of the voltage supplied to the electric motor to manage the speed and acceleration as per the driver's instructions communicated via acceleration/brakes.
- Electric Motor – Converts electrical energy to mechanical energy delivered to the wheels. Many motor generators can perform regeneration as well.
- Charger – Converts AC received through the charge port to DC and controls the amount of current flowing into the battery pack.

The powertrain could be an overnight charging powertrain or an opportunity charging powertrain based on the requirement of an operator. The figure below indicates the powertrain of an Electric bus.

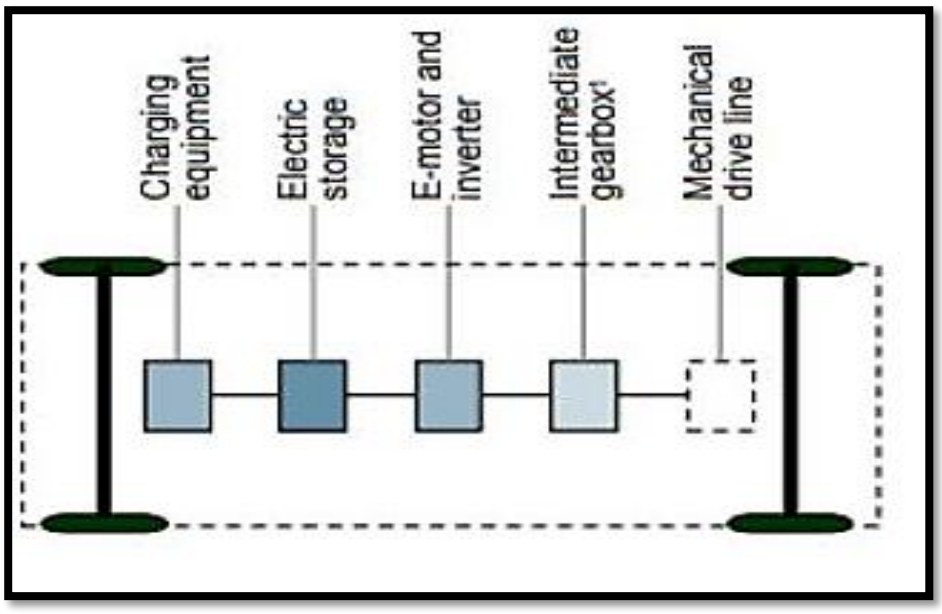


Fig. 4.3: Block diagram of Electric Bus Powertrain components

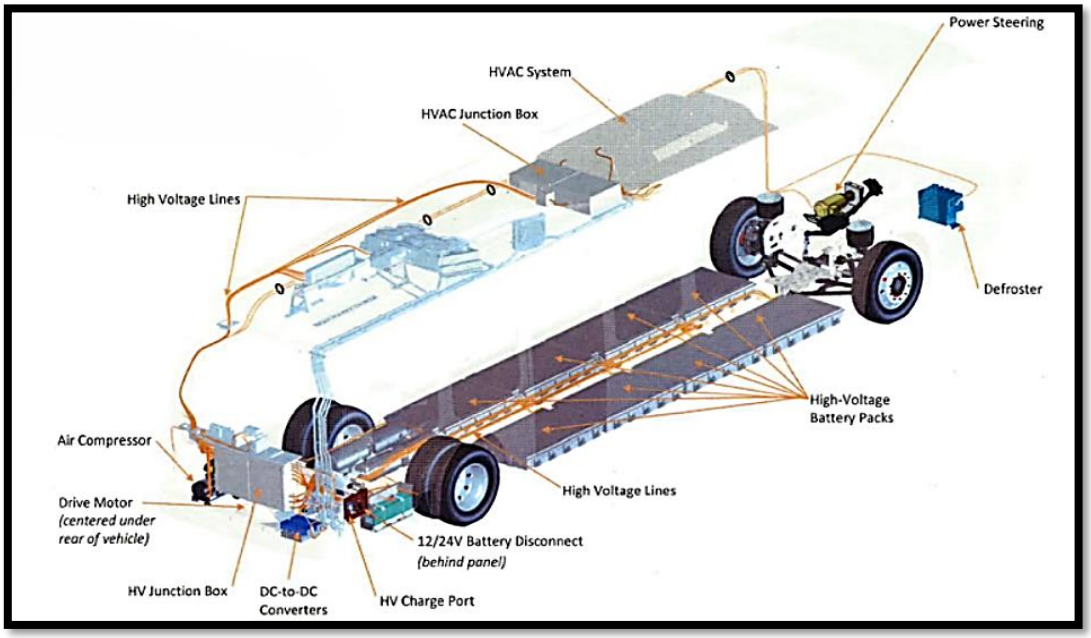


Fig. 4.4: Electric Bus Powertrain components

Electric Vehicles in India

Are you interested in exploring the latest trends in the transportation industry? We will explore the world of electric trucks and unveil their groundbreaking features, advantages, and environmental impact. Electric trucks have emerged as a revolutionary force for adapting the transportation industry with sustainable and cost-effective alternatives to traditional petrol and diesel vehicles. Get ready to be amazed by the wonders of electric trucks!

1. Tata Ultra E.9:

The Tata Ultra E.9 is a beacon of innovation in the electric truck landscape. With a Gross Vehicle Weight (GVW) of 9000 kg, this truck is tailored for urban transportation needs. Its fully electric drivetrain ensures zero tailpipe emissions, contributing to a cleaner environment. The spacious cabin, advanced safety features, and range of 120-150 km make it a versatile and eco-friendly choice for businesses.

Fig 4.5: Tata Ultra E.9

2. Eicher Pro 2055 EV:

The Eicher Pro 2055 EV embodies economic efficiency and environmental responsibility. With a GVW of 5500 kg, this truck offers superior mileage and reduced operational costs. Its load body options cater to diverse cargo transportation needs, while its eco-friendliness aligns with global sustainability goals. Safety features such as hydraulic brakes ensure a secure ride, making it an ideal choice for businesses committed to green practices.

Fig 4.6: Eicher Pro 2055 EV

3. Olectra 6x4 Electric Tipper:

The Olectra 6x4 Electric Tipper excels in heavy-duty transportation, boasting a GVW capacity of 28000 kg and a powerful 362 horsepower engine. Its versatility and zero tailpipe emissions make it suitable for various terrains and applications.

Fig 4.7: Olectra 6x4 Electric

With reduced operational costs and a focus on sustainability, this electric tipper offers a compelling solution for businesses seeking efficiency and environmental stewardship.

Fig 4.8: Omega Seiki Mobility M1KA

4. Omega Seiki Mobility M1KA:

The Omega Seiki Mobility M1KA offers a 90 kWh Lithium NMC battery and zero emissions, it covers up to 250 km on a single charge, making it ideal for last-mile delivery services. Its compact design and impressive operating range position it as a versatile choice for urban transportation.

5. Ashok Leyland BOSS 1218 EV:

The Ashok Leyland BOSS 1218 EV Truck combines advanced safety features with exceptional engine performance. With zero tailpipe emissions and a range of 300-350 km per charge, it offers efficiency and practicality in the electric truck segment.

Fig 4.9: The Ashok Leyland BOSS 1218 EV

6. Tata Starbus Urban 9/12 m

Tata Starbus Urban electric bus is made by Tata Motors. It can fit more than 31 people and goes as fast as 75 km/h. It weighs about 17800 kg and has a big battery of 186 kWh. The motors are super strong, giving out 245 kW of power. You can charge it up in 2 to 3 hours and it can run for over 150 km without stopping.

Fig 4.10: Tata Starbus Urban Electric bus

7. Ashok Leyland Circuit S:

The Ashok Leyland Circuit S is the first electric bus made in India. It can travel up to 120 kilometres on just one charge and can seat between 35 to 65 people. The starting price is around Rs. 1.5 crore. It's powered by Sun Mobility's swappable battery and has a powerful output of 200HP. This bus needs less maintenance because it has fewer moving parts and a smaller battery.

Fig 4.11: Ashok Leyland Circuit S

8. Olectra C9

The Olectra C9 is 12 meters long and seats 45–49 people. It's equipped with two strong 180 kW electric motors that can produce a lot of power. The battery lasts for about 300 km and can be charged in 2 to 3 hours using a fast-charging system.

Fig. 4.12: Olectra C9

9. JBM ECO-LIFE Electric

ECO-LIFE is India's first all-electric bus. It comes in two sizes: 9m and 12m, and can carry over 35 passengers. The lithium-ion battery has a 261-kWh capacity and powers of 181 kW motor outputting 2500 rpm. It has a GVM of 18940 kg. Depending on traffic conditions, it can travel 150-200 km in 10-15 hours at 70 km/h.

Fig 4.13: ECO-LIFE

10. Eicher Skyline Pro

Eicher Skyline Pro is the electric bus manufactured by Eicher Motors. The parent company of Eicher Motors is the reputed Eicher Motors which used to manufacture traditional heavy automobiles have entered the Electric Vehicle industry. The company introduced Skyline Pro which is one of the leading electric bus manufacturing platforms. It can accommodate up to 60 people, not including the driver. The electric motor provides a maximum power of 90 hp.

Fig 4.14: Eicher Skyline Pro

Advantages of Electric Trucks:

Electric trucks offer numerous advantages for drivers, businesses, and the environment. They provide quiet and comfortable operation, substantial torque for handling heavy payloads, and lower maintenance costs. Moreover, as zero-emission vehicles, they contribute to mitigating air pollution and reducing the carbon footprint. With competitive pricing, lower operating costs, and government incentives, electric trucks represent a sound investment for businesses seeking sustainability and cost-effectiveness. here is a list of the best EV cars in India.

Know Your Progress

Multiple Choice Questions (MCQs)

1. **What is the primary function of the Battery Management System in an HCEV?**

A. Converting DC to AC
B. Storing energy
C. Managing battery health and performance
D. Controlling the motor speed

2. **Which component of the HCEV powertrain converts DC to AC?**

A. Battery Pack
B. DC-AC Converter
C. Vehicle Control Unit
D. Cooling System

3. **Which component is responsible for converting electrical energy to mechanical energy in an HCEV?**

A. Battery Pack
B. Motor Controller
C. DC-DC Converter
D. Traction Motor

Fill in the Blanks

1. The _____ converts the DC supplied by the battery pack to AC and supplies it to the electric motor.
2. The _____ system in HCEVs manages the voltage supplied to the motor to control speed and acceleration.
3. The _____ component in HCEVs ensures that the high voltage is distributed properly to various parts of the vehicle.

Short Answer Questions

1. What are the environmental benefits of using electric trucks compared to traditional diesel trucks?
2. Describe the purpose of the Battery Management System (BMS) in HCEVs.
3. Compare and contrast the powertrain components of an HCEV with those of an Internal Combustion Engine (ICE) vehicle.
4. Explain the role of the Vehicle Control Unit (VCU) in the functioning of an HCEV.
5. How does the hydraulic system function in an HCEV, and what are its primary uses?

Activities

1. Make the diagrams of HCEV components and label each component.
2. Visit a workshop near your city and practice maintenance tasks on an HCEV model, such as battery health checks, cooling system maintenance, and software updates.
3. Assign students to research and present on one of the electric truck models discussed (e.g., Tata Ultra E.9, Ashok Leyland BOSS 1218 EV). They should cover its specifications, benefits, and potential challenges.

Session 2: Reading of Owner's (Manufacturer) Manual and Service Manual

OWNER'S MANUAL

The manual from the vehicle manufacturer has information on how to operate, maintain, and care for your vehicle. It covers controls, maintenance, troubleshooting, and specifications. It includes details on features, maintenance schedule, fluid capacities, warranty information, visual aids, maintenance instructions, troubleshooting, and safety precautions. The manual also emphasizes safe driving practices and provides guidelines for child safety features and recommendations for using child seats.

Fig. 4.15: Owner's Manual

SERVICE MANUAL

Service manuals are essential for technicians working with electric vehicles. They provide detailed diagnostic and repair information to streamline workflow and ensure consistent and accurate repairs. The manual includes diagnostic procedures, repair instructions, technical specifications, special tools and equipment, visual aids and diagrams, maintenance and service procedures, and safety precautions. Having a service manual on hand is crucial for optimal performance when working on electric vehicles.

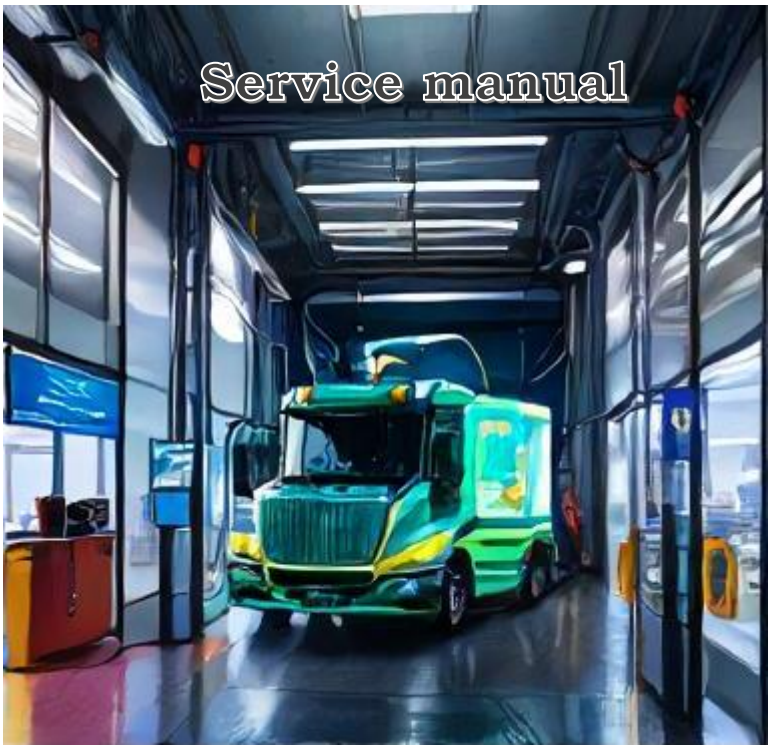


Fig. 4.16: Service Manual

WARRANTY

Category	**Project**	**Time (Month)**	**6**	**12**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
		Mileage * 1000 kilometer	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Replacement and maintenance	Reducer oil		R	R	R	R	R	R	R	R	R	R
	Brake fluid		I	I	R	I	I	R	I	I	R	I
	Door lock, hinge, stopper lubrication		I	I	I	I	I	I	I	I	I	I

Three Electrical inspection	Appearance status of power battery	I	I	I	I	I	I	I	I	I	I
	High-voltage wiring harness and its various high-voltage part seven Connection status, motor low voltage control line bundle	I	I	I	I	I	I	I	I	I	I
	Charger, DC-DC Converter cooling	I	I	I	I	I	I	I	I	I	I
	Power battery system	I	I	I	I	I	I	I	I	I	I
	Vehicle control system	I	I	I	I	I	I	I	I	I	I
Chassis and Brake Inspection	Chassis Fasteners torque	I	I	I	I	I	I	I	I	I	I
	Brake Inspection Brake system hard pipes, hoses, and related components	I	I	I	I	I	I	I	I	I	I
	Transmission shaft, Ball Pin Sheath	I	I	I	I	I	I	I	I	I	I
Consumable inspection	Tyre : Tread depth, nut torque, tyre pressure	I	I	I	I	I	I	I	I	I	I
	Lighting system, electric horn, wiper	I	I	I	I	I	I	I	I	I	I

Explanation of symbols in the table

I-Check these items and their associated parts and, if necessary, correct, tighten, clean, replenish, adjust, or replace.

R-replace or change.

①If necessary, perform four-wheel alignment or tyre dynamic balance.

② Check the tyre condition before driving, and check the tyre pressure with a tyre pressure gauge at least once a month.

VEHICLE IDENTIFICATION NUMBER (VIN)

The Vehicle Identification Number (VIN) is a unique identifier that is legally required for all vehicles. The VIN is usually engraved in several locations for safety and tracking purposes.

To find the VIN, you can look under the front passenger seat, where it is engraved on the beam. Simply move the seat back to its end and lift the protective cover to reveal the VIN.

Alternatively, the VIN can also be found in the following locations:

1. Inside the front compartment
2. On the VCU (Vehicle Control Unit)
3. On the upper part of the middle channel
4. Inside the left or right middle pillar
5. On the lower side of the right B-pillar
6. On the left side wall wheel pack
7. On the inner side of the tailgate.

The VIN is usually attached to the body bracket on the lower left corner of the windshield and is visible from the outside of the vehicle through the windshield. This ensures that the VIN can be easily checked and verified by law enforcement and other authorised personnel.

Immobilisation /Stabilization/Lifting of the Heavy Commercial

To turn the vehicle OFF, follow either the procedure:

1. Park the bus in a safe location;
2. Set the parking brake and select “Neutral” on the push-button Shift selector and turn the Master Run Control to the “OFF” position, as indicated in Fig. 4.17:

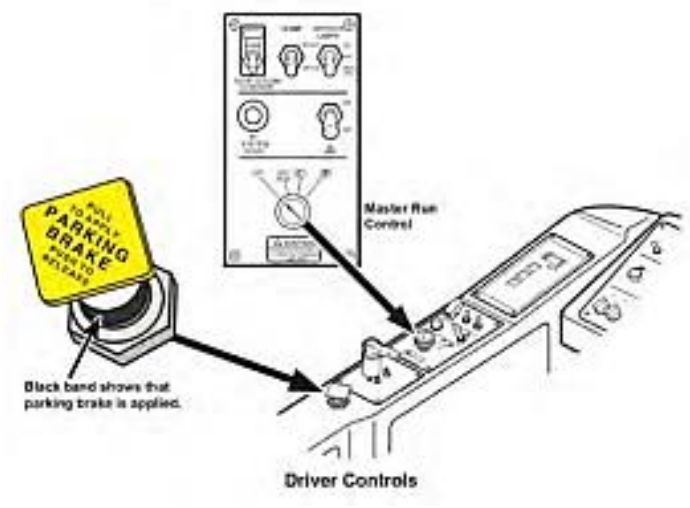


Fig. 4.17: Parking break

3. Release the air pressure from the front door motors by moving the "Door Air" lever, located at the rear of the driver's left console) to the "RELEASE" position. This action avoids automatic door closure;
4. Wait at least 60 seconds;
5. Disable the system by rotating the 12/24V front disconnect switch 2A or by rotating the rear door disconnect switch 2B as shown in Fig. 4.18.

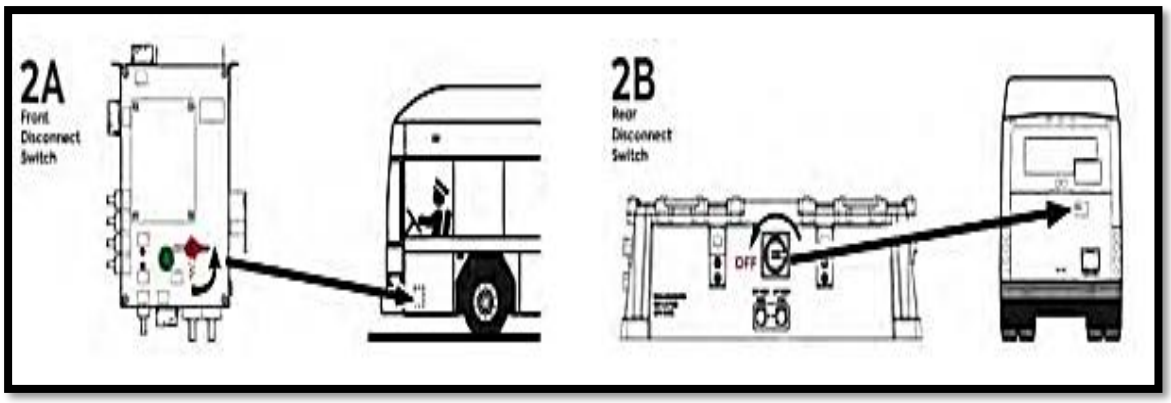


Fig. 4.18: Disable the system by rotating

6. Wait 10 minutes after shutdown before accessing High-Voltage components.
7. The (Fig. 4.19) to prevent the possibility of the jack sliding from under the bus.

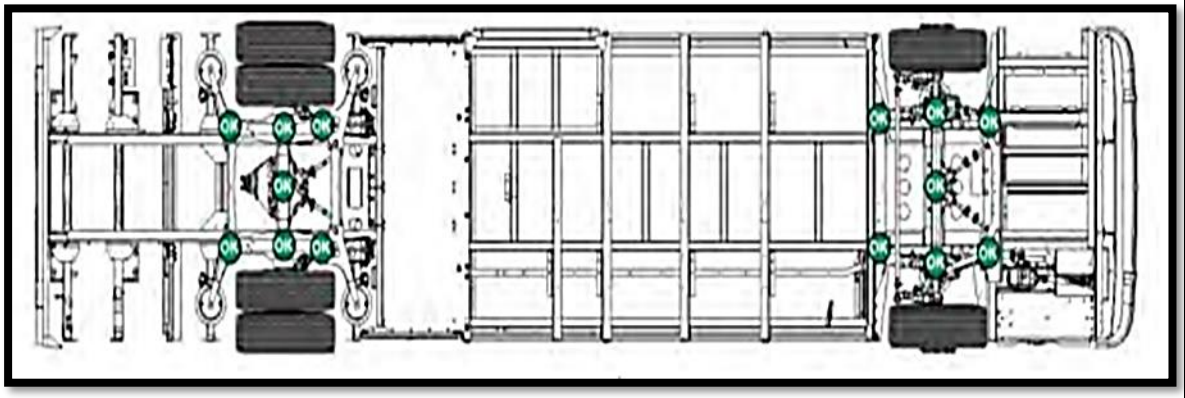


Fig. 4.19: Floor Jack Must be Located Properly

8. Do not position the jack under the "dropped" frame rails in the centre section of the bus!
9. Block or chock the front and rear of the wheel on the opposite side of the bus being raised to help prevent the bus from moving.
10. If a flat tyre is to be removed, raise the bus so an inflated spare tyre will just clear the surface.
11. Jacking the bus to change a front tyre can be done on the front axle beam and at other frame locations indicated by the "OK" symbol. Jacking the bus to change a rear tyre can be done on the rear axle and at the locations on the rear suspension indicated by an "OK" symbol.

High-Voltage Battery Information

General First-Aid Measures and Environmental Aspects

Under normal conditions of use, the battery does not present any risk of exposure to its content. However, unforeseen circumstances (e.g., a vehicle collision) may cause damage to one or more battery cells with uncontrolled increases in temperature and pressure (thermal runaway), which can lead to several possible hazards, as described below:

1. Exposure to High Voltage (>60V):

1) Avoid contact with HV cabling and components. ALWAYS assume the HV system is energized.
2) Avoid contact with a damaged HV battery, a significant shock hazard may exist.
3) NEVER cut orange HV cabling or penetrate HV components with tools.
4) HV system shutdown procedures are designed to disable the vehicle's HV system, not to discharge the HV battery.

2. The HV Battery will remain energized

- Even with the HV batteries completely discharged (State of charge = 0), the system remains within the class B voltage definition and should therefore be disconnected.
- Sparks, smoke, or bubbling noises coming from the HV battery are signs of a potentially overheating battery, which could result in a delayed fire.

Follow local medical protocols and First Aid SOPs for any burn, electrical, or other injuries.

Exposure to electrolyte mixture:

- Wear appropriate PPE if exposure to electrolyte is expected. It is highly recommended due to the possibility of severely irritating fumes.
- Any clothing or PPE that may have come into contact with electrolytes should be either decontaminated or discarded appropriately.

Inhalation in Non-Fire situations:

- If you detect leaking fluids, sparks, smoke, or bubbling noises coming from the HV battery, ventilate the vehicle by opening the windows to prevent the build-up of fumes.
- If electrolytes leak and get exposed to the air, electrolytic vapours may be released. Even in a non-fire situation, the electrolytic vapours may be toxic or at least severely irritating. If vapours are inhaled, immediately move to fresh air.

Safety measures for Battery handling:

- The battery assembly cover should never be breached or removed under any circumstances, including fire. Doing so might result in severe electrical burns, shocks, or electrocution.

Harmful and/or flammable fumes:

- Contents of HV batteries should be considered corrosive, toxic, and/or flammable.
- If you detect unusual odours or experience eye, nose, throat, or skin irritation, use full PPE.

- If you detect leaking fluids, sparks, smoke, or bubbling noises coming from the HV battery, ventilate the vehicle by opening doors and windows to prevent the build-up of fumes.
- Parks, smoke, or bubbling noises coming from the HV battery are signs of a potentially overheating battery, which could result in a delayed fire.

Spill/leak hazards from HV batteries:

- HV Li-Ion batteries are considered dry cell batteries, and if damaged or broken, electrolyte leakage should be minimal.
- The HV batteries of this vehicle are liquid-cooled. If such batteries are damaged, coolant may leak.
- The coolant is a water/glycol/ethylene solution, similar to that of the conventional vehicle radiators, and should not be confused with a battery electrolyte.
- If damage is widespread, cross-contamination with battery electrolyte is possible.

Know Your Progress

Multiple Choice Questions (MCQs)

1. Which section of the owner's manual typically contains information about the vehicle's features and specifications?
   A. Introduction
   B. Controls
   C. Maintenance
   D. Table of Contents

2. What is the primary purpose of a service manual?

   A. To provide an overview of the vehicle's history
   B. To guide vehicle operation and maintenance for owners
   C. To offer detailed repair instructions and diagnostics for technicians
   D. To list safety features and protocols

3. Where can the Vehicle Identification Number (VIN) commonly be found?
   A. On the lower left corner of the windshield
   B. On the steering wheel
   C. Inside the glove compartment

D. On the roof of the vehicle

4. What should you do first to turn off a heavy commercial vehicle?
   A. Release the air pressure from the front door motors
   B. Set the parking brake
   C. Turn the Master Run Control to the "OFF" position
   D. Move the "Door Air" lever to the "RELEASE" position

5. What is a key safety measure when handling high-voltage batteries?
   A. Always assume the HV system is de-energized
   B. Cut orange HV cabling if necessary
   C. Avoid contact with HV cabling and components
   D. Remove the battery assembly cover if there are sparks

Fill in the Blanks

1. Visual aids in the owner's manual include _____ and diagrams to clarify instructions.
2. Service manuals are designed for _____ professionals.
3. The Vehicle Identification Number (VIN) is usually visible through the _____.
4. Before accessing high-voltage components, wait _____ minutes after shutdown.

Short Answer Questions

1. Describe the purpose of the Vehicle Identification Number (VIN).
2. Discuss the differences between an owner's manual and a service manual.
3. Describe the process of immobilizing and lifting a heavy commercial vehicle safely.
4. What are the risks associated with handling high-voltage batteries, and how can they be mitigated?
5. How does the maintenance schedule in the service manual help in maintaining vehicle performance and safety?

Activities

1) Collect the owner's manual and have them locate specific information, such as maintenance schedules, fluid capacities, or safety instructions in Heavy Commercial Electric Vehicles.

2) Make a diagram of a Heavy Commercial Electric Vehicles with numbered parts and have them label each part using the owner's manual and service manual as references.

Session 3: Routine Inspection of Components and Maintenance of Heavy Commercial Electric Vehicles

Users should do maintenance as follows, which will decide the performance of the vehicle and life of the vehicle:

Maintenance of Battery

Battery electrolytes are poisonous and dangerous and may cause severe burns, injury, etc. Always wear protective clothing, gloves, and goggles when handling batteries, electrolytes, and charging your battery.

1) Cleaning

a) The exterior of the battery, the connection wires, and the bolts should always be kept clean and dry. When cleaning, please make sure all vent caps are tightly in place. Clean the battery top with a cloth or brush and a solution of baking soda and water. When cleaning, do not allow any cleaning solution, or other foreign matter to get inside the battery. This should be done every week.

b) Clean battery terminals and the inside of cable clamps using a post and clamp cleaner. Clean terminals will have a bright metallic shine. This should be done when it is necessary.

c) Reconnect the clamps to the terminals and thinly coat them with petroleum jelly (Vaseline) to prevent corrosion.

2) Checking the terminals and nuts

The connection of the battery should always be kept in good condition. Please check every week on whether any battery cable terminal or nut has become loose, to prevent any spark or damage to terminals. Please check every week to see if any battery cable is damaged or not. Any damaged battery cable should be replaced immediately.

3) No foreign matter

Do not place any objects on the battery and do not connect the positive pole to the negative pole. This may cause a short circuit, dangerous spark, or may cause damage to the battery or injury to your body.

4) Recharging

a) As long as you use the vehicle, regardless of how long you have used it, the battery should be fully recharged on the same day. Any delay in the re-charging will cause a negative effect on the battery.
Note: the lead-acid battery does not develop a memory, so it does not need to be fully discharged before recharging.

b) If the vehicle is going to be kept unused for a certain long time, the battery shall be fully recharged first. After that, the battery shall be fully recharged every 2 weeks.

c) When driving, the driver shall be always aware of the drop level of the battery power from the battery power meter, any drop means the battery power is diminishing. Besides, the driver shall estimate the distance needed to be taken, and recharge the battery at a proper time in case the vehicle cannot get back to the recharging station in time for recharging.

5) Checking the liquid level

During the use of the battery, the water inside the electrolyte will be consumed because of electrolysis and volatilization, and that will cause the liquid level be drop, therefore it's a must to check the liquid level frequently, we recommend checking it every week. Add distilled water if the liquid level is under the standard.

6) Watering

Flooded batteries need distilled water. More importantly, watering must be done at the right time and in the right amount, or else the battery's performance and longevity suffer. Distilled water should always be added after fully charging the battery. Before charging, there should be enough water to cover the plates. If the battery has been discharged partially or fully, the water level should also be above the plates. Keeping the water at the correct level after a full charge will prevent having to worry about the water level at a different state of charge. Depending on the local climate, charging methods, applications, etc. It's recommended that batteries be checked once a month until you get a feel for how thirsty your batteries are.

Important things to remember:

1. Do not let the plates get exposed to air. This will damage (corrode) the plates.

2. Do not fill the water level in the filling well to the cap. This most likely will cause the battery to overflow with acid, consequently losing capacity and causing a corrosive mess.
3. Do not use water with a high mineral content. Use distilled water only.

The electrolyte is a solution of acid and water so skin contact should be avoided. Step-by-step watering procedure:

1. Open the vent caps and look inside the fill wells.
2. Check the electrolyte level; the minimum level is at the top of the plates.
3. If necessary add just enough water to cover the plates at this time.
4. Put batteries on a complete charge before adding any additional water.
5. After charging, open the vent caps and look inside the fill wells.
6. Add water until the electrolyte level is 1/8" below the bottom of the fill well.
7. A piece of rubber can be used safely as a dipstick to help determine this level.
8. Clean, replace, and tighten all vent caps.

7) Testing

Visual inspection alone is insufficient to determine the battery's overall health. Both open-circuit voltage and specific gravity readings can give a good indication of the battery's charge level, age, and health. Routine voltage and gravity checks will not only show the state of charge but also help spot signs of issues with the vehicle, such as undercharging and over-watering, and possibly even locate a bad or weak battery. The following steps outline how to properly perform routine voltage and specific gravity testing on batteries.

I. Specific Gravity Test (Flooded batteries only}

1. Do not add water at this time.
2. Fill and drain the hydrometer 2 to 4 times before pulling out a sample.
3. There should be enough sample electrolytes in the hydrometer to completely support the float.
4. Take a reading, record it, and return the electrolyte to the cell.
5. To check another cell, repeat the 3 steps above.
6. Check all cells in the battery.
7. Replace the vent caps and wipe off any electrolytes that might have been spilled.
8. Correct the readings to 80° F
   Add .004 to readings for every 10° above 80° F Subtract .004 for every 100 below 80° F
9. Compare the readings.
10. Check the state of charge using Table 1.

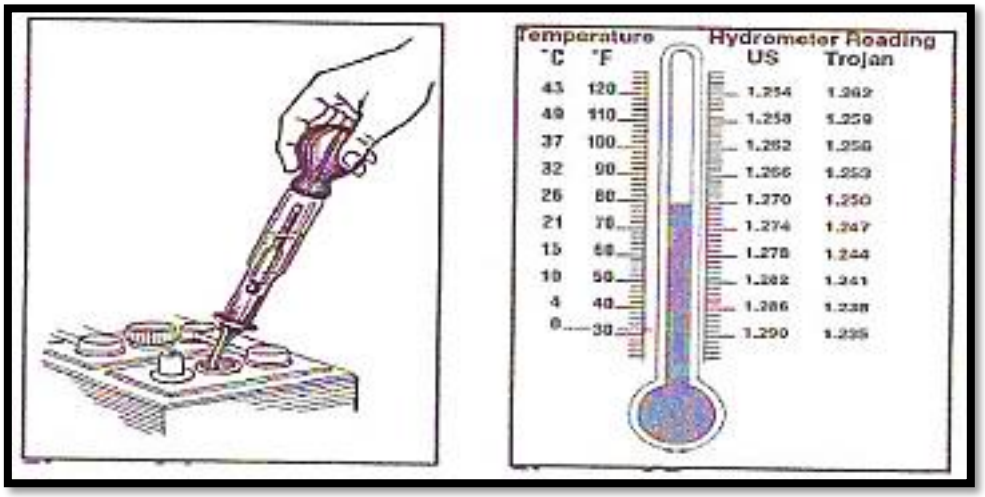


Fig. 4.20: Use of Hydrometer

The readings should be at or above the factory specification of 1.277 +/.007. If any specific gravity readings register low, then follow the steps below.

1. Check and record voltage level(s).
2. Put battery(s) on a complete charge.
3. Take specific gravity readings again.

If any specific gravity readings still register low then follow the steps below.

1) Check voltage level(s).
2) Perform equalization charge. Refer to the Equalizing section for the proper procedure.
3) Take specific gravity readings again.

If any specific gravity reading still registers lower than the factory specification of 1.277+/- .007 then one or more of the following conditions may exist:

1. The battery is old and approaching the end of its life.
2. The battery was left in a state of discharge for too long.
3. Electrolyte was lost due to spillage or overflow.
4. A weak or bad cell is developing.
5. The battery was watered excessively previous to testing.

Batteries in conditions 1 - 4 should be taken to a specialist for further evaluation or retired from service.

II. Open-Circuit Voltage Test

For accurate voltage readings, batteries must remain idle (no charging, discharging) for at least 6 hrs.

1. Disconnect all loads from the batteries.

2. Measure the voltage using a DC voltmeter.
3. Check the state of charge from Table 4.1.
4. Charge the battery if it registers 0% to 70% charged.

If the battery registers below the Table values, the following conditions may exist:

1. The battery was left in a State of Discharge for too long.
2. The battery has a bad cell.

Batteries in these conditions should be taken to a specialist for further evaluation or retired from service.

Table 4.1. State of charge as related to specific gravity and open circuit voltage

Percentage of Charge	Specific gravity Corrected to 80° F	Open Circuit Voltage					
		6V	8V	12V	24V	36V	48V
100	1.277	6.37	8.49	12.73	25.48	38.20	50.93
90	1.258	6.31	8.41	12.62	25.24	37.85	50.47
80	1.238	6.25	8.33	12.50	25.00	37.49	49.99
70	1.217	6.19	8.25	12.37	24.74	37.12	49.49
60	1.195	6.12	8.16	12.24	24.48	36.72	48.96
50	1.172	6.05	8.07	12.10	24.20	36.31	48.41
40	1.148	5.98	7.97	11.96	23.92	35.87	47.83
30	1.124	5.91	7.88	11.81	23.63	35.44	47.26
20	1.098	5.83	7.77	11.66	23.32	34.97	46.63
10	1.073	5.75	7.67	11.51	23.02	35.42	46.03

Battery Installation

Tighten the battery cables to battery terminals with a torque of 95-1051bs/inch or 10.7-11.9 N.M., make sure there is nothing else between the battery cable lug and battery terminal post. When working with the battery, DO NOT put wrenches or any other metal objects across the battery terminals, otherwise, an arc can occur, and it may cause an explosion of the battery and physical injury. The battery is to be installed or replaced only by a qualified electrician.

Battery Charging

Check your vehicle to see which kind of charger it has. The onboard charger is either installed in the rear bag well, under the seat, or on the front body. When it's an onboard charger, a separate charging cord will be provided with the vehicle for connecting the charger and AC electricity.

The following are the charging steps:

1. Turn the power key to OFF.
2. Connect the DC output plug to the vehicle receptacle, and then connect it to your local AC power outlet.
3. The charger will turn off automatically when the battery is fully charged.
4. After the charger turns off, disconnect the plug on the AC charging cable from the AC power outlet first, and then disconnect the DC output plug from the vehicle receptacle.
5. It is prohibited to open the housing of the charger.
6. Only a qualified electrician is allowed to open the housing of the charger.
7. The charger should be stored in a safe and dry room with good ventilation.
8. The charger should be packed properly and stored if not used for a long time.
9. Read carefully the operation manual for the charger for detailed operation instructions.

Equalizing charge

Equalizing is an overcharge performed on flooded lead acid batteries after they have been fully charged. It reverses the buildup of negative chemical effects like stratification, a condition where acid concentration is greater at the bottom of the battery than at the top. Equalizing also helps to remove sulfate crystals that might have built up on the plates, which is called Sulfation. If left unchecked it will reduce the overall capacity of the battery.

When the battery is fully charged and remains connected to the charger, every 8 hours the charger will charge 8 minutes to maintain the battery. After 20 hours, the equalizing charge will start and last 2 hours. Equalizing charge can also be started manually by pressing down the 'STOP' button for 5 seconds when charging. Equalizing charge will start in 1 hour when the battery is fully charged.

Equalizing is recommended when low or wide-ranging specific gravity (+/- .015) is detected after fully charging a battery. An equalizing charge is recommended every month for the batteries when they are used.

Maintenance of the Gear Box

1. The clearance for the clutch should be kept between 2-3mm.

2. The friction plate should be changed periodically; the friction value on one side should not exceed 2mm.
3. Adjust the flatness of the platen spring plate (feeling manual): first tighten the screws diagonally, and use your hand to check the flatness of the spring plate. If not flat, tighten the screws for the non-flat part.
4. Change the gear oil inside the gearbox periodically (for new vehicles, change the oil after one month or if the total running distance exceeds 1200kms; change the oil again two months later, then change the oil every half a year).
5. Clean the gearbox before changing the oil.

Maintenance of the Traction Motor

1. For the DC motor, the carbon brush should be checked every 3 months to see if it is worn or not as it is an easily worn part. If it is not replaced in time before it becomes worn out, it will damage the motor badly. The brush spring shall also be checked when checking the carbon brush.
2. Do not keep the motor running idly for long periods. Any idle running of the motor should be avoided.
3. Removal of mud, sand, and other clinging objects shall be done frequently to facilitate the heat-radiation.
4. Periodically use the low-pressure air to remove the dust from the carbon brush and the commutator. Periodically check the connection between the carbon brush and the commutator.

Item	Symptoms	Possible Causes
1.	All Copper plates turn black	The pressure of the brush is incorrect
2.	The commutating copper turns black in a certain order and groups	Short circuit between commutating copper or among the armature coil; poor welding or disconnection happens between the commutating copper and the armature coil
3.	The commutating copper turns black disorderly	The central line of the commutator deviates or its surface is not round and not smooth
4.	The brush wears out, changes colors and breaks	The motor vibrates; the clearance between the brush and its holder is too big; the clearance between the brush and commutator is too big; the mica between different commuters extrudes; the brush is made by of the wrong materials; the brush is wrong in type

5.	Big Sparks	The motor is overloaded; the commutator is not clean; not round or not smooth; mica or some commutator is coming out; the brush is not ground properly; the brush is big from pressure; the brush is wrong in type; the brush is jammed in the brush holder; the brush holder becomes loose or vibrating; the polarity and sequence of magnetic poles becomes wrong.	
6.	The brush and its wires get hot	Big sparks from the brush; poor contact between the brush and soft wires; small section area of soft wires	
7.	The brush is noisy	The surface of the commutator is not smooth.	

Maintenance of the Speed Controller

The speed controller of the vehicle is wholly imported and adopts high-frequency technology to realize the control of speed, torque, and brake with smoothness, silence, high efficiency, and energy-saving operation.

- Prevents the vehicle from running away when started. When the vehicle starts, the controller will inspect the signal from the accelerator, if the signal exceeds 20%, the High-Power Density (protection unit in the controller) will prohibit the output of the controller.
- When the vehicle starts, the “protection unit in the controller” will take effect. The controller will self-check when the vehicle is running. If any defect is detected, the controller will stop the vehicle to protect the operator and the vehicle.

Cleaning

It is recommended that the controller be kept clean and dry and that its fault history file be checked and cleared periodically. Periodically cleaning the controller exterior will help protect it against corrosion and possible electrical control problems created by the dirt, grime, and chemicals that are part of the operating environment and that normally exist in battery-powered systems. Please use the following cleaning procedure for routine maintenance:

1) Turn the power key to the OFF position.
2) Turn off the power by disconnecting the battery.

3) Discharge the capacitors in the controller by connecting a load (such as a contactor coil or a horn) across the controller's B+ and B- terminals.
4) Remove any dirt or corrosion from the connector areas. The controller should be wiped clean with a moist cloth. Dry it before reconnecting the battery. The controller should not be subjected to pressured water flow from either a standard hose or a power washer.
5) Make sure the connections are tight but do not over-tighten them.

Faulty History File

A vehicle program can be used to access the controller's fault history file. This will help to read out all the faults the controller has experienced since the last time the history file was cleared. Faults such as contactor faults may be the result of loose wires; contractor wiring should be carefully checked. Faults such as over temperature may be caused by operator habits or by overloading.

After a problem has been diagnosed and corrected, it is a good idea to clear the fault history file. This allows the controller to accumulate a new file of faults. By checking the new history file at a later date, you can readily determine whether the problem was indeed fixed. Or check the problems according to the flashing of the STATUS light on the top of the controller, please refer to the details mentioned in our service manual which is available separately.

1 D — per day, 1W —per week, 1M — per month 10 — per quarter 1Y — per year

ITEM	DESCRIPTIONS	1D	1W	1M	1Q	1Y
Battery	Check the liquid level. Please add distilled water if necessary.		y			
	Charge the battery	Y				
	Tighten the nut on the battery cable		Y			
	Check if the battery is over-discharged (the battery power meter flashing)	Y				
	Check the liquid density of the battery, the standard density should be 1.275±0.005 (25).		Y			
	Check to see if the battery is charged fully in 2 ways: a) using the hydrometer; and b) checking the battery power meter.	Y				

	Clean the surface of the battery		Y			
Charger	Observe the charging status, and check to see if the charger plug becomes hot.	Y				
	Clean the surface of the charger. Do not get any water inside the charger.		Y			
Controller	Check to see if all terminals are tightened properly. Please do this after the power is off.				Y	
	Clean the surface of the controller.				Y	
	Check if the solenoid is in order, checking its touching point.					Y
Motor	Check if any water gets in. Check if it becomes too hot.	Y				
	Check if the carbon brush should					Y
	Check whether the accelerator pedal works well and if it can be released freely and automatically.				Y	
Chassis and body	Check whether the brake drum and the brake shoe should be replaced or not.				Y	
	Check to see if the hand brake functions.				Y	
	Check to see if the hose and tube for the brake fluid is leaking.			Y		
	Check to see if the brake fluid inside the brake fluid tank is enough.			Y		
	Check the air pressure inside the tyre, and check if the tyre surface is worn. Check to see if the nuts are tightened properly.		Y			
	Check to see if the shock absorber has any oil leaking, flat, or abnormal noise.			Y		
	Check if there is oil leaking on the gearbox and the rear end.		Y			
	Add the lubricant inside the wheel hub, and steering system.				Y	

	Adjust the toe-in of the front end					
	Clean the body and seat				Y	
After the above maintenance, drive the vehicle to check to see if the vehicle works properly.						

Know your progress

Multiple Choice Questions (MCQs)

1. What should be worn when handling batteries, electrolytes, and charging your battery?
   A. Protective clothing, gloves, and goggles
   B. Casual clothing
   C. Only gloves
   D. Sunglasses and a hat
2. How often should the exterior of the battery be cleaned?
   A. Daily
   B. Weekly
   C. Monthly
   D. Yearly
3. What should you do if the battery liquid level is under the standard?
   A. Add regular tap water
   B. Ignore it
   C. Add distilled water
   D. Add saltwater
4. When is the best time to add distilled water to a flooded battery?
   A. Before charging
   B. During charging
   C. After charging
   D. When the battery is completely discharged
5. What should be done if any battery cable is found to be damaged?
   A. Tape it up
   B. Ignore it
   C. Clean it
   D. Replace it immediately

Fill in the Blanks

1. The electrolyte in the battery is a solution of _____ and water.
2. To prevent corrosion, battery terminals should be coated with _____ after cleaning.

3. When the vehicle starts, the controller will inspect the signal from the _____.
4. If the vehicle is unused for a long period, the battery should be recharged every _____.
5. Equalizing charge is recommended every _____ for batteries when they are in use.

Short Answer Questions

1. Why is it important to wear protective gear when handling batteries and electrolytes?
2. Describe the proper way to clean battery terminals.
3. What should you do if you notice that the battery power meter is flashing, indicating over-discharge?
4. Explain the step-by-step procedure for properly maintaining a vehicle battery.
5. What are the consequences of improper watering of flooded batteries and how can they be avoided?
6. Describe the maintenance procedure for a vehicle's speed controller.

Activities

1. Demonstration of cleaning and maintaining a vehicle battery, including checking liquid levels and performing specific gravity tests.
2. Diagnosing and troubleshooting battery issues based on specific symptoms and test results.

Session 4: Troubleshooting of Components of Heavy Commercial EVs

There is no certain mode to diagnose and eliminate the malfunction of Electric Vehicles. During maintaining and checking, we suggest you first listen, then look and feel. Below are the diagnoses and maintenance of some common malfunctions.

1) The vehicle doesn't move. Turn on the power key, and step on the accelerator pedal, the vehicle doesn't move.

Malfunction	Possible reason	Troubleshooting
Turn on the power key, The Volta meter has no signal	The connector (s) in the circuit is loose or open	Tighten or connect
	The fuse of the controller or main circuit is open	Change fuse

	Battery cable(s) is loose or disconnected	Tighten or change
	The power key is broken	Change
	The Volta meter is broken	Change
	Battery terminals connected improperly	Adjust
Turn on the power key, Volta meter has a signal.	Improper operating procedure	Operate properly
	Controller Failure	Check or Change
	Solenoid Failure	Check, repair, change
	Accelerator Failure	Repair or Change
	Motor Failure	Repair or change
	The parking brake doesn't loosen	Loosen parking brake
	Over-heat protection	Check, eliminate

2) Lose control when the vehicle starts running: speed cannot be adjusted

Malfunction	**Possible reason**	**Troubleshooting**
The vehicle runs at full speed when it just starts	Terminals of Solenoid stick together	Check, repair
	Controller failure	Change
	Potentiometer failure	Repair, change
The vehicle stops immediately after it starts	Internal short of Motor	Repair, change
	The motor is assembled too tight or blocked	Repair, change
	Controller failure	Repair, change
	Accelerator Failure	Repair, change
Normal at low-speed Weak power at high speed	Controller Failure	Check, change
	Motor Failure	Check, change
	Accelerator Failure	Check, change

3) Vehicle cannot change direction: vehicle can only run in one direction

Malfunction	Possible reason	Troubleshooting
Vehicles can only run in one direction	Gearbox failure	Change
	Controller Failure	Change

4) Possible reason and troubleshooting of the malfunction of the Electric Vehicle mechanical system

System	Malfunction	Possible reason	Troubleshooting
Transmission System	Abnormal sound when running	Clearance of the rear axle decelerating gear is too big, or the decelerating gear is broken	Adjust, change
		The transmission cross shaft is worn out	Change
		The gear of the transmission is worn out or damaged	Change
		Flange bearing damage	Change
		Motor bearing damage	Change
		Gear fluid is deficient or empty	Add gear fluid
	Hard to shift gear, and/or gear shift jumps in different positions	The clutch cannot separate smoothly	Adjust
		Gear shift tight wire damaged	Change
		The gear inside the transmission case is worn out	Change
		The orientation pin is loose	Change
Steering System	Steering heavy	The pressure of the front tyre is low	Check pressure and Inflate
		The screw plug of the Redirector is too tight	Adjust
		Lack of lube in the redirector	Maintain, add lubricant
		Toe-in abnormal	Adjust
		The clearance of the tension rod ball is too big	Change
		The steering knuckle and master pin are not lubricating	Add Lubricant
		The steering shaft or its plastic cover is worn out	Change

	Steering unstable (wheels flirt)	A rack of redirectors worn out	Change Redirector
		The screw plug of the Redirector is too tight	Adjust
		Toe-in adjusted improperly	Adjust
		Bearing of front wheel worn out '	Change
		Tie rod ball and joint worn out	Change tie rod
		Redirector loose	Tighten
Driving System	Deflected Running	The pressure of two front tyre s is different	Inflate
		Toe-in is too big or too small	Adjust
		The tightness of the left and right drum bearings of the front wheels is different	Adjust
		The brake of one wheel is too tight	Adjust or Change
		The spring shock absorber is abnormal	Change
		Front suspension loose	Change
	Abnormal Tyre Wear	Tyre pressure is not to specification	Inflate or exchange
		Toe-in is improper	Adjust
		Drum bearing loose	Change
		A U-type bolt of the leaf spring is loose	Tighten
		Rim distorted (out of round), frame distorted (out of round)	Tighten
		The brake force of each wheel is different	Adjust
		Overexerting, accelerating, or braking frequently	Alter operation
Brake System	Brake fail	Master cylinder and/or wheel cylinder damaged, leaking oil	Check, eliminate, change
		Brake fluid is low or empty	Add fluid
		Air enters into oil pipe	Let air out
		The free travel of the brake pedal is too long or the clearance of the arrester is too big	Adjust
		The brake drum wears out or	Change
		The master cylinder leaks oil internally	Change

	Braking deviation	The clearance of the left brake drum shoe and the right brake drum shoe is different	Adjust
		Oil on one of the arrester's brake shoe	Clean or change
		Tyre pressure is different	Repair or Change
		One-wheel cylinder's piston blocks	Adjust
		Wheel aligned improperly	Adjust
		The brake drum becomes out-of-round	Change
	Braking drag	The brake pedal has no free travel	Adjust
		The clearance between the brake shoe and the drum is too small or the releasing spring is disabled.	Adjust or Change
		The piston of the wheel cylinder is ineffective	Check, Change
		The piston of the master cylinder is ineffective	Change
		The parking brake is ineffective	Change spring
	Braking noise	Shoes distort	Change
		Brake facing wears out	Change
		Eye winker in brake system	Check, Eliminate
		Brake drum breach, scrape to uneven	Change

Know Your Progress

Multiple Choice Questions (MCQs)

1. What could be a possible reason for the electric vehicle not moving when the power key is turned on and the accelerator pedal is pressed?
   A. Loose battery terminals
   B. Broken accelerator
   C. Overheated motor
   D. Worn-out solenoid
2. In case of losing control when the electric vehicle starts running, what component failure might lead to the inability to adjust speed?
   A. Motor failure
   B. Solenoid failure
   C. Accelerator failure
   D. Controller failure

3. What could be the possible reason if the electric vehicle can only run in one direction?
   A. Controller failure
   B. Motor failure
   C. Gearbox failure
   D. Solenoid failure
4. What could cause the steering to feel heavy in an electric vehicle?
   A. Low tyre pressure
   B. Worn-out steering shaft
   C. Loose tie rod ball
   D. Damaged controller
5. Which component failure might lead to braking deviation in an electric vehicle?
   A. Brake drum distortion
   B. Oil on the brake shoe
   C. Ineffective wheel cylinder piston
   D. Misaligned steering

Fill in the Blanks

1. In case of the vehicle not moving, turn on the power key and check if the Volta meter has _____.
2. If the electric vehicle runs at full speed when starting, the possible reason could be terminals of solenoid sticking together due to _____.
3. If the vehicle can only run in one direction, the probable cause might be _____ failure.
4. Steering heavy in an electric vehicle might indicate a lack of lubrication in the _____.
5. Abnormal tyre wear in an electric vehicle could be due to improper _____.

Short and Long Type Questions

1. Explain the procedure for troubleshooting when an electric vehicle doesn't move despite turning on the power key and pressing the accelerator pedal.
2. Discuss the possible reasons and troubleshooting steps for losing control when an electric vehicle starts running.
3. How would you diagnose and rectify the issue if an electric vehicle can only run in one direction?

4. Describe the maintenance procedures for addressing abnormal tyre wear in an electric vehicle.
5. Analyze the steps involved in troubleshooting braking deviation in an electric vehicle.

Activities

1. Organize a field trip to a Heavy commercial Electric Vehicle maintenance facility where students can observe professionals diagnosing and repairing electric vehicle malfunctions.

Module 5	Innovation, Technology and Environmental Impacts

Module Overview

In this Module, we'll explore the incredible advancements that make electric vehicles possible. From the powerful batteries that store energy to the intricate systems that control the vehicle's movement, there's so much to discover. Why is innovation in electric vehicles important? Well, it's because these innovations are shaping the future of transportation. They're making vehicles safer, more efficient, and even more fun to drive!

Throughout this session, we'll learn about the latest technologies driving the electric vehicle industry forward. We'll explore how electric vehicles are changing the way we think about transportation and how they're paving the way for a cleaner, greener future

Learning Outcomes

After the competition of this module, you will able to:

1) Understand Energy Storage Systems in EVs
2) Identify and explain the characteristics, advantages, and challenges of each type of energy storage system.
3) Learn about different charging methods for EV batteries, including Level 1, Level 2, DC fast charging, and wireless charging.
4) Understand the latest advancements in battery technology, including innovations in battery chemistry, temperature management systems, smart battery management systems, and cycle life testing.
5) Learn about the concept and benefits of battery-swapping techniques as an alternative to traditional charging methods.
6) Understand the Health and hazardous waste

Module Structure

Session 1: Batteries for Electric Vehicles and their parameters
Session 2: Charging Methods of Electric Vehicle (EV) Batteries
Session 3: Key Technology Trends Shaping EVs
Session 4: Hazardous Waste

Session 1: Batteries for Electric Vehicles and their parameters

Fig. 5.1: A type of Battery

Energy storage systems, usually batteries, are essential for all-Electric Vehicles, plug-in hybrid Electric Vehicles (PHEVs), and hybrid Electric Vehicles (HEVs).

Types of Energy Storage Systems

The following energy storage systems are used in all-Electric Vehicles, PHEVs, and HEVs.

1) Lithium-ion batteries

Lithium-ion batteries are currently used in most portable consumer electronics such as cell phones and laptops because of their high energy per unit mass and volume relative to other electrical energy storage systems. They also have a high power-to-weight ratio, high energy efficiency, good high-temperature performance, long life, and low self-discharge. Most components of lithium-ion batteries can be recycled, but the cost of material recovery remains a challenge for the industry. Most of today's all-Electric Vehicles and PHEVs use lithium-ion batteries, though the exact chemistry often varies from that of consumer electronics batteries. Research and development are ongoing to reduce their relatively high cost, extend their useful life, use less cobalt, and address safety concerns in regard to various fault conditions.

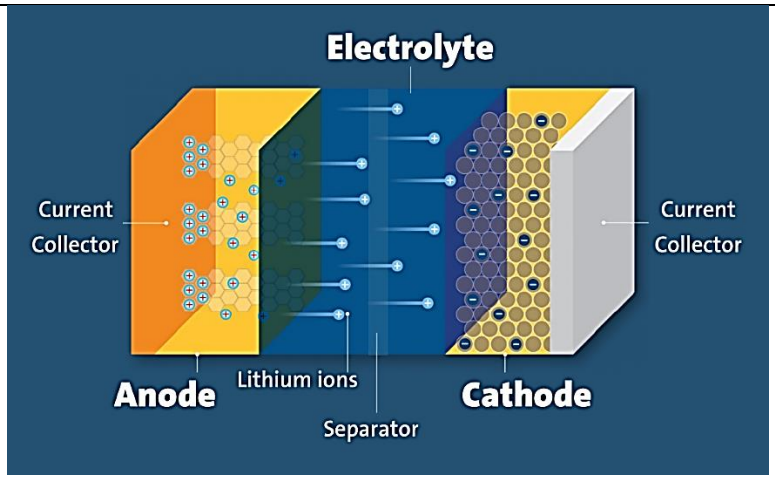


Fig. 5.2: Schematic of the Lithium-ion battery

2) Nickel-Metal Hydride Batteries

Nickel-metal hydride batteries, used routinely in computer and medical equipment, offer reasonable specific energy and specific power capabilities. Nickel-metal hydride batteries have a much longer life cycle than lead-acid batteries and are safe and abuse-tolerant. These batteries have been widely used in HEVs. The main challenges with nickel-metal hydride batteries are their high cost, high self-discharge rate, heat generation at high temperatures, and the need to control hydrogen loss.

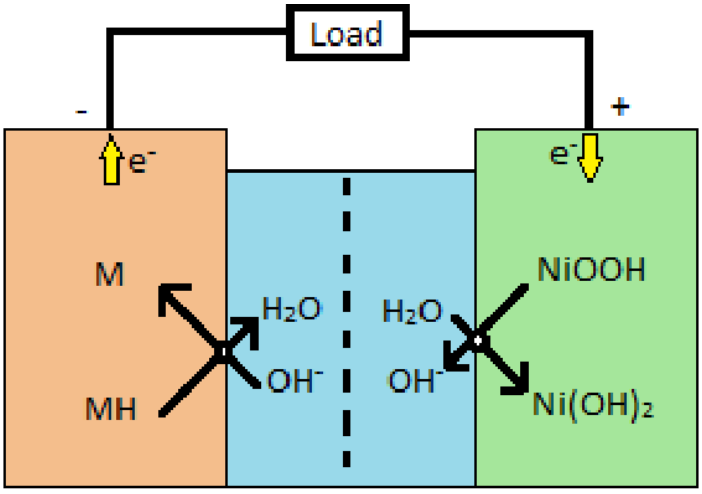


Fig. 5.3: Schematic of the Nickel-metal hydride battery

3) Lead-Acid Batteries

Lead-acid batteries can be designed to be high power and are inexpensive, safe, recyclable, and reliable. However, low specific energy, poor cold-temperature performance, and short calendar and lifecycle impede their use. Advanced high-power lead-acid batteries are being developed, but these batteries are only used in commercially available electric-drive vehicles for ancillary loads. They are also used for stop-start functionality

in internal combustion engine vehicles to eliminate idling during stops and reduce fuel consumption.

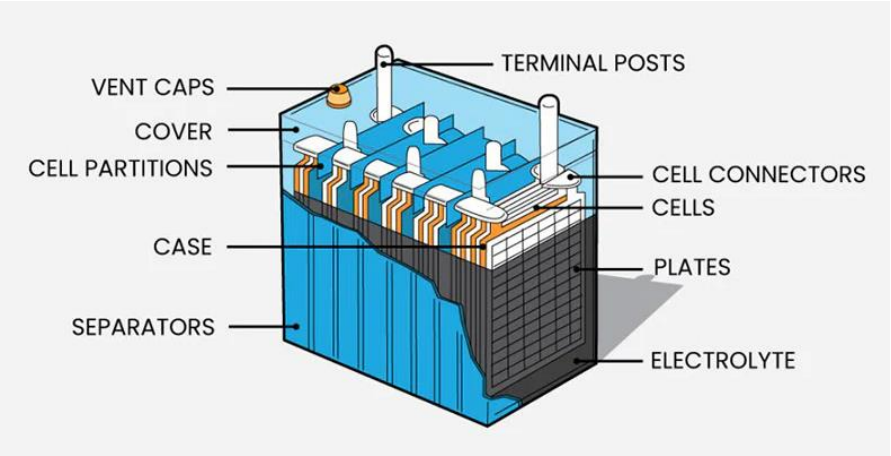


Fig. 5.4: Schematic of the Lead-acid battery

4) Ultracapacitors

Ultracapacitors store energy in the interface between an electrode and an electrolyte when voltage is applied. Energy storage capacity increases as the electrolyte-electrode surface area increases. Although ultracapacitors have low energy density, they have very high-power density, which means they can deliver high amounts of power in a short time. Ultracapacitors can provide vehicles additional power during acceleration and hill climbing and help recover braking energy. They may also be useful as secondary energy-storage devices in electric-drive vehicles because they help electrochemical batteries level load power.

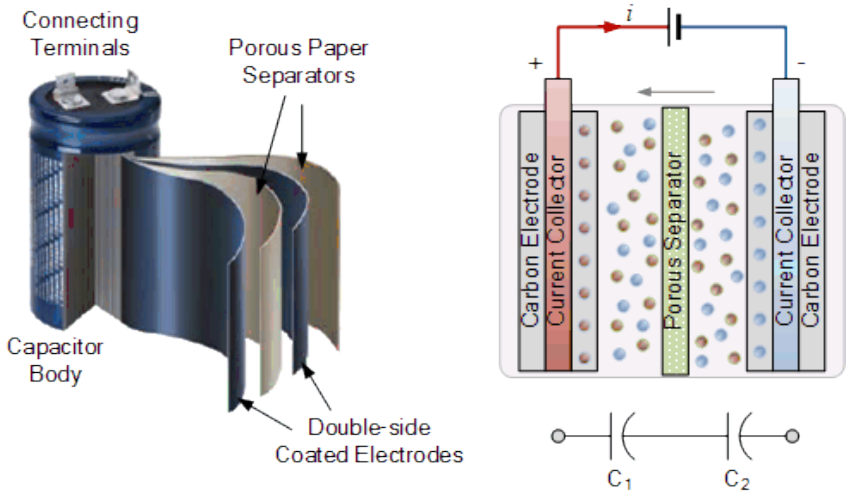


Fig. 5.5: Schematic-of-the-Lithium-ion-battery

BATTERY PARAMETERS

Batteries are crucial to modern technology, as they power everything from smartphones to electric vehicles. It's important to understand the parameters that define battery performance to optimize their use and efficiency. In this guide, we will explore the key battery parameters, their significance, and how they impact various applications.

1. Capacity (mAh or Ah)

Capacity is perhaps the most fundamental battery parameter, representing the amount of energy stored within the battery. It is typically measured in milliampere-hours (mAh) or ampere-hours (Ah). A higher capacity indicates that the battery can store more energy and deliver power for a longer duration before requiring recharging. Capacity directly influences the runtime of devices and the range of Electric Vehicles.

2. Voltage (V)

Voltage refers to the electrical potential difference between the positive and negative terminals of a battery. It determines the force with which electrons move through an electrical circuit. Different applications require batteries with specific voltage levels to operate optimally. For example, while small electronic devices like smartphones typically operate on low voltage (3.7V), Electric Vehicles require much higher voltages to power their motors efficiently.

3. Energy Density (Wh/kg or Wh/L)

Energy density represents the amount of energy stored in a battery per unit of mass (Wh/kg) or volume (Wh/L). Higher energy density batteries can store more energy within the same physical space or weight, making them ideal for applications where space and weight are critical factors, such as portable electronics and Electric Vehicles. Advances in battery technology aim to increase energy density to enhance the performance and range of various devices.

4. Power Density (W/kg or W/L)

Power density measures the rate at which a battery can deliver energy per unit of mass (W/kg) or volume (W/L). It reflects the battery's ability to provide high bursts of power when needed, such as during acceleration in Electric Vehicles or high-demand tasks in electronic devices. Batteries with higher power density can deliver energy more quickly, enabling better performance in applications requiring rapid energy transfer.

5. Cycle Life

Cycle life refers to the number of charge-discharge cycles a battery can undergo before its capacity drops below a certain threshold. It is a critical parameter for rechargeable batteries, as it determines their longevity and reliability over time. A higher cycle life indicates that the battery can endure more charging and discharging cycles before requiring replacement, making it suitable for long-term use in various applications.

6. Self-Discharge Rate

Self-discharge rate measures the rate at which a battery loses its charge when not in use. Batteries with lower self-discharge rates retain their charge for longer periods, making them suitable for applications where long-term storage is required, such as emergency backup systems and remote sensors. Minimizing self-discharge is essential for preserving battery capacity and extending shelf life.

7. Temperature Range

The temperature range defines the operating conditions within which a battery can perform effectively and safely. Extreme temperatures can adversely affect battery performance, efficiency, and even safety. Batteries designed for specific applications, such as automotive or aerospace, must withstand a wide range of temperatures without compromising performance or reliability.

8. Internal Resistance

Internal resistance, also known as impedance, represents the opposition to the flow of current within a battery. It affects the battery's efficiency, voltage stability, and ability to deliver power under load. Lower internal resistance results in less energy loss and improved overall performance, particularly in high-current applications like Electric Vehicles and power tools.

9. Depth of Discharge (DoD)

Depth of discharge refers to the percentage of a battery's capacity that has been discharged relative to its total capacity. It is a crucial parameter for rechargeable batteries as exceeding certain DoD levels can shorten the battery's lifespan. Understanding DoD helps users optimize battery usage to prolong its cycle life and maintain performance over time.

10. State of Charge (SoC)

State of charge indicates the current level of charge in a battery relative to its maximum capacity. It is typically expressed as a percentage, with 100% representing a fully charged battery and 0% indicating a completely discharged battery. SoC monitoring is essential for effectively managing battery usage, preventing overcharging or deep discharging, and ensuring optimal performance and longevity.

11. Rate Capability

Rate capability refers to a battery's ability to deliver or accept charge at different rates of charging or discharging. It is crucial for applications with varying power demands, such as Electric Vehicles, where rapid acceleration or regenerative braking requires high-rate charging and discharging. Batteries with excellent rate capability can adapt to dynamic power demands without sacrificing performance or efficiency.

Know Your Progress

Multiple Choice Questions (MCQ)

1. Which type of battery is most commonly used in all-electric vehicles and PHEVs due to its high energy per unit mass and volume?

   A. Lead-Acid Batteries
   B. Nickel-Metal Hydride Batteries
   C. Lithium-Ion Batteries
   D. Ultracapacitors

2. What is a key challenge associated with Nickel-Metal Hydride batteries?

   A. Low energy density
   B. High self-discharge rate
   C. High power density
   D. Inability to recycle components

3. Which battery parameter measures the amount of energy stored in the battery per unit mass or volume?

   A. Voltage
   B. Capacity
   C. Power Density
   D. Energy Density

4. What is the main advantage of ultracapacitors compared to other types of batteries?

   A. High energy density
   B. High power density
   C. Low self-discharge rate
   D. Long cycle life

5. Which parameter indicates the number of charge-discharge cycles a battery can undergo before its capacity drops significantly?

   E. Self-Discharge Rate
   F. Internal Resistance
   G. Cycle Life
   H. Rate Capability

Fill in the Blanks

1. _____ is a critical parameter for rechargeable batteries, indicating their longevity and reliability over time.
2. Batteries with higher _____ can deliver energy more quickly, enabling better performance in high-demand applications.
3. _____ batteries are inexpensive, safe, recyclable, and reliable, but have low specific energy and poor cold-temperature performance.
4. The _____ rate measures how quickly a battery loses its charge when not in use.
5. _____ refers to the percentage of a battery's capacity that has been discharged relative to its total capacity.

Short Answer Questions

1. What are the advantages of lithium-ion batteries that make them suitable for use in electric vehicles?

2. What role do ultracapacitors play in electric vehicles?

3. Discuss the various types of batteries used in electric vehicles, highlighting their key characteristics and challenges.

4. How do battery parameters such as capacity, voltage, and cycle life impact the performance and usability of electric vehicles?

5. Evaluate the environmental and economic implications of using different types of batteries in electric vehicles.

Activities

1. Analyse the different types of batteries (lithium-ion, nickel-metal hydride, lead-acid, and ultracapacitors). Also create a presentation highlighting their characteristics, advantages, disadvantages, and current uses in electric vehicles.

2. Analyze how these companies have addressed battery-related challenges and discuss the impact of these solutions on the market and the environment.

Session 2: Charging Methods of Electric Vehicle (EV)

In today's world, where sustainability and eco-friendliness are becoming increasingly vital, Electric Vehicles (EVs) are gaining traction as a viable alternative to traditional gas-powered cars. One of the critical aspects of owning an EV is understanding how to charge its batteries efficiently. Let's delve into the different charging methods available for EV batteries and how they work:

1. Level 1 Charging

Level 1 charging, also known as trickle charging, is the most basic method of charging your EV. It involves using a standard household outlet, typically 120 volts, to charge the vehicle's battery. While convenient because it utilizes readily available outlets, Level 1 charging is relatively slow, typically adding around 2-5 miles of range per hour of charging. This method is ideal for overnight charging at home or when access to higher-voltage charging stations is limited.

2. Level 2 Charging

Level 2 charging offers a significant improvement in charging speed compared to Level 1. It utilizes a 240-volt power source, commonly found in residential garages or dedicated charging stations. With Level 2 charging, EV owners can add around 10-60 miles of range per hour, depending on the vehicle's battery capacity and charging infrastructure. This method is ideal for daily charging needs, providing a faster turnaround time without the expense of installing specialized equipment.

3. DC Fast Charging

DC fast charging, also known as Level 3 charging, is the fastest method available for charging EV batteries. Unlike Level 1 and Level 2 charging,

which use alternating current (AC), DC fast charging delivers direct current (DC) to the vehicle's battery, allowing for much faster charging rates. EV owners can typically add around 60-80% of battery capacity in just 20-30 minutes, making it ideal for long-distance travel or quick refuelling stops during busy days. However, DC fast charging stations are less common than Level 1 and Level 2 chargers and may require additional usage fees.

4. Wireless Charging

Wireless charging is an innovative technology that eliminates the need for physical plugs and cables, making the charging process even more convenient for EV owners. This method utilizes electromagnetic fields to transfer energy from a charging pad to a receiver installed on the vehicle, allowing for seamless charging without the hassle of plugging in. While still relatively uncommon, wireless charging offers the potential for effortless EV charging at home, in parking lots, or even on the road in the future.

Types of Charging Ports for Electric Vehicles

Electric vehicles (EVs) come with various charging port types, each with its specific design, capabilities, and compatibility. Understanding these types is crucial for EV owners to ensure they can charge their vehicles efficiently at home, at work, or at public charging stations.

1. Type 1 (SAE J1772)

This is a single-phase plug primarily used in North America and Japan.

Features:

- **Current:** Can support up to 80 amps, but typically used for 30 amps.
- **Voltage:** Supports 120V and 240V.
- **Usage:** Commonly found in home charging stations and public charging points.
- **Compatibility:** Suitable for Level 1 (slow) and Level 2 (faster) charging.

2. Type 2 (Mennekes)

This is a three-phase plug used widely in Europe.

Features:

- **Current:** Can support up to 32 amps per phase.
- **Voltage:** Supports 400V.
- **Usage:** Used for home, workplace, and public charging stations.

- **Compatibility:** Compatible with Level 2 (fast) and Level 3 (rapid) charging.

3. Combined Charging System (CCS)

Also known as Combo 1 (CCS1) in North America and Combo 2 (CCS2) in Europe, it combines AC and DC charging.

Features:

- **Current:** Up to 200 amps for DC fast charging.
- **Voltage:** Supports both low voltage (AC) and high voltage (DC).
- **Usage:** Suitable for both slow and ultra-fast charging.
- **Compatibility:** CCS ports allow for rapid charging at public stations and are compatible with many new EV models.

4. CHAdeMO

A fast-charging DC system was developed in Japan.

Features:

- **Current:** Typically, up to 125 amps.
- **Voltage:** Up to 500V.
- **Usage:** Used primarily for rapid charging in public stations.
- **Compatibility:** Widely adopted by Japanese car manufacturers like Nissan and Mitsubishi, though its usage is decreasing in favor of CCS.

5. Tesla Supercharger

Proprietary charging connector used exclusively by Tesla vehicles.

Features:

- **Current:** Up to 300 amps.
- **Voltage:** Varies, supporting high-speed DC charging.
- **Usage:** Found at Tesla Supercharger stations worldwide, designed for quick top-ups on long journeys.
- **Compatibility:** Exclusively compatible with Tesla vehicles, though adapters are available for other port types.

Fig. 5.5: Type of charging

Key Considerations for EV Charging Ports

- **Charging Speed:** Different ports support different charging speeds, ranging from slow (Level 1) to ultra-fast (Level 3).
- **Vehicle Compatibility:** Not all EVs are compatible with all types of charging ports. It's important to know your vehicle's charging port type and ensure compatibility with available charging infrastructure.
- **Availability:** Availability of charging stations with specific port types can vary by region. For example, CCS is becoming more common in Europe and North America, while CHAdeMO is more prevalent in Japan.

Specifications

Technical specifications for electric vehicle chargers vary across Level 1, Level 2, and Level 3 charging stations across different countries. The table below showcases the mapping of different charger specification in India:

S.No	Charging Station	Voltage (V)	Power (kW)	Type of Vehicle	Type of compatible charger
1	Level 1 (AC)	240	<=3.5 kW	4w ,3w,2w	Type 1, Bharat AC-001
2	Level 1 (DC)	>=48	<=15 kW	4w,3w,2w	Bharat DC-001
3	Level 2 (AC)	380-400	<=22 kW	4w,3w,2w	Type 1, Type 2, GB/T, Bharat AC-001
4	Level 3 (AC)	200-1000	22 to 4.3 kW	4w	Type 2

5	Level 3 (DC)	200-1000	Up to 400 kW	4w	Type 2, CHAdeMO, CCS1, CCS2

The longevity of Electric Vehicle (EV) batteries is a crucial factor in their overall sustainability and cost-effectiveness. As technology advances, manufacturers and researchers are continually seeking ways to enhance battery life. Here are some key strategies:

a) Battery Chemistry Optimization: Innovations in battery chemistry, such as the use of advanced materials like lithium-ion phosphate (LFP) or solid-state electrolytes, can improve battery performance and longevity. These advancements aim to mitigate issues like degradation and capacity fade over time.
b) Temperature Management Systems: Maintaining optimal operating temperatures is vital for preserving battery health. EVs are equipped with sophisticated thermal management systems to regulate temperature extremes, thereby minimising stress on the battery cells and extending their lifespan.
c) Smart Battery Management Systems (BMS): BMS technology plays a crucial role in monitoring and controlling various parameters within the battery pack, including temperature, voltage, and state of charge. By implementing intelligent BMS algorithms, EV manufacturers can optimize charging and discharging cycles to prolong battery life.
d) Cycle Life Testing and Validation: Rigorous testing protocols, including accelerated ageing tests and real-world driving simulations, help assess battery durability and reliability. By putting batteries through various real-life scenarios, manufacturers can pinpoint weaknesses and enhance battery designs to ensure longer lifespan and better performance.

Exploring Battery Swapping Techniques:

Battery swapping presents an innovative solution to address the limitations of traditional charging infrastructure, offering EV owners a faster and more convenient alternative to recharging. Here's how battery swapping works and its potential benefits:

a) Efficient Battery Exchange Stations: Battery swapping stations are equipped with robotic systems capable of swiftly removing depleted battery packs from EVs and replacing them with fully charged ones. This process significantly reduces the time required for recharging, making it ideal for situations where fast turnaround is essential.
b) Enhanced Convenience and Flexibility: Battery swapping eliminates waiting while the vehicle charges, offering EV owners greater flexibility and convenience during long journeys or busy schedules. Moreover, it

mitigates concerns about range anxiety, as drivers can quickly exchange batteries at strategically located swapping stations.

c) Reduced Battery Degradation: By minimising the reliance on fast charging, which can accelerate battery degradation, battery swapping can potentially extend the overall lifespan of EV batteries. Swapping out batteries allows for gentler charging cycles, preserving battery health over the vehicle's lifetime.

Battery swapping has the potential to bring benefits, but it faces challenges such as the need for standardized battery units, significant infrastructure investments, and compatibility issues with different electric vehicle models. Addressing concerns about the environmental impact of battery pack manufacturing and recycling is also important for ensuring a sustainable solution.

Know Your Progress

Multiple Choice Questions (MCQ)

1. What is the primary difference between Level 1 and Level 2 charging?
   A. Level 1 uses a 120-volt outlet, while Level 2 uses a 240-volt outlet.
   B. Level 1 uses direct current, while Level 2 uses alternating current.
   C. Level 1 is faster than Level 2.
   D. Level 1 requires specialized equipment, while Level 2 does not.
2. Which charging method allows EV owners to add 60-80% of battery capacity in just 20-30 minutes?
   A. Level 1 Charging
   B. Level 2 Charging
   C. DC Fast Charging
   D. Wireless Charging
3. Which type of charging port is proprietary and used exclusively by Tesla vehicles?
   A. Type 1 (SAE J1772)
   B. Type 2 (Mennekes)
   C. CHAdeMO
   D. Tesla Supercharger
4. What is a key advantage of wireless charging for EVs?
   A. It is faster than DC Fast Charging.
   B. It eliminates the need for physical plugs and cables.
   C. It is the most cost-effective charging method.
   D. It is available at all public charging stations.

5. Which battery chemistry innovation aims to improve battery performance and longevity?
   A. Nickel-Cadmium
   B. Lithium-Ion Phosphate (LFP)
   C. Alkaline
   D. Lead-Acid

Fill in the Blanks

1. Level 1 charging typically adds around _____ miles of range per hour of charging.
2. DC Fast Charging delivers direct current (DC) to the vehicle's battery, allowing for much faster charging rates than Level 1 and Level 2, which use _____.
3. The Combined Charging System (CCS) can support both low voltage (AC) and high voltage (DC) charging, making it suitable for both slow and _____ charging.
4. Maintaining optimal operating temperatures is vital for preserving battery health, achieved through sophisticated _____ management systems.
5. Battery swapping stations are equipped with _____ systems capable of swiftly removing depleted battery packs and replacing them with fully charged ones.

Short Answer Questions

1. Describe how wireless charging works for electric vehicles.
2. What are the compatibility considerations for using different types of EV charging ports?
3. How does a Smart Battery Management System (BMS) contribute to the longevity of EV batteries?
4. Explain the differences between Level 1, Level 2, and DC Fast Charging in terms of speed, voltage, and typical use cases.
5. Discuss the potential benefits and drawbacks of battery-swapping techniques for electric vehicles.
6. How do temperature management systems and battery chemistry optimization contribute to the enhancement of EV battery life?

Activities

1. Create a chart comparing Level 1, Level 2, and DC Fast Charging, including aspects such as voltage, charging speed, typical use cases, and advantages/disadvantages of each method.
2. Design a blueprint for a new EV charging station, considering factors such as location, type of charging ports available, power requirements, and amenities for users.

Session 3: Key Technologies Trends Shaping Electric Vehicles

What are the next big advances in Electric Vehicle technology? How does wireless charging technology work and how can we use it for charging electric car batteries? How does autonomous driving work and what are the various levels of vehicle autonomy? How can we smart charge Electric Vehicles from renewable sources of energy to make them even greener? How is the future for Electric Vehicles powered by means other than a battery like fuel cells and solar cells?

This session will provide the answers to all the above questions and discuss many such interesting and trending topics. We will begin the Unit by discussing key emerging technologies for future Electric Vehicles focussing on the vehicle powertrain and battery and solar and fuel cell Electric Vehicles. Next, we will learn about the concepts of wireless charging of Electric Vehicles and battery swap technology. In the last part, we will look at why and how we can charge Electric Vehicles from renewable energy sources like wind and solar energy in the future.

1. **AI-Powered Vehicle Health Checks:** AI-powered diagnostics are becoming essential in monitoring the health of electric vehicles (EVs). These systems can predict and identify potential issues before they become serious problems, enhancing vehicle reliability and longevity. Machine learning algorithms analyze data from various sensors to provide real-time updates on the condition of the vehicle, helping in proactive maintenance.
2. **Advanced Driver Assistance Systems (ADAS):** ADAS technologies are rapidly evolving, offering features like lane-keeping assist, adaptive cruise control, and automated emergency braking. These systems enhance driver safety by reducing human error and improving reaction times to potential hazards. The integration of AI in ADAS allows for continuous learning and improvement, making driving safer and more efficient.

3. **Improved Connectivity Features:** Connectivity features in EVs are expanding, offering seamless integration with smart devices and enhanced infotainment options. These features include real-time traffic updates, over-the-air software updates, and vehicle-to-everything (V2X) communication. Improved connectivity not only enhances the user experience but also enables better fleet management and remote diagnostics.
4. **Charging Infrastructure Development:** The expansion of charging infrastructure is critical for the widespread adoption of EVs. Efforts are being made to increase the number of fast-charging stations and develop standardized charging protocols. Innovations like wireless charging and ultra-fast chargers are also being explored to reduce charging times and improve convenience for EV owners.
5. **Smart Grids:** Smart grids are being developed to manage the increased electricity demand from EVs efficiently. These grids use advanced metering infrastructure and IoT devices to optimize energy distribution and integrate renewable energy sources. Smart grids can also support vehicle-to-grid (V2G) technologies, allowing EVs to supply power back to the grid during peak demand periods.
6. **Advancements in Battery Technology:** Battery technology continues to advance, with significant improvements in energy density, charging speed, and lifespan. Solid-state batteries, for example, promise higher energy storage and improved safety compared to traditional lithium-ion batteries. Research is also being conducted on alternative materials and chemistries to further enhance battery performance.
7. **Sustainable Material Disposal:** As the number of EVs increases, the disposal of batteries and other materials becomes a concern. Efforts are being made to develop sustainable disposal and recycling methods. Innovations in material science aim to create batteries that are easier to recycle, reducing the environmental impact and promoting a circular economy.
8. **Energy Efficiency and Regenerative Braking:** Energy efficiency remains a key focus in EV development. Regenerative braking systems, which convert kinetic energy back into electrical energy during braking, are becoming more advanced. These systems improve overall efficiency and extend the driving range of EVs, making them more practical for everyday use.

Obstacles to Enhancing EV Technology

1. **Safety Concerns With ADAS:** While ADAS technologies offer significant safety benefits, there are concerns about their reliability and the potential for over-reliance by drivers. Ensuring these systems are robust

and can handle a wide range of driving scenarios is critical to gaining public trust and widespread adoption.

2. **Integration of Connectivity Features:** Integrating advanced connectivity features poses challenges related to cybersecurity and data privacy. Ensuring secure communication channels and protecting user data from cyber threats are paramount as vehicles become more connected.
3. **Limitations in Battery Technology:** Despite advancements, current battery technology still faces limitations, including high costs, limited driving range, and long charging times. Continued research and development are needed to overcome these barriers and make EVs more accessible to a broader audience.

Resolving Current Challenges in EV Technology

1. **Robust Testing and Safety Standards for Autonomous Driving:** To address safety concerns with autonomous driving, rigorous testing and the establishment of robust safety standards are essential. Regulatory frameworks need to evolve to ensure these systems are thoroughly vetted and can operate safely in diverse conditions.
2. **Enhanced Connectivity Protocols and Cybersecurity Measures:** Developing enhanced connectivity protocols and implementing stringent cybersecurity measures can mitigate risks associated with connected vehicles. Collaboration between automakers, technology companies, and regulatory bodies is crucial to create secure and reliable systems.
3. **Innovations in Battery Technology:** Continued innovation in battery technology is necessary to address current limitations. Research into new materials, such as solid-state electrolytes and silicon anodes, can lead to batteries with higher energy densities, faster charging times, and longer lifespans. Investment in recycling technologies is also essential to manage the environmental impact of used batteries.

Know Your Progress

Multiple Choice Questions (MCQ)

1. **What is a key benefit of AI-powered diagnostics in electric vehicles (EVs)?**

   A. Enhanced entertainment features
   B. Predictive maintenance and real-time health monitoring
   C. Faster acceleration
   D. Better fuel efficiency

2. **Which technology allows EVs to return power to the grid during peak demand periods?**

   A. Wireless charging
   B. Regenerative braking
   C. Vehicle-to-grid (V2G)
   D. Adaptive cruise control

3. **What is one of the primary challenges in integrating advanced connectivity features in EVs?**

   A. Limited driving range
   B. High production costs
   C. Cybersecurity and data privacy
   D. Inconsistent battery performance

4. **What advancement in battery technology promises higher energy storage and improved safety?**

   A. Solid-state batteries
   B. Nickel-cadmium batteries
   C. Lead-acid batteries
   D. Alkaline batteries

5. **What does ADAS stand for in the context of electric vehicles?**

   A. Automated Data Analysis System
   B. Advanced Driver Assistance Systems
   C. Autonomous Driving and Safety
   D. Automotive Diagnostic Alert System

Fill in the Blanks

1. AI-powered diagnostics in EVs use _____ algorithms to analyze data from various sensors.
2. _____ is a system that converts kinetic energy into electrical energy during braking in EVs.
3. The integration of _____ in ADAS allows for continuous learning and improvement.
4. _____ grids use advanced metering infrastructure and IoT devices to optimize energy distribution for EVs.
5. Wireless charging technology for EVs involves transferring energy through _____ fields. electromagnetic

Short Answer Questions

1. Explain how wireless charging technology works for electric vehicles.
2. What are the various levels of vehicle autonomy, and how do they differ?

3. Describe how smart grids can support the charging of electric vehicles.
4. Analyze the potential of fuel cells and solar cells as alternatives to traditional batteries in electric vehicles.

Activities

1. Design a conceptual wireless charging station for electric vehicles, including technical specifications, safety features, and user interface design. They should present their designs and explain how they would implement the technology in urban areas.
2. Visit to a local EV charging station or a renewable energy plant (e.g., solar or wind farm). Observe the operations and prepare a report on how renewable energy is integrated into EV charging infrastructure.

Session 4: Hazardous Waste

Simply defined, hazardous waste is waste with properties that make it dangerous or capable of harming human health or the environment. Hazardous waste is generated from many sources, ranging from industrial manufacturing process wastes to batteries and may come in many forms, including liquids, solids gases, and sludges.

Exposure to chemicals commonly used in workplaces can lead to a variety of short- and long-term health effects such as poisoning, skin rashes and disorders of the lung, kidney and liver. A quarter of all Victorian employees regularly use hazardous substances such as chemicals, flammable liquids and gases in their work. A hazardous substance can take many forms, including gas, powder, liquid, solid or dust. The product may be pure or diluted. Manufacturers and importers of hazardous substances are legally obliged to include warning labels and Safety Data Sheets with their products. This information offers advice on safe handling practices.

Common hazardous substances

Many industrial, agricultural and medical organizations use hazardous substances. The degree of hazard depends on the concentration of the chemical. Some of the **Common hazardous substances in the workplace include:**

- Acids

- Caustic substances
- Disinfectants
- Glues
- Heavy metals, including mercury, lead, cadmium and aluminium
- Paint
- Pesticides
- Petroleum products
- Solvents.

The side effects of hazardous substances

Health effects depend on the type of hazardous substance and the level of exposure (concentration and duration). A hazardous substance can be inhaled, splashed onto the skin or eyes, or swallowed. Some of the possible health effects can include:

- poisoning
- Nausea and vomiting
- Headache
- Skin rashes, such as dermatitis
- Chemical burns
- Birth defects
- Disorders of the lung, kidney or liver
- Nervous system disorders.

The Hazardous industrial wastes in India can be categorized broadly into two categories, given below:

. Hazardous wastes produced from various industries in India. The major HW generating industries in India include petrochemicals, pharmaceuticals, pesticides, paint and dye, petroleum, fertilizers, asbestos, caustic soda, inorganic chemicals and general engineering industries. HW from these industrial sectors contains heavy metals, cyanides, pesticides, complex aromatic compounds and other chemicals, which are toxic, flammable, reactive, and corrosive or have explosive properties.

. Hazardous industrial wastes brought into India from foreign countries for recycling and re-processing. This can be even called imported waste, which is used as raw material by some industries in India or Waste is used for mere recovery of metals.

Hazardous Waste Management Rules 2016

For the first time, Rules have been made to distinguish between Hazardous Waste and other wastes. Other wastes include: Waste tyre, paper waste, and metal scrap, used electronic items, etc. And are recognized as a resource for

recycling and reuse. These resources supplement the industrial processes and reduce the load on the virgin resource of the country.

The salient features of Hazardous and Other Wastes (Management & Trans-boundary Movement) Rules, 2016 include the following: -

- The ambit of the Rules has been expanded by including 'Other Waste'.
- Waste Management hierarchy in the sequence of priority of prevention, minimization, reuse, recycling, recovery, co-processing; and safe disposal has been incorporated.
- All the forms under the rules for permission, import/export, filing of annual returns, transportation, etc. Have been revised significantly, indicating the stringent approach for management of such hazardous and other wastes with simultaneous simplification of procedure.
- The basic necessity of infrastructure to safeguard the health and environment from waste processing industry has been prescribed as Standard Operating Procedure (sops), specific to waste type, which has to be complied by the stakeholders and ensured by SPCB/PCC while granting such authorization.
- Procedure has been simplified to merge all the approvals as a single window clearance for setting up of hazardous waste disposal facility and import of other wastes.
- Co-processing as preferential mechanism over disposal for use of waste as supplementary resource, or for recovery of energy has been provided.
- The approval process for co-processing of hazardous waste to recover energy has been streamlined and put on emission norms basis rather than on trial basis.
- The process of import/export of waste under the Rules has been streamlined by simplifying the document-based procedure and by revising the list of waste regulated for import/export.
- The import of metal scrap, paper waste and various categories of electrical and electronic equipment's for re-use purpose has been exempted from the need of obtaining Ministry's permission.
- The basic necessity of infrastructure to safeguard the health and environment from waste processing industry has been prescribed as Standard Operating Procedure (sops) specific to waste type.
- Responsibilities of State Government for environmentally sound management of hazardous and other wastes have been introduced as follows:
    - To set up/ allot industrial space or sheds for recycling, pre-processing and other utilization of hazardous or other waste.
    - To register the workers involved in recycling, pre-processing and other utilization activities.

- To form groups of workers to facilitate setting up such facilities.
- To undertake industrial skill development activities and ensure the safety and health of workers.

- A list of processes generating hazardous wastes has been reviewed considering technological evolution in the industries.
- The list of Waste Constituents with Concentration Limits has been revised as per international standards and drinking water standards.

The following items have been prohibited for import:

1. Waste edible fats and oil of animals, or vegetable origin;
2. Household waste;
3. Critical Care Medical equipment;
4. Tyres for direct re-use purposes;
5. Solid Plastic wastes including Pet bottles;
6. Waste electrical and electronic assembly scrap;
7. Other chemical wastes especially in solvent form.

- State Government is authorized to prepare an integrated plan for effective implementation of these provisions, and have to submit an annual report to the Ministry of Environment, Forest and Climate Change.
- The State Pollution Control Board (SPCB) is mandated to prepare an annual inventory of the waste generated; waste recycled, recovered, utilized including co-processed; waste re-exported and waste disposed and submitted to the Central Pollution Control Board by the 30th day of September every year.

Hazardous Wastes in Automobile repair and maintenance

Various hazardous wastes like used motors, various types of used oils, parts, cleaning solvents paints etc. are generated during repair and maintenance. These wastes should be disposed of as per the procedure given below;

Used motor and hydraulic Oils

These oils should be sent to waste oil recyclers. If the oils are recycled, the amount produced does not count toward the quantity of waste used in the determination of your generator status. A written agreement should be developed with the recycler stating what is done with the used oils. Do not mix your hydraulic and motor oil until you contact your used oil dealer to determine if the dealer needs to collect it separately. Never mix mineral spirits and other spent solvents with the used oil.

Parts-cleaning Solvents

Parts-cleaning solvents are hazardous wastes and the amount generated counts toward the determination of your generator status. These solvents must be shipped to a hazardous waste treatment, storage, and disposal

(TSD) facility using a licensed transporter. An alternative method is to contract with a solvent recycler who will supply fresh solvent and pick up the spent material. In either case, you first need to obtain a generator identification number (GIN) and use the manifest system for shipping the waste material. Do not add any other materials to the solvent drum without checking with the recycler or EPA-permitted TSD facility.

Since solvents will be the main source of your hazardous waste, the amount of solvent produced will probably determine your generator status. For example, if you produce less than 25 gallons each month, you are a conditionally exempt small quantity generator (CESQG); if you produce one 55-gallon drum each month, you are a small- quantity generator (SQG); and if you produce four 55-gallon drums each month, you are a large- quantity generator (LQG).

Paints

Allow paint cans to dry and place them in the trash dumpster. Eliminate the need to dispose of leftover paint by never mixing more than needed for a specific job.

Oil Dry

The oil dry used to absorb spills of oil on the floor can be put in the dumpster.

Brake Shoes

Brake shoes should be assumed to contain asbestos unless proven otherwise and should be returned to the supplier or sent to a landfill approved for asbestos disposal. The shoes should be wrapped in a plastic bag that is approved and properly marked for asbestos. Used Batteries Return used batteries to the supplier for recovery of the lead.

Antifreeze

There are two alternatives to handling antifreeze from coolant systems:

- Collect antifreeze from coolant systems and return to a used oil dealer, or
- Collect antifreeze from coolant system, pass through a filter, and reuse.

Air Conditioner Refrigerant

Reclaim and recycle refrigerant using approved extraction and recovery equipment. Residues from equipment may be considered hazardous waste. Individuals must be trained and certified in the use of extraction and recovery equipment as of January 1, 1992.

Information on training and certification programs can be obtained from:

- Mobile Air Conditioning Society (MACS)
- National Institute for Automobile Service Excellence (ASE)

Mineral Spirits

Collect the mineral spirits that are used for cleaning painting equipment and other parts. Check with your solvent recycler to see if this waste can be put in with the waste solvents; otherwise, collect it separately. Putting spent solvents, such as mineral spirits, in with used oil could render the used oil a hazardous waste that must be sent to a TSD facility.

Used Oil Filters

Punch a hole in the filter and thoroughly draining the oil into a used oil container or crush with a press. Then, there are two options for disposal: send the filter to a recycling facility, or, if a Toxicity Characteristic Leaching Procedure (TCLP) test indicates the material is not hazardous, send the filter to a lined landfill. Because the regulations presently are not definitive, you may want to use a hazardous waste disposal firm to be safe.

Waste water

If the wastewater stream contains waste oil, solvents, and other material from operations such as engine washing, a grit/oil separator should be put in the wastewater discharge. The oil skimmed from the top can be put in with the used oil if there is not too much water in the oil. The grit on the bottom must be checked using a TCLP to determine if it is a hazardous waste. If the material is not hazardous, it can be sent to a sanitary landfill, but first solidify the sludge by mixing it with a sorbent.

Underground Storage Tanks (USTS)

Underground storage tanks used for oil, gasoline, and mineral spirits must be registered with the Environmental Protection Division.

RECYCLING BATTERIES

Widespread battery recycling would help keep hazardous materials from entering the waste stream, both at the end of a battery's useful life and during its production. After the collection of spent batteries, the material recovery from recycling would also reintroduce critical materials back into the supply chain and would increase the domestic sources for such materials. Work is now underway to develop battery-recycling processes that minimize the life-cycle impacts of using lithium-ion and other kinds of batteries in vehicles. But not all recycling processes are the same and different methods of separation are required for material recovery:

- **Smelting**: Smelting processes recover basic elements or salts. These processes are operational now on a large scale and can accept multiple kinds of batteries, including lithium-ion and nickel-metal hydride. Smelting takes place at high temperatures where organic materials, including the electrolyte and carbon anodes, are burned as fuel or reductant. The valuable metals are recovered and sent to refining so that the product is suitable for any use. The other

materials, including lithium, are contained in the slag, which is now used as an additive in concrete.

- **Direct recovery**: At the other extreme, some recycling processes directly recover battery-grade materials. Components are separated by a variety of physical and chemical processes, and all active materials and metals can be recovered. Direct recovery is a low-temperature process with minimal energy requirement.
- **Intermediate processes**: The third type of process is between the two extremes. Such processes may accept multiple kinds of batteries, unlike direct recovery, but recover materials further along the production chain than smelting does.

Separating the different kinds of battery materials is often a stumbling block in recovering high-value materials. Therefore, battery design that considers disassembly and recycling is important for electric-drive vehicles to succeed from a sustainability standpoint. Standardizing batteries, materials, and cell design would also make recycling easier and more cost-effective.

Know Your Progress

Multiple Choice Questions (MCQs)

1. Which of the following is NOT a common hazardous substance found in the workplace?
   A. Acids
   B. Disinfectants
   C. Pesticides
   D. Water

2. Which category of hazardous waste includes heavy metals like mercury, lead, and cadmium?
   A. Agricultural waste
   B. Household waste
   C. Industrial waste
   D. Medical waste

3. According to the Hazardous Waste Management Rules 2016, which of the following wastes is prohibited for import?
   A. Waste tyres
   B. Metal scrap
   C. Household waste
   D. Paper waste

4. Which hazardous waste management method involves using waste as a supplementary resource for energy recovery?
   A. Co-processing
   B. Landfilling
   C. Incineration
   D. Deep-well injection

5. In hazardous waste management, what does the abbreviation GIN stand for?
   A. General Identification Number
   B. Generator Identification Number
   C. General Industrial Number
   D. Generator Industrial Number

Fill in the Blanks

1. Hazardous waste can take many forms, including liquids, solids, gases, and _____.
2. A quarter of all Victorian employees regularly use hazardous substances such as chemicals, flammable liquids, and _____ in their work.
3. The degree of hazard of a substance depends on the _____ of the chemical.

Short Answer Questions

1. Explain the significance of Safety Data Sheets provided by manufacturers and importers of hazardous substances.
2. Name three health effects that exposure to hazardous substances can cause.
3. Explain the process and benefits of co-processing as a mechanism for hazardous waste management.
4. Discuss the steps involved in the proper disposal of used motor and hydraulic oils in an automobile repair and maintenance facility.
5. What measures should be taken to handle and dispose of parts-cleaning solvents in an automobile repair shop?
6. How do the Hazardous Waste Management Rules 2016 streamline the import/export of waste?

Activities
1. Present a report on the different types of hazardous waste generated in their locality or country. Also identify the sources, types of waste, and current disposal methods, and suggest improvements. 2. Prepare safety posters highlighting the dangers of hazardous substances and safe handling practices. These posters can be displayed in school or shared with the community.

ANSWER KEY

UNIT 1: Tools and Equipment Used for Maintenance of Electric Vehicles

Session 1: Types of Tools

Multiple Choice Questions (MCQs)	1. B	2. C
	3. C	4. C
	5. B	
Fill in the Blanks	1. Infrared Thermometer	2. Socket
	3. Battery Load Tester	4. Safety Goggles
	5. Electric Vehicle Lift	

Unit 2: Routine Service & Repair of Two and Three EVs

Session 1: Components of Two and Three-Wheeler EVs

Multiple Choice Questions (MCQs)	1. B	2. B
	3. B	4. A
	5. D	
Fill in the Blanks	1. Frame and Chassis	2. Charging
	3. Regenerative	4. Electrical
	5. Controller Area Network (CAN)	

Session 2: Reading of Owner's (Manufacturer) Manual and Service Manual

Multiple Choice Questions (MCQs)	1. B	2. C
	3. C	4. B
	5. D	
Fill in the Blanks	1. Service	2. Index
	3. Maintenance Schedule	4. Schematic
	5. Troubleshooting and Problem Resolution	

Session 3: Types of Faults, Causes, and Rectification Procedures and Repair Work

Multiple Choice Questions (MCQs)	1. C	2. B
	3. A	4. D
	5. B	
Fill in the Blanks	1. Seat	2. Vehicle Body
	3. 2 ½ Inches	4. 6.0
	5. Disc Brakes	

Unit 3: Routine Service and Repair of Four-Wheeler EVs

Session 1: Components of Four-Wheeler EVs and their Functions

Multiple Choice Questions (MCQs)	1. A	2. B
	3. A	4. C
	5. D	
Fill in the Blanks	1. Traction Battery Pack	2. Power Inverter
	3. Controller	4. Charger
	5. Thermal Management System	

Session 2: Reading of Owner's (Manufacturer) Manual and Service Manual

Multiple Choice Questions (MCQs)	1. C	2. C
	3. A	4. B
	5. C	
Fill in the Blanks	1. Owner's Manual	2. Service Manuals
	3. Vin	4. Visual Aids

Session 3: Types of Faults, Causes, and Rectification Procedures and Repair Work

Multiple Choice Questions (MCQs)	1. D	2. B
	3. A	4. C
	5. A	
Fill in the Blanks	1. Brake	2. Horn
	3. Frame	4. Loose

Unit 4: Routine Service and Repair of Heavy Commercial EVs

Session 1: Major Components of Heavy Commercial Electric Vehicles

Multiple Choice Questions (MCQs)	1. C	2. B
	3. D	
Fill in the Blanks	1. DC-AC Converter	2. Motor Control
	3. HV Power Distribution Unit	

Session 2: Reading of Owner's (Manufacturer) Manual and Service Manual

Multiple Choice Questions (MCQs)	1. B	2. C
	3. A	4. B
	5. C	
Fill in the Blanks	1. Illustrations	2. Skilled
	3. Windshield	4. 10

Session 3: Routine Inspection of Heavy Commercial Components Maintenance

Multiple Choice Questions (MCQs)	1. A	2. B
	3. C	4. C
	5. D	
Fill in the Blanks	1. Acid	2. Petroleum Jelly (Vaseline)
	3. Accelerator	4. 2 Weeks
	5. Month	

Session 4: Trouble Shooting of Components of Heavy Commercial EVs

Multiple Choice Questions (MCQs)	1. A	2. D
	3. C	4. A
	5. B	
Fill in the Blanks	1. Signal	2. Internal Short
	3. Gearbox	4. Redirector
	5. Toe-In	

UNIT 5 Innovation and Technology

Session 1: Batteries for Electric Vehicles and their Parameters

Multiple Choice Questions (MCQs)	1. C	2. B
	3. D	4. B
	5. C	
Fill in the Blanks	1. Cycle Life	2. Power Density
	3. Lead-Acid	4. Self-Discharge
	5. Depth of Discharge (DoD)	
Session 2: Charging Methods of Electric Vehicle (EVs) Batteries		
Multiple Choice Questions (MCQs)	1. A	2. C
	3. D	4. B
	5. B	
Fill in the Blanks	1. 2.5	2. Alternating Current (AC)
	3. Ultra-Fast	4. Thermal
	5. Robotic	
Session 3: Key Technology Trends Shaping EVs		
Multiple Choice Questions (MCQs)	1. B	2. C
	3. C	4. A
	5. B	
Fill in the Blanks	1. Machine Learning	2. Regenerative Braking
	3. AI (Artificial Intelligence)	4. Smart
	5. Electromagnetic	
Session 4: Hazardous Waste		
Multiple Choice Questions (MCQs)	1. D	2. C
	3. C	4. A
	5. B	
Fill in the Blanks	1. Sludges	2. Gases
	3. Concentration	

Glossary

Term	Definition
Battery Capacity	The total amount of energy that a battery can store, is typically measured in kilowatt-hours (kWh).
Battery Management System (BMS)	A system that manages the battery pack, ensuring its safe operation, balancing the cells, and maximizing performance and lifespan.
Battery Swapping	A method of recharging electric vehicles by replacing depleted batteries with fully charged ones at dedicated swapping stations.
BEV (Battery Electric Vehicle)	A type of electric vehicle that runs entirely on electricity stored in batteries and has no internal combustion engine.
CCS (Combined Charging System)	A standardized charging protocol for electric vehicles that combines AC and DC charging into a single connector system.
CHAdeMO	A quick charging method for electric vehicles, allowing fast DC charging using a specific connector standard developed in Japan.
CHAdeMO Adapter	A device that enables electric vehicles with different charging standards to use CHAdeMO charging stations.
Charge Cycle	One complete charge and discharge of a battery is used as a measure of battery life and durability.
Charging Connector	The plug is used to connect an electric vehicle to a charging station. Different types of connectors include CHAdeMO, CCS, and Tesla's proprietary connector.
Charging Infrastructure	The network of charging stations and related equipment necessary to support the widespread adoption of electric vehicles.
Charging Speed	The rate at which an electric vehicle's battery can be recharged, is typically measured in kilowatts (kW).
Charging Station	An infrastructure component that supplies electric energy for the recharging of electric vehicles.
DC Fast Charging	A method of rapidly charging an electric vehicle’s battery using direct current (DC) at high power levels, typically found at public charging stations.
Drive Cycle	A standardized set of driving conditions is used to test and compare the performance and efficiency of vehicles, including electric vehicles.
Drivetrain	The group of components that deliver power to the driving wheels of a vehicle, including the electric motor, transmission, and other related parts.
Electrified Powertrain	A powertrain that uses electrical energy, either partially (as in hybrids) or fully (as in electric vehicles), to drive the vehicle.
Electric Motor	The component of an electric vehicle that converts electrical energy into mechanical energy to drive the vehicle.
Electrolyte	The medium within a battery allows ions to move between the cathode and anode, facilitating the chemical reactions that store and release energy.

Energy Density	The amount of energy stored in a given system or region of space per unit volume or mass is important for determining the efficiency of batteries in electric vehicles.
Energy Recovery System	Systems in electric vehicles that capture and reuse energy, such as regenerative braking systems.
EVSE (Electric Vehicle Supply Equipment)	The equipment used to deliver electrical energy from an electricity source to charge an electric vehicle's battery.
FCEV (Fuel Cell Electric Vehicle)	A type of electric vehicle that uses a fuel cell to generate electricity from hydrogen to power its electric motor.
HEV (Hybrid Electric Vehicle)	A vehicle that combines a conventional internal combustion engine with an electric propulsion system but cannot be plugged in to charge the battery.
Home Charging Station	A personal electric vehicle charging setup typically installed in a garage or driveway, allowing for convenient overnight charging.
Inverter	A device that converts the direct current (DC) from the battery into alternating current (AC) to power the electric motor.
Kilometers per kWh (km/kWh)	A measurement of how efficiently an electric vehicle uses energy, indicating the distance traveled per kilowatt-hour of electricity consumed.
kW (Kilowatt)	A unit of power measurement indicating the rate at which energy is used or generated.
kWh (Kilowatt-hour)	A unit of energy measurement that indicates the amount of energy a battery can store or a vehicle can use.
Level 1 Charging	The slowest form of charging, using a standard household outlet (120V) to charge an electric vehicle.
Level 2 Charging	A faster form of charging that uses a 240V outlet, similar to what is used for large appliances like dryers and ovens.
Lithium-ion Battery	The most common type of battery used in electric vehicles is known for its high energy density and long cycle life.
Load Balancing	The process of distributing electrical load evenly across the grid or charging network to prevent overloading and ensure reliable power supply.
Mobility as a Service (MaaS)	An integrated transportation concept that combines various forms of transportation services into a single accessible on-demand service, often including EV options.
Off-Peak Charging	Charging an electric vehicle during times of low electricity demand, typically at night, to take advantage of lower electricity rates.
Onboard Charger	A device within an electric vehicle that converts AC power from a charging station to DC power to charge the battery.
Peak Charging Rate	The maximum power level at which an electric vehicle's battery can be charged, is often specified in kilowatts (kW).

PHEV (Plug-in Hybrid Electric Vehicle)	A vehicle that combines a conventional internal combustion engine with a battery that can be recharged by plugging into an external source of electric power.
Power Electronics	The technology used to convert and control electrical power in electric vehicles, including inverters, converters, and charging systems.
Powertrain	The main components that generate power and deliver it to the road surface, include the battery, electric motor, and transmission.
Range	The distance an electric vehicle can travel on a single charge.
Range Anxiety	The fear or concern that the battery of an electric vehicle will run out of power before reaching the next charging station or destination.
Regenerative Braking	A technology that allows an electric vehicle to recover energy during braking and store it in the battery.
Renewable Energy Charging	The use of renewable energy sources, such as solar or wind power, to charge electric vehicles, reduces their overall carbon footprint.
Second-Life Battery	The use of EV batteries that are no longer suitable for vehicle use but still have sufficient capacity for other energy storage applications.
Smart Charging	Charging systems that use real-time data and communication to optimize the timing and power level of EV charging to benefit the grid and reduce costs.
State of Charge (SOC)	A measurement of the current energy level of a battery as a percentage of its total capacity.
State of Health (SOH)	An indicator of the overall condition of a battery, representing its remaining capacity and ability to deliver energy compared to its original state.
Supercharger	A high-power charging station developed by Tesla that provides fast charging for Tesla vehicles.
Thermal Management System	A system in an electric vehicle that regulates the temperature of the battery pack to ensure optimal performance and longevity.
Torque	A measure of the rotational force produced by the electric motor, crucial for acceleration and performance in electric vehicles.
Ultra-Fast Charger	Charging stations capable of delivering extremely high-power levels (often above 150 kW), significantly reduce the time required to recharge an electric vehicle.
V2G (Vehicle-to-Grid)	A system in which plug-in electric vehicles communicate with the power grid to sell demand response services by returning electricity to the grid.
Vehicle Emissions Standard	Regulations set by governments to limit the amount of pollutants that vehicles can emit, often driving the adoption of electric vehicles.
Wireless Charging	A technology that allows electric vehicles to be charged without a physical connection, typically through inductive charging pads embedded in parking spots or roads.
Zero Emissions Vehicle (ZEV)	A vehicle that produces no tailpipe emissions, typically including battery electric vehicles (BEVs) and hydrogen fuel cell vehicles (FCEVs).