

MECHANIC ELECTRIC VEHICLE

NSQF LEVEL - 4

2nd Year

TRADE PRACTICAL

SECTOR: AUTOMOTIVE

(As per revised syllabus July 2022 - 1200Hrs)



Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA



**NATIONAL INSTRUCTIONAL
MEDIA INSTITUTE, CHENNAI**

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Sector : Automotive
Duration : 2 Years
Trade : Mechanic Electric Vehicle - 2nd Year Trade Practical - NSQF Level - 4
(Revised 2022)

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Mechanic Electric Vehicle 2nd Year Trade Practical in Automotive Sector** under **Yearly Pattern**. The NSQF Level - 4 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Director General, Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

ATUL KUMAR TIWARI, I.A.S

Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

May 2024
New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVET/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032

EXECUTIVE DIRECTOR

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material **(Trade Practical)** for the trade of **Mechanic Electric Vehicle 2nd Year NSQF Level - 4 (Revised 2022)** under **Automotive** Sector for ITIs.

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Shri. S. Gopalakrishnan	-	Assistant Manager, NIMI, Chennai - 32.

NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intended to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the course. These exercises are designed to ensure that all the skills in compliance with NSQF Level - 4 (Revised 2022) syllabus are covered.

The manual is divided into Seven modules

Module 1	Traction Motor and Battery Management System
Module 2	Vehicle Control and HVAC System
Module 3	Battery Charging System
Module 4	Drive by Wire Systems
Module 5	Electrical and Electronic Control System
Module 6	Electronic Control Transmission System
Module 7	Electric Vehicle Regulations

The skill training in the shop floor is planned through a series of practical exercises centered around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual, a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the Course of the **Mechanic Electric Vehicle 2nd Year NSQF Level - 4 (Revised 2022) in Automotive**. The contents are sequenced according to the practical exercise contained in NSQF Level - 4 (Revised 2022) syllabus on Trade Theory attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptual capabilities for performing the skills.

The trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indications about the corresponding practical exercises are given in every sheet of this manual.

It will be preferable to teach/learn trade theory connected to each exercise at least one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not for the purpose of self-learning and should be considered as supplementary to class room instruction.

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LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No	Learning Outcome	Ref. Ex.No.
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2	Identify and develop Battery Pack Components, monitor and check performance of high voltage rechargeable energy storage system and Battery Management System. (NOS: ASC/N1435)	2.1.102 - 2.1.110
3	Perform battery testing, charging and cycling operations. (NOS: ASC/N1435, ASC/N1437)	2.1.111 - 2.1.117
4	Test and troubleshoot Accessory and Auxiliary Components - Power Steering, Braking and HVAC Comfort System. (NOS: ASC/N1435, ASC/N1437)	2.1.118 - 2.2.130
5	Operate and troubleshoot Electric Vehicle Charging Ecosystem (NOS: ASC/N9433)	2.3.131 - 2.3.134
6	Drive an Electric Vehicle following the safety rules for driving. (NOS: ASC/N1435, ASC/N1437)	2.4.135 - 2.4.139
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SYLLABUS

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 75 Hrs.; Professional Knowledge 18 Hrs.	Apply the knowledge of power transmission system in electric vehicle, its basic components and functions; electric vehicle motor, its speed control technique and motor controller. (NOS: ASC/N1435, ASC/N1437)	100.Study Motor Controller working. Remove and install rotor from stator and diagnose motor rotor position sensor. (35hrs)	Induction motor - drive, working principle, Study- state, volts, Hertz control, electronic control, electric Motor to wheel transmission s y s t e m components & its working principles, speed control technique, Voltage inverter, Switched Reluctance motor -working Principle, Different component, control system, motor circuit. Advantages and disadvantages of various motors. (9 Hrs)
		101.Diagnose drive/traction motor-generator assembly for improper operation (such as an inoperative condition, noise, shudder, overheating. (40 hrs)	Motor controller working principle and basic components. Motor cooling system and working component, Theoretical torque calculation, reason for heating, noise and failure of motor. (9 Hrs)
Professional Skill 75 Hrs.; Professional Knowledge 18 Hrs.	Identify and develop Battery Pack Components, monitor and check performance of high voltage rechargeable energy storage system and Battery Management System. (NOS: ASC/N1435)	102.Develop Battery Pack with Series Parallel Configuration. (10 hrs) 103.Identify different cell chemistries. (05 hrs) 104.Identify different cell geometries. (05 hrs) 105.Identification of various sensors installed - Battery Temperature Mapping. (05 hrs) 106.Verify cell performance against supplier data sheet. (05 hrs) 107.Conduct Voltage, Current and Temperature Measurement with BMS. (10 hrs) 108.Configuration of BMS with software application. (10 hrs) 109.Balance cells with external circuits. (10 hrs) 110.Verify SoC mapping for charging and discharging Use Data to map Battery SoH. (15hrs)	Cells - Cell Types Lead Acid/Li-ion/ NiMH, NiCad etc., Chemistries and Geometries, Cell Selection and sizing, Handling Cells, Understanding Cell Charging and Discharging Curves, Understand Temperature impact on cell, Internal resistance, Cell Construction and Manufacturing, Life cycle of various types of batteries Battery Module and Pack Development - Battery Pack Configuration, Pack and Module Construction, Configurations, Types and Energy Concepts, Voltage, and Temperature Measurement, C u r r e n t Measurement, T h e r m a l Management, Pack Sealing Sensors used in B M S Battery capacity and rating Battery charging and discharging calculation. (09 Hrs) Battery Management System (BMS)/Energy Management System (EMS) - Need of BMS, Voltage, Current and Temperature Monitoring, Cell Balancing - Types, Active, Passive, SoC Determination, S o C Algorithms, Battery cooling System. (09 Hrs)

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 75 Hrs.; Professional Knowledge 27 Hrs.	Perform battery testing, charging and cycling operations. (NOS: ASC/N1435, ASC/N1437)	111.Connecting battery to a charger for battery charging, Inspecting & testing a battery after charging. (08 hrs) 112.Perform safe storage, handle, and dispose of high voltage battery systems. (08 hrs) 113.Replace defective Battery Module of 48V Module Systems. (05 hrs) 114.Check battery assembly sensors for proper functioning. (04 hrs) 115.Diagnose, repair, and test high voltage battery systems. (10 hrs) 116.Diagnose, repair, and testing of EV battery controls. (10 hrs) 117.Measure and Diagnose the cause(s) of excessive Key-off battery drain (parasitic draw) and do corrective action. (30 hrs)	Understanding charge and discharge cycles, Understanding State of Charge and State of Health, Battery Life, Cycles of Operation, SoH, Concept of State of Energy (SoE) and State of Power (SoP) Battery handling at swapping Stations (17 Hrs). Using second life batteries - selection, redeployment, refurbishment Battery Disposal, Storing Batteries. (10 Hrs)
Professional Skill 150 Hrs.; Professional Knowledge 45 Hrs.	Test and troubleshoot Accessory and Auxiliary Components - Power Steering, Braking and HVAC Comfort System. (NOS: ASC/N1435, ASC/N1437)	118.Check Cooling Requirement for EV Components. (15 hrs) 119.Check battery cooling fan for proper functioning. (10 hrs) 120.Check cooling system optimal performance for Inverter assembly. (10 hrs) 121.Inspection of power steering control module circuit. (10 hrs) 122.Checking & adjusting power steering fluid, Pressure testing a power steering system, Flushing a power steering system. (15 hrs) 123.Identification of various sensors installed. (10 hrs) 124.Trouble shooting and remedy for steering wheel feels heavy at low speed, poor recovery from turns, Vehicle pulls to one side during straight driving. (10 hrs) 125.Identify and locate the components of Car AC system in a given vehicle. (10 hrs) 126.Check a heating system, Compressor rotation test, air Gap check, Refrigerant recovery - evacuating - charging of A/c system. (10 hrs) 127.Check charge state of refrigerant. Check AC system and its components for proper functioning. (10 hrs)	EV Thermal Management - Cooling of Battery Pack, Motor and Inverter, Active and Passive Cooling, Fluid Based Cooling, Ethylene Glycol, Forced Air Cooling, Cabin Air Based Cooling Description of Electric power assisted steering, Basic electric power steering operation. Electronic adjustable-rate shock absorbers, Electric brakes, Electro hydraulic braking (EHB), ABS brake system, Antilock braking system operation, Principles of ABS braking, ABS master cylinder, Hydraulic control unit, Wheel speed sensors, ABS with Electronic Brake force Distribution (EBD) control unit. (25 Hrs) Heating Ventilation Air Conditioning (HVAC) legislation, Vehicle heating, ventilation & cooling systems, Basic air- conditioning principles, Air- conditioning capacity, Air- conditioning refrigerant, Humidity. Description and function of Fixed orifice, Control devices, Thermostatic expansion valve system, Thermal expansion valves, Air- conditioning compressors, Condensers & evaporators, Receiver drier, Lines & hoses, TX valve construction, Temperature monitoring thermostat,

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		<p>128. Check e-Compressor, Carry out the diagnostic procedure for the following trouble - No cooling. (10 hrs)</p> <p>129. Intermittent cooling, insufficient cooling, abnormal noise from compressor, magnetic clutch, condenser, evaporator, and blower. High pressure gauge- Pressure high and low. Low pressure gauge Pressure high and low. (05 hrs)</p> <p>130. Identification of ABS components, checking of ABS warning lamp, Electronic Brake Distribution (EBD). (25 hrs)</p>	<p>Refrigerants, Pressure switches, Heating elements. Air-conditioning ECU, Ambient air temperature sensor, Servo motors, Electric servo motors, Automatic climate control sensors, Evaporator temperature sensor, Blower speed control, Ventilation systems Electric Inverter Compressor: Principle of working, types and advantages over conventional compressor. HVAC system and Compressor. (20 Hrs)</p>
<p>Professional Skill 50 Hrs.;</p> <p>Professional Knowledge 09 Hrs.</p>	<p>Operate and troubleshoot Electric Vehicle Charging Ecosystem (NOS: ASC/N9433)</p>	<p>131. Identify Type of Charger and Voltage Levels. (15 hrs)</p> <p>132. Operate Standard Chargers Determine Charging Time under various conditions. (15 hrs)</p> <p>133. Requirement of charging inputs for different types of chargers. (10 hrs)</p> <p>134. Diagnosis and remedy for Charger not responding, Charger not delivering expected current. (10 hrs)</p>	<p>Charging system- The purpose of Charging system, charging system components, charging system circuit, AC Charger, DC Charger, Solar Integrated (MPPT based) Charger High voltage charging systems, Charger cooling. Constant Current (CC) & Constant Voltage (CV) Charging Standard - Chademo, GB/T, DC001, CCS - Protocols, Connectors Electric Vehicles charging station - Type of Charging station, Selection and Sizing of charging station, Components of charging station, Single line diagram of charging station. Terms associated with EV Charging Station Charging Station Indicators, Charging Station Installation, Charging Station for swappable battery packs DC/DC converter, working principle, Type, Calculation. Relay, operation, types and application. Rule based and optimization-based control, Software based control, Thermal management system, Cell load distribution, SOC and SOH determination. Repair and maintenance of Electric Vehicle system. Chopper circuit of DC motor. (09 Hrs)</p>
<p>Professional Skill 50 Hrs.;</p> <p>Professional Knowledge 09 Hrs.</p>	<p>Drive an Electric Vehicle following the safety rules for driving. (NOS: ASC/N1435, ASC/N1437)</p>	<p>135. Carry out Drive by Wire Architecture Learn. (10 hrs)</p> <p>136. Riding Modes - Accelerator Pedal to Torque. (10 hrs)</p>	<p>Drive by Wire System - Accelerator Pedal Acceleration and Braking in EV Functional Safety Understanding driving pattern, accessories usage (HVAC) and</p>

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		137. Mapping Troubleshoot and Repair - Accelerator Pedal not working. (10 hrs) 138. Troubleshoot and Repair - Brake not working. (10 hrs) 139. Drive an EV. (10 hrs)	drive cycle and driver dependency. (05 hrs) Electronic Controlled Brake: Principle of Regenerative Braking., Regenerative Brake cooperative control operation. Riding Modes - Sport and Comfort, Driver Behavior, Economy mode. (04 hrs)
Professional Skill 300 Hrs.; Professional Knowledge 90 Hrs.	Diagnose, repair, and testing of EV vehicles and subsystems and EV components. (NOS: ASC/N1435, ASC/N1437)	140. Trace the light circuit - test bulbs, align head lamps, A i m i n g headlights. (07 hrs) 141. Changing a headlight bulb, checking of a head light switch and to replace if faulty. (08 hrs.) 142. Trace the wiring circuit of lighting system. (10 hrs) 143. Remove and install wiper motors and wiper switches. (07 hrs.) 144. Hands-on and practice to Identify different location of various ECUs in vehicle. Identify antitheft system. (15 hrs) 145. Remove and install new horn. (03 hrs) 146. Practice on Identifying Proximity sensor, Parking sensor, crash sensor, Rain and Light Sensor. (30 hrs) 147. Remove and install power door lock and tracing the circuit. (10 hrs) 148. Identification of A i r conditioning components. (25 hrs) 149. Hands on adjustment of A/C inside the cabin. (10 hrs) 150. Do the preventive maintenance of FATC/ HVAC machine. (15 hrs) 151. Demonstrate working of grinding machine. (15 hrs) 152. Automatic transmission Identification of Automatic transmission components and related sensors. (15 hrs) 153. Perform RCA and tracing of wiring circuit in auto transmission. (15 hrs) 154. Perform Electronic Power Steering Identification of EPS components and related sensors. (15 hrs)	Lighting system, Lamps/light bulbs (Halogen, Xenon and LED), Lamp/light bulb information, LED lighting. Headlight & dimmer circuits, Park & taillight circuits, Brake light circuits, turn signal circuit, Cornering lights, Fog lights circuit, interior lights- courtesy, reading and instrument panel lights, Smart lighting, Reverse lights Temperature monitoring thermostat. Air-conditioning ECU, Blower speed control, Ventilation systems. Accessories: Horn circuit, wiper circuit, power window components and circuit Power door lock circuit, automatic door lock circuit. Antitheft system, immobilizer. (20 hrs) ECU Communications- Communication between different ECUs. LIN Bus, MOST Bus, CAN Bus. (10 hrs)
		155. Hands-on for RCA and Tracing wiring circuit in EPS. (10 hrs)	Electronic control transmission Continuously variable transmission (C.V.T.) - Description of Electric

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		<p>156.Practice on Recognition of EV symbols. (10 hrs)</p> <p>157.Tracing wiring circuit of parking sensor, co- passenger sensor and seat belt. (10 hrs)</p> <p>158.Check the accuracy of grinding machine after assembly. (10 hrs)</p> <p>159.Tracing wiring circuit of parking sensor, co- passenger sensor and seat belt. (10 hrs)</p> <p>160.Practice of safety precautions and procedures to be observed while working with EV Kit and related tools. (25 hrs)</p> <p>161.Study the Gear Box and explain the function of Gear Box & calculate gear ratio of it. (15 hrs)</p> <p>162.Form internal threads with taps to standard size. (10 hrs)</p>	<p>power assisted steering, Basic electric power steering operation. (30 hrs)</p> <p>Automatic Transmissions - Torque converters, Torque converter principles, drive plate, Converter operation, Torque multiplication, Fluid flow, Heat exchanger, Lock-up converters, clutches. Planetary gearing. (30 hrs)</p>
Professional Skill 65 Hrs.; Professional Knowledge 18 Hrs.	Demonstrate regulatory requirements for electric vehicle and new trends in electric vehicle. (NOS: ASC/ N9434)	<p>163.To list out various requirements for electric vehicle. (25 hrs)</p> <p>164.Understanding recycling and reuse vehicle. (10 hrs)</p> <p>165.Understanding latest development. (10hrs)</p> <p>166.Understanding autonomous vehicle system. (10 hrs)</p> <p>167.Understanding o f autonomous vehicle system components like LIDAR, object detection, AI cameras, ADAS, collision detection sensor. (10 hrs)</p>	Study of electric vehicle regulations. Study of electric vehicle recycling and reuse. Study of advancement of electric vehicle. Study of autonomous vehicle system architecture. (18 hrs)

Dismantle and assemble the traction motor

Objectives: At the end of this exercise you shall be able to

- study the traction motor controller working
- remove the traction motor from the vehicles
- dismantle the motor and diagnose motor rotor position sensor
- remove and install rotor from stator.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 Set.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
• Test lamp	- 1 No.	• Cleaning solvent	- as reqd.
• User manual	- 1 No.	• controller	- 1 No.
Equipments/Machineries		• Rotor	- 1 No.
• Electric vehicle	- 1 No.	• Stator	- 1 No.
• Test bench	- 1 No.	• Rotor position sensor	- 1 No.
• Work bench	- 1 No.		

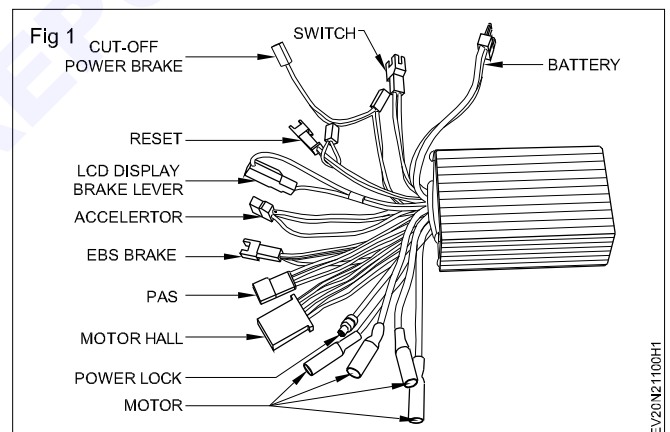
PROCEDURE

TASK 1: Study the working of traction motor controller in electric vehicle

- 1 Select the electric vehicle for dismantle and assemble the traction motor and their power controller.
- 2 Park the vehicles on the shop floor.
- 3 Study the user manual for find the location of accelerator petrol, controller, traction motor and their electrical wire connections and mechanical connections with traction motor.
- 4 Trace the battery power flow to traction motor.
- 5 Locate the accelerator pedal and their wire connection with accelerator pedal and their wire connection with accelerator pedal sensor. (Figs 1 & 2)

Note: The accelerator pedal sends a signal to the controller, which adjust vehicle speed by changing the frequency of the AC power from the inverter to motor. The motor connects and turns the wheel through cog.

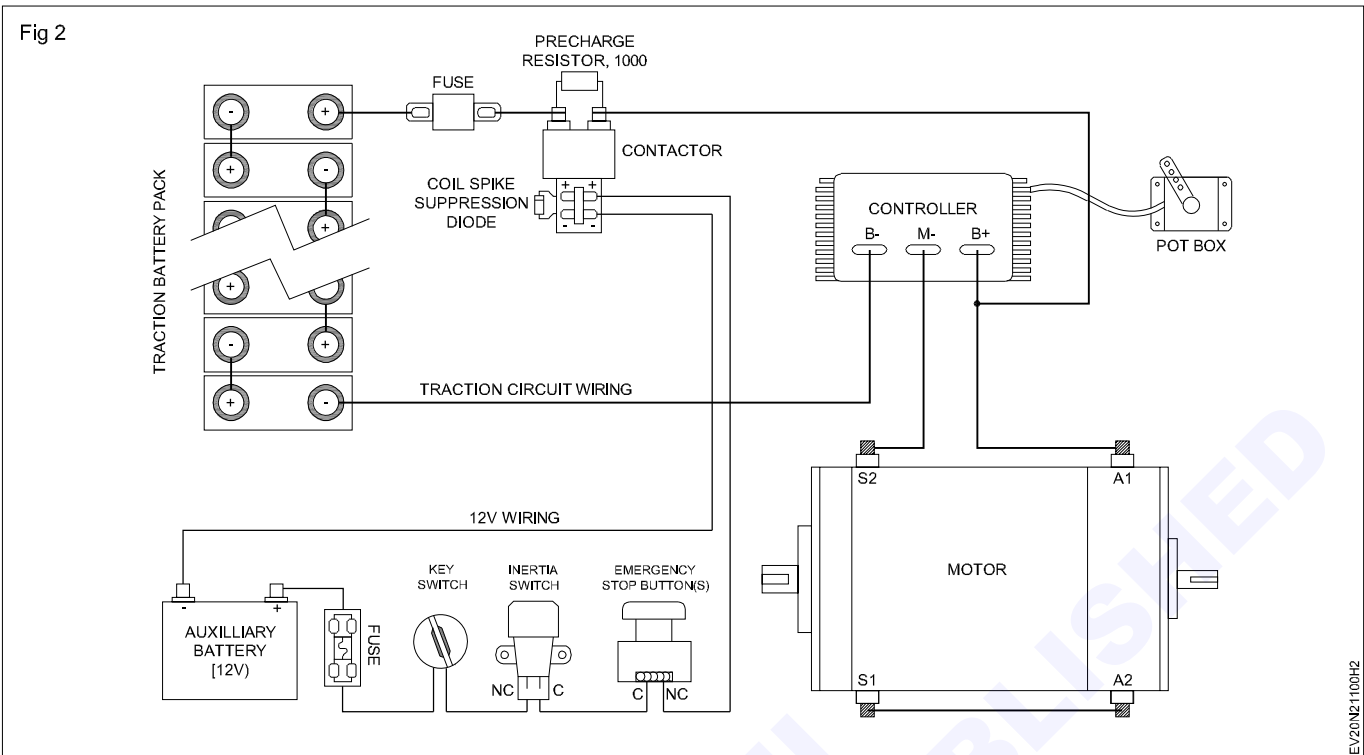
- 6 Identify the controller and their wire connections. (Fig 1)
- 7 Identify the traction motor and their electrical and mechanical connections.
- 8 Check the fuse rated to around the maximum battery current rating of motor.
- 9 Ensure you are well known the EV controller wiring circuit and their function.
- 10 Check the extra safety devices inserted in series with the other 12V devices.



- 11 Ensure the function of EV controller which is increase or decrease the power to traction motor according to accelerator pedal movement.
- 12 Switch on the ignition power supply.
- 13 Ensure battery power is fully charged and power flow to all circuits. (Fig 2)
- 14 Apply pressure on pot box lever (accelerator pedal) slowly and you feel that motor start to work according power supply to motor from the battery power through inverter to motor.
- 15 Ensure if you are gradually increase the accelerator, pedal, the motor speed also increase, it means controller is functioning properly.
- 16 If found any malfunctioning, check the controllers wire connections and accelerator pedal sensor circuits.

17 Rectify the defects and recheck the controller functions.

18 Ensure the controller is functioning properly as per the movement of accelerator pedal.

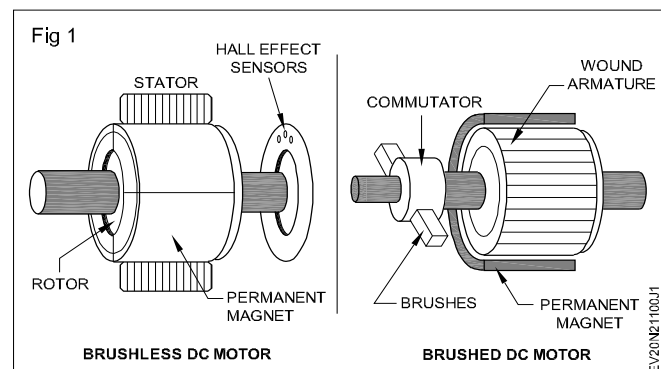


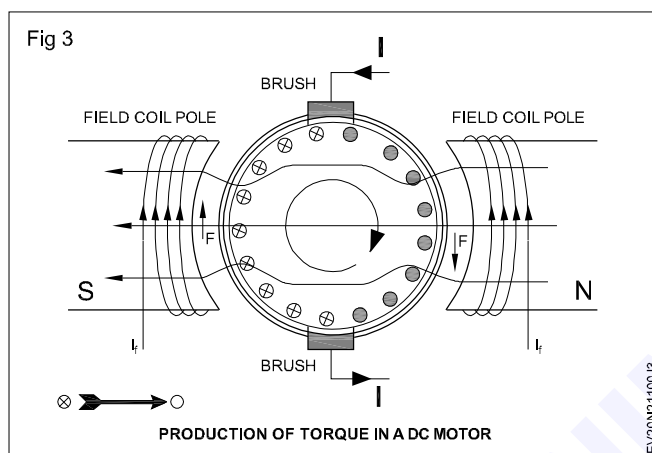
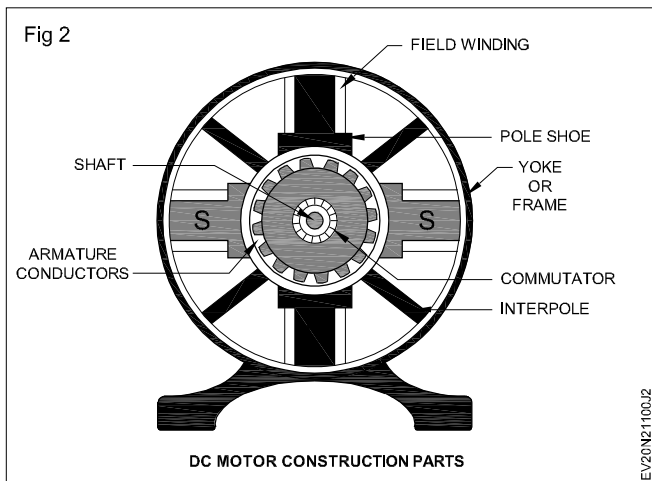
TASK 2: Remove the traction motor from the vehicles

- 1 Locate the traction motor in a vehicle.
- 2 Identify the Electrical and mechanical connections with traction motor.
- 3 Use the PPE before start the work (Personal and work place safety).
- 4 Carefully disconnect the battery power supply cable connection with traction motor.
- 5 Disconnect the motor controller wire connections with traction motor.
- 6 Disconnect inverter and motor wire connections.
- 7 Remove the mechanical connections and clutch with tractions motor.
- 8 Dismount the motor mountings and remove the motor from the vehicles with help of your co-worker.
- 9 Place the motor on the work bench.

TASK 3: Dismantle the motor and diagnose the motor rotor position sensor and other defects

- 1 Clean the motor outer body.
- 2 Study the type of motor whether a AC or DC motor, if AC motor single phase or three phase motor. (Fig 1)
- 3 Select the tools for dismantle the motor.
- 4 Remove the cooling fan cover.
- 5 Remove the fan.
- 6 Loosen the both side end shield mounting bolts.
- 7 Remove the both and shield with bearing
- 8 Remove the rotor from the stator winding. (Fig 2 & 3)
- 9 Remove the stator coil from the motor housing.





Note: Safety rules of electric motor

- Work area must always be kept well fit and clean.
- PPE must be wear assembling and testing motor.
- Motor must not be left unattended.
- Rated operating voltage must not be exceeded. High voltages might cause over heating and create fire while you are testing the motor.
- Motor must be tested under your instructors guidelines or presence.

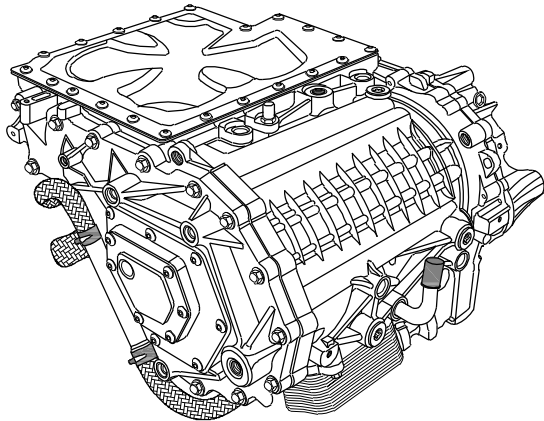
- 10 Clean the all dismantled motor parts.
- 11 Inspect the parts for damages or weakness.
- 12 Inspect the bearing for noise, wear and damage.
- 13 Test the stator and rotor continuity or any other damages.
- 14 Inspect the rotor's stack slot, stack tooth, winding coil, Armature shaft, armature stack, commutator bar etc.
- 15 Check the commutator and brushes.
- 16 Check the fan blades for damages.
- 17 Check the wiring terminal.
- 18 Check the traction motor position sensor.
- 19 Ensure all dismantled parts of motor are cleared and tested and defective parts are replace with suitable original parts.

TASK 4: Traction motor assembling and testing

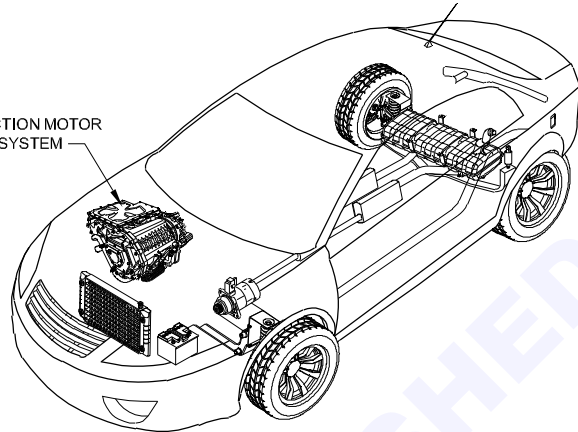
- 1 Clean the parts before assembling the motor.
- 2 Apply lubricant wherever necessary.
- 3 Refer the workshop manual for sequence of motor parts assembling.
- 4 Assemble field coil in motor housing and connect the wire with wire terminals.
- 5 Fix the bearings in end plate.
- 6 Fix the armature/rotor inside of field coil(stator) and fix the carbon brushes and end shield plate.
- 7 Fix the end shield plate mounting screws.
- 8 Rotate the rotor for free rotation and ensure no noise from the motor.
- 9 Mount the cooling fan on the rotor shaft.
- 10 Fix the fan guard and rotor position sensor etc.
- 11 Take motor to test bench and fix the motor with test bench electrical and mechanical connections.
- 12 Switch on the power of test bench and give load to traction motor by operating pot lever (accelerator pedal).
- 13 Check the motor functioning performance and heat of torque production.
- 14 Ensure motor is working as per manufacturers specifications.
- 15 Switch off the test bench power to motor and disconnect the electrical and mechanical connections from motor remove the motor from the test bench.
- 15 Carry the motor to vehicle location and fix the motor in the vehicles and connect the all connections with motor.
- 16 Ensure all wire connections and mechanical connections are connected with traction motor. (Fig 1)
- 17 Connect the battery power with motor controller and motor. Start and move the vehicles for check the performance of traction motor.

Note: Brush less DC motor uses hall effects sensor for detect and adjust the angle of the rotor. Brushed DC motor uses a commutator that reverses the current every half cycle and creates single direction torque.

Fig 1



TRACTION MOTOR
SYSTEM



EV20N21100Z1

Practice to diagnose improper operation of traction motor

Objectives: At the end of this exercise you shall be able to

- diagnose the cause for inoperative condition of drive motor
- diagnose the cause for motor noise
- diagnose the cause for motor shudder
- diagnose the cause for motor overheating.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
• Test lamp	- 1 No.	• Insulation tape	- as reqd.
Equipments/Machineries		• Wire	- as reqd.
• Electric vehicles	- 1 No.	• Bearing	- as reqd.
		• Carbon brush	- as reqd.
		• Cable connector	- as reqd.

PROCEDURE

TASK 1: Diagnose the cause for in-operative condition of drive motor

- | | |
|---|---|
| <ol style="list-style-type: none"> 1 Check the battery power if low power, recharge the battery. 2 Check the battery pack wire connection if disconnected, connect it properly. 3 Check the inverter's function, if found any defect rectify it. 4 Check the controller if found defective replace it. 5 Check the accelerator pedal sensor, if found defective replace it. 6 Check the controller wire connections, if found any loose connections tighten it. 7 Check the traction motor wire connections, if found loose connection tighten it. 8 Check the motor, if not rotate remove and repair it. 9 Check the motor bearing if found worn out or noise replace it. | <ol style="list-style-type: none"> 10 Check the rotor's eccentricity, if found rotor shaft w/o replace it. 11 Check the damaged magnet if found damaged replace the magnet. 12 Check the mounting bolt looseness if found loose fitting tighten it. 13 Check the drive shaft for bent, if found drive shaft bent, replace it. 14 Check current sensor, voltage sensor, speed sensor and other sensor related to motor, if found any malfunctioning sensor replace it. 15 Check power on/off switch for open, if found defective replace it. 16 Check DC link capacitor, if found defective replace it. |
|---|---|

TASK 2: Tracing the cause for noise in electric vehicle's drive motor

- | | |
|---|---|
| <ol style="list-style-type: none"> 1 Start the vehicle and move the vehicles by pressing the accelerator pedal. 2 Very carefully watch the noise from the drive motor. 3 If found any noise from the drive motor, bring the vehicles to workshop. 4 Place the vehicle on the ram and apply safety devices. 5 Disconnect the mechanical drive connection to wheel drive from the motor. | <ol style="list-style-type: none"> 6 Ensure the wheel drive connection is disconnected completely. 7 Start the motor and diagnose the cause for drive motor noise. whether it is cause of bearing, less gap between rotor and field coil, rotor shaft bent or any other causes. 8 If found any noise in motor, stop the motor power and disconnect the battery power. 9 Disconnect the motor wire connection and remove the motor mounting bolts. |
|---|---|

- 10 Remove the motor from the vehicle and place it on the work bench for service.
- 11 Dismantle the motor and clean the dismantle parts.
- 12 Inspect the dismantled motor parts like motor bearing motor cooling fan, rotor shaft, motor mounting bolt end shield plate. Carbon brush, carbon bursh spring, commutator etc.
- 13 If DC motor check hall effect sensor, which is used for proper positioning the rotor shaft.
- 14 Check the inverters output incase of AC motor drive if it's output is lower than specified limit, replace the inverter for proper output voltage/AC current.

- 15 Replace the defective motor parts and assemble the motor as in reverse the motor dismantling .
- 16 Refer the workshop manual for sequence of motor parts assembling.
- 17 Test the motor with test bench.
- 18 Ensure the no noisy from the motor.
- 19 Fix the motor in the vehicle and connect the all electrical and mechanical connections, tighten it as specified limit as recommended by the manufacturers.
- 20 Start the vehicle and ensure the no any noise found from the motor.

TASK 3: Diagnose the cause for traction motor shudder

- 1 Check the drive motor balance if found imbalances correct it for proper balancing.
- 2 Check the reduction gears alignment. if found misaligned gears align the gears.
- 3 Check the rotor shaft bearing too tighten or too loosen if found any malfunction the bearing replace the bearing.
- 4 Check the general wear and tear of motor roller bearing, rotor shaft, reduction gears or drive belts if found replace the damaged parts for avoid vibration.
- 5 Check the motor's angular misalignment, if misalignment happens over time, it can be because of shifting components, faulty reassembling or thermal expansion, cause radial or axial vibration main cause for vibration of the drive motor is as following defects.
- 6 Loose mounting bolts of drive motor.
- 7 Shaft misalignment.
- 8 Motor shaft thermal expansion.
- 9 Rotor shaft weariness.
- 10 Excess clearance between gears.
- 11 Worn out bearing balls.
- 12 Loose drive gears or belts.
- 13 Broken/cracked belts.
- 14 Loose mechanical connections.
- 15 Any ended cooling fan blades.
- 16 Motor coupling dry lubrication etc.

TASK 4: Diagnose the cause for electric vehicle motor over heating

- 1 Check the motor load if the motor is over load reduce motor load to reduce heat of motor.
- 2 Check the motor resistance if the low resistance motor can be over heat, motor over heat pave the way for short circuits and current leakages, which have motor at risk of failure.
- 3 Check the motor start and stop frequency plays a big role in heat damage, excessive motor starting and stopping create a high heat it leads to wear on the integrity of components.
- 4 Motor and transmission parts excessive vibration leads to raise excessive heat to unsafe levels and stress components beyond their capacity for heat.
- 5 Check the contamination of dust and debris, it will also raise the internal temperature of motor, which leads to excessive heat over a longer period of time. Do proper maintenance of motor for avoid contamination deposit on the motor parts.

Practice on develop a battery pack with series, parallel configuration

Objectives: At the end of this exercise you shall be able to

- develop a battery pack with series connection
- develop a battery pack with parallel connection.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 Set.	• Cotton waste	- as reqd.
• Soldering iron	- 1 Set.	• Soap oil	- as reqd.
• PPE kit	- 1 Set.	• Battery cable	- as reqd.
Equipments/Machineries		• Battery terminals	- as reqd.
		• Soft solder	- as reqd.
• Electric vehicle	- 1 No.		
• Electric vehicle batteries	- 1 Set.		

PROCEDURE

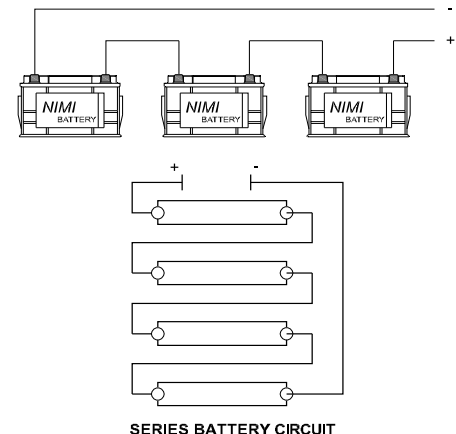
TASK 1: Develop a battery pack with series connection

- 1 Select the batteries for connecting in series.
- 2 Select the battery voltage and amp hour.
- 3 Preplan the required voltage and amp hour and number of batteries to achieve the desired voltage and amp-hour of battery pack.
- 4 Arrange the battery pack case.
- 5 Arrange the batteries closer to each other to reduce the voltage drop across the system.
- 6 Connect the first battery's negative terminal to second battery's positive terminal as shown in Fig 1.
- 7 Continue this process until you connect all batteries collected by you for achieve desired voltage.
- 8 Ensure all batteries are connected properly and ensure the terminal wire connection tightness before start battery power.
- 9 Measure the system overall output voltage and ampere to see for support your application required higher voltage and ampere hour.

- 10 Ensure your series battery connection provide the voltage and ampere hour as your desired specification, if need add or reduce the battery to increase or decrease the voltage and ampere hour.

Note: Ensure the selected batteries are same voltage and amp-hour and same size.

Fig 1



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TASK 2: Develop a battery pack with parallel connection (Fig 1)

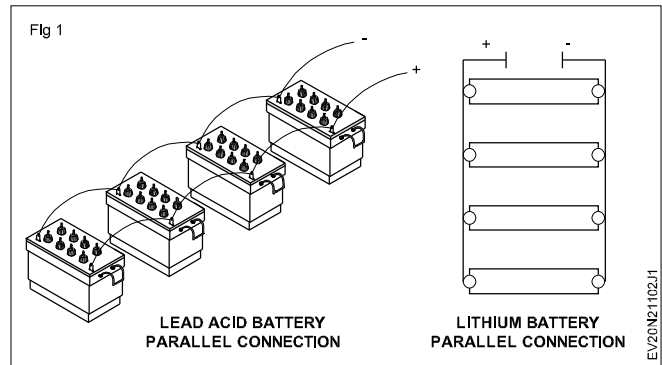
- 1 Select the required voltage and amp hour ratings.
- 2 Select the batteries capacities ratings as same voltage and amp hour.
- 3 Ensure the batteries are arranged closer to each other to prevent excessive voltage drop across the system.
- 4 Connect the first battery's negative terminal to the second batteries negative terminal continue the process

until you connect the negative terminal of all the batteries.

- 5 Connect the first battery's positive terminal to the second battery's positive terminal as it is continue the process until the you connect the positive terminal of all the batteries of pack.

- 6 Measure the parallel battery pack system's overall output voltage and ampere to meet your exact specification for support application required.
- 7 If the parallel battery pack is properly connected to the system.

Note: Before connecting batteries in series vs parallel, check the battery manufacturers manual to know if the batteries can be connected in series or parallel.



Practice to identify different cell chemistries

Objectives: At the end of this exercise you shall be able to

- identify the lead acid battery cell chemistry
- identify the lithium battery cell chemistry.

Requirement			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Hydrometer	- 1 No.	• Soap oil	- as reqd.
• Cell tester	- 1 No.	• Distilled water	- as reqd.
Equipments/Machineries		• Electrolyte	- as reqd.
• Electric vehicle	- 1 No.		
• Lead acid battery	- 1 No.		
• Lithium battery	- 1 No.		

PROCEDURE

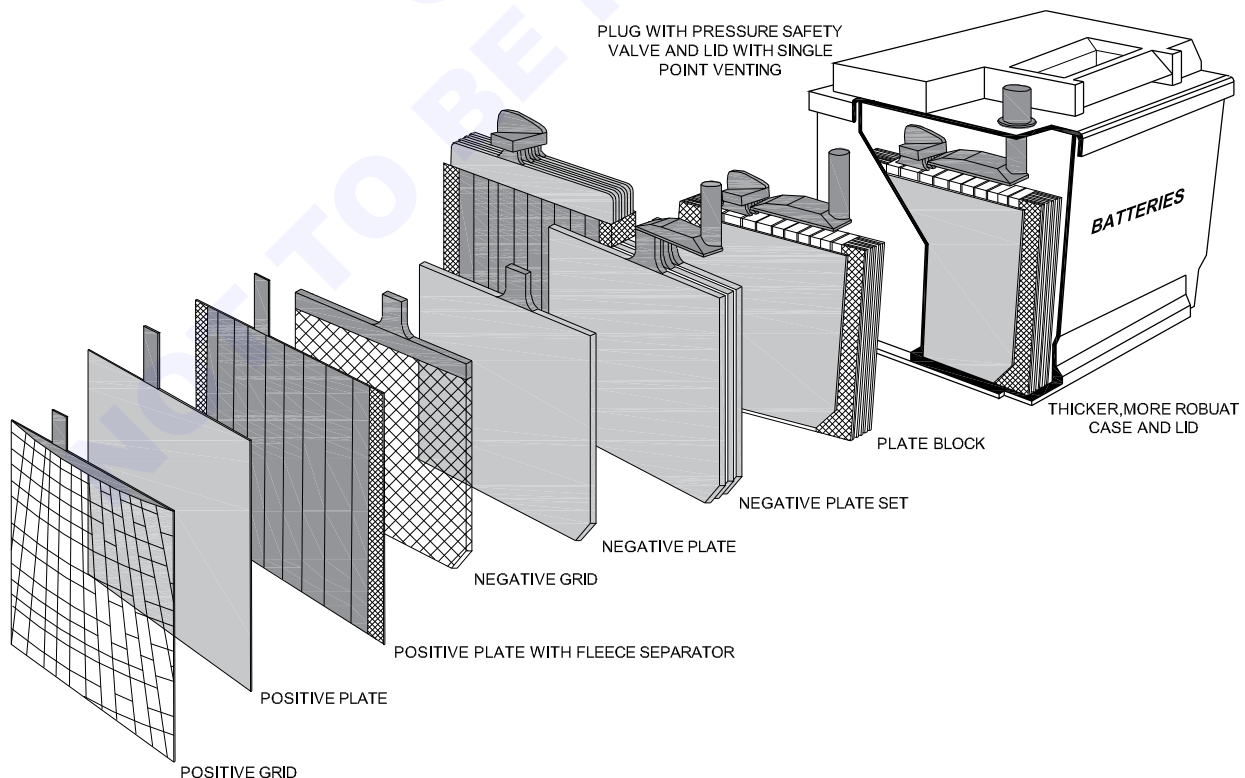
TASK 1: Identify the lead acid battery cell points and battery cell chemistry

- 1 Park the electric vehicles on the shop floor.
- 2 Identify the location of battery and their connections.
- 3 Study the battery charging and discharging procedure.
- 4 Identify the different types of battery testing instruments.

Note: Instructor has to display any one type of the lead oxide battery cut model to show and explain the function of each battery parts and their cell chemistry.

- 5 Identify the lead acid battery's internal and external parts construction method. (Fig1)

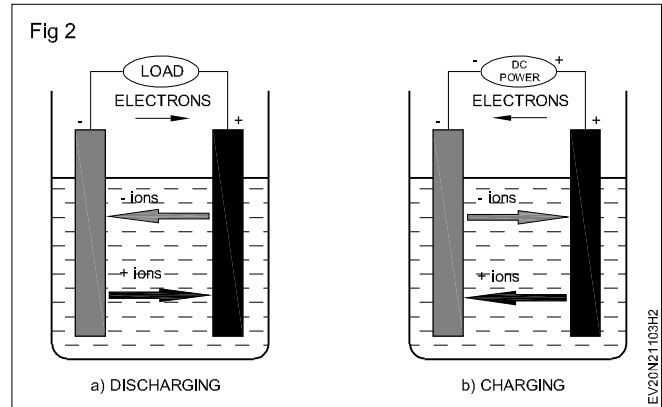
Fig 1



LEAD-ACID BATTERIES FOR HYBRID ELECTRIC VEHICLES AND BATTERY ELECTRIC VEHICLES

EV20N21103H1

- 6 Study the lead acid battery electrolyte liquid combination and their function while charging and discharging the battery.
- 7 To know the chemical reaction of each cell, take one mirror glass and fill with electrolyte upto level marked on the glass.
- 8 Place the negative and positive plate in the glass.
- 9 Ensure do not touch with each other or place the one separator between them.
- 10 Connect the DC power wire for charging process.
- 11 Connect the DC power to charge the battery cell.
- 12 Look the battery charging process in the sample cell glass chemical reaction process as shown Fig 2.
- 13 In this chemical reaction process negative electrode is stable conductor and the positive electrode need to be stable in the contact with electrolyte and act as an effective oxidizing agent. The electrolyte act as high ionic conductivity as shown in Fig 2.
- 14 The electrolyte is usually isolated from the rest of the battery so the electric circuit is incomplete action, so the cell can retain the electrical energy as chemical energy without discharging.



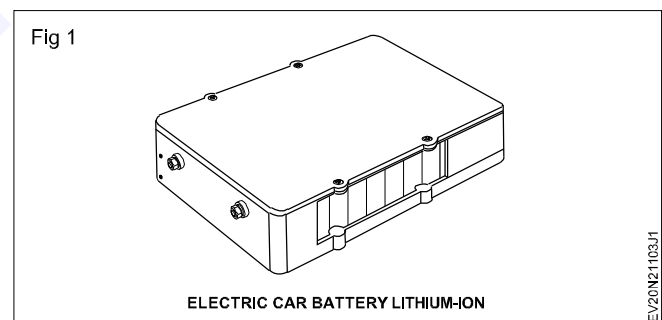
- 15 Now connect the load as per the capacity of your test battery cell as shown in Figure 2(a) and see the battery cell chemical reaction the electron flow from the negative plate to positive plate and ions move from positive plate to negative plate as shown in Figure 2(b).
- 16 Battery cell power discharging process is opposite to battery cell charging process.

Note: When the battery cell charging or discharging power of battery will get heat it means battery is working properly.

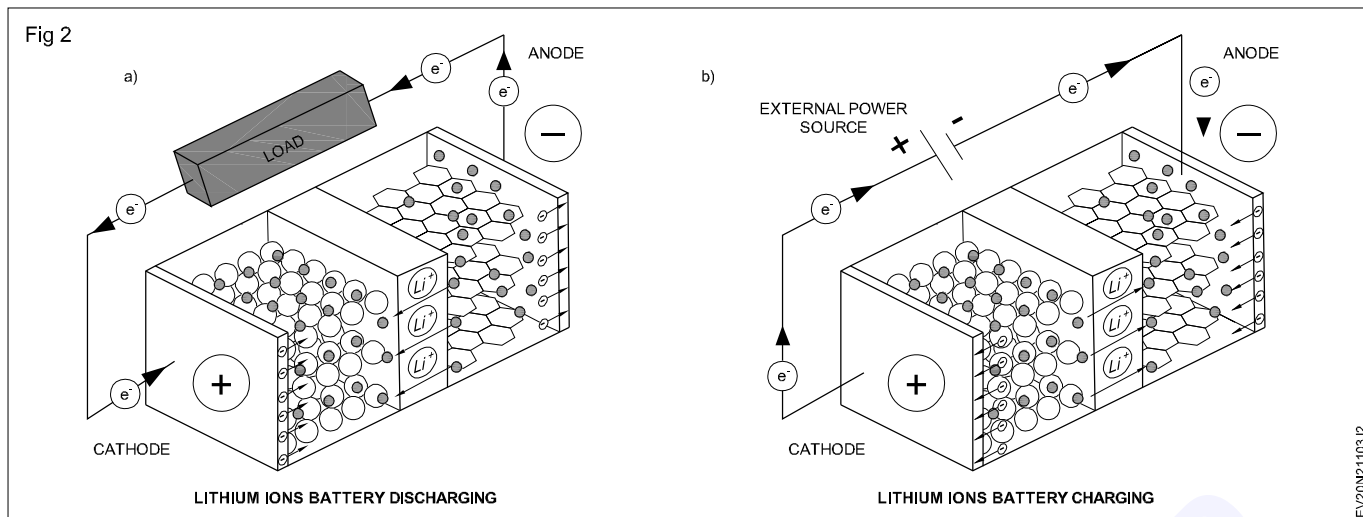
TASK 2: Identify the Lithium iron battery chemistries

- 1 Instructor has to provide cut model lithium battery cell to show demo on lithium-iron battery chemistry.
- 2 Place the cut view model lithium battery on the work bench.
- 3 Study the battery manual for know the battery ingredients and their functions.
- 4 Study the cut view model battery.
- 5 Identify the battery cell's inside materials.
- 6 Identify the positive and negative electrodes (cathode, anode, electrolyte and separator).
- 7 Connect the power to battery charge.
- 8 Ensure while charging battery lithium iron are store in the anode and not cathode.
- 9 Test the electrolyte, whether it is composed of salts solvent and add the salts in passage for lithium irons move.
- 10 Ensure the separator is absolute barrier between cathode and it prevents the direct flow of electrons. The separator is prevented from shorting by a separator.

- 11 Ensure the lithium metal oxides are used in cathode and lithium carbon compounds are used in the anode.
- 12 Ensure the reduction take place at the cathode. (Fig 1)



- 13 Ensure the oxidation takes place at the anode. (Fig 2)
- 14 Ensure the electrodes are able to move lithium iron move easily in and out of their structures.



Write down the different type of batteries cell chemistry in Table 1

Type of battery	Average cost	Energy density Recommendation	Discharge	Discharge cycle
Lead acid battery	120 kwh	180wh/kg	80-90%	200-300
Lithium iron phosphate	90Kwh	160 wh/kg	100%	2500
Lithium Nickel Magnetic cobalt	130kwh	200wh/kg	80-90%	1000
Lithium Nickel cobalt	130Kwh	200wh/kg	80-90%	1000

Practice to identify different cell geometries

Objectives: At the end of this exercise you shall be able to

- **identify the automobile battery cell geometry.**

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	-1 No.	• Cotton waste	- as reqd.
• Battery manual	-1 No.	• Soap oil	- as reqd.
Equipments/Machineries			
• Electric vehicle	- 1 No.		
• Electric vehicles battery	- 1 No each.		

PROCEDURE

Identify the battery cell geometry (Fig 1)

Note:

- 1 Battery cell geometry refers to the physical shape and structure of biological cells**
- 2 The instructor has to be demonstrate the battery cell geometry**

- 1 Identify the different type of batteries used in an automobile.
- 2 Lay out the batteries on the work bench.
- 3 Study the battery manual for achieve the battery cell geometry.
- 4 Measure the each batteries size.
- 5 Note the each type of batteries size.
- 6 Note the each battery cells organelles and internal structure of each battery cell.

- 7 Note the cell membrane of each type of battery cells.
- 8 Study and note the batteries role in cells mobility, division and intracellular transport (Cell connectivity network).
- 9 Study each type of batteries function during charging and discharging while because the geometry of a cell often relates to its specific function with an organism.
- 10 Write down the different types of batteries geometry in table 1

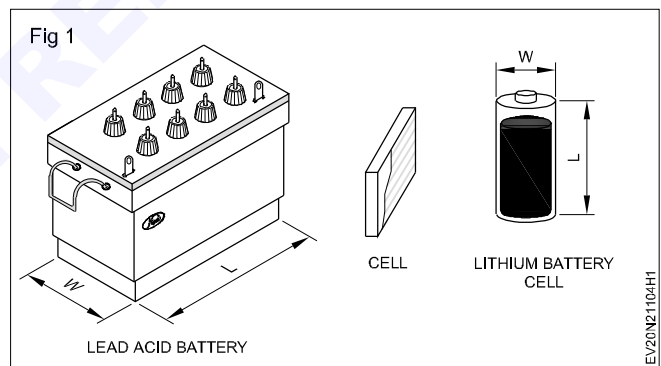


Table 1

S.No	Battery type	Battery Shape	Battery Size	Organelles	Cell membrane	Function
1	Lead acid battery	Rectangular				
2						
3						
4						
5						
6						
7						
8						

Practice to identify the various sensors installed in battery management system

Objectives: At the end of this exercise you shall be able to

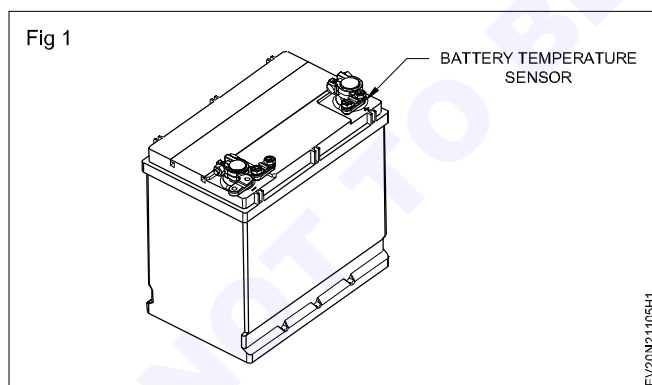
- Identify the various sensors installed on battery management system.

Requirement			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries		• Sensors	- as reqd.
• Electric vehicle	- 1 No.		

PROCEDURE

Identify the sensor position in battery management system

- 1 Select the any one of electrical vehicle.
- 2 Park the vehicle on the shop floor with adopting vehicle safety.
- 3 Study the vehicle manual battery management system circuit and their safety device.
- 4 Trace the battery temperature mapping sensor's location in the BMS circuits.
- 5 Identify the battery temperature mapping sensors and their function which is connected between battery to ECM connector. (Fig 1)



Note:

- The ECM determines the battery temperature according to fluctuation in Voltage, when the battery temperature is high the ECM determines to reduce the amount of current supplied from the generator in order to product the battery.
- The battery temperature sensor installed on battery current sensor detects battery temperature, the temperature sensor changes according to the battery temperature.
- The battery temperature sensor is connected to the ECM. The ECM supplies 5V from the thermistor battery terminal to the battery temperature sensor through the resistor 'R'. The battery temperature sensor and resistor R are connected in series.
- The battery temperature sensor is commonly positioned right next to the terminal clamp and it is connected to the vehicle's body for ground. how ever the location depend on the vehicle some cases sensor have it on the positive terminal of the battery. Some vehicle have two battery sensor one on each terminal.

Practice to verify battery cell performance

Objectives: At the end of this exercise you shall be able to

- **verify the battery cell performance and compare it with supplier data sheet.**

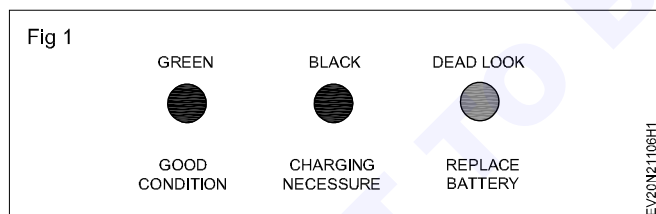
Requirements			
Tools/Equipments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Battery Manual	- 1 No.	• Soap oil	- as reqd.
• Battery cell testing instrument	- 1 No.	• Distilled water	- as reqd.
• Multimeter	- 1 No.		
• Hydrometer	- 1 No.		
Equipments/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

Check the battery cell performance and compare it with battery supplier's data sheet

Note: The instructor has to be provide battery and battery data sheet and show demonstration on battery testing

- 1 Select the any type of battery used in electric vehicles.
- 2 Collect the battery testing instruments.
- 3 Study the battery data sheet.
- 4 Visually check the container cover and terminals, if any physical damage is present, replace the battery
- 5 Check the indicator (if the battery has the indicator).
- 6 Always look right down when viewing the indicator and lightly tap the indicator on the battery to dislodge any air bubbles. (Fig 1)



- 7 If the OCV is below 12.4V recharge the battery immediately.
- 8 Connect the battery tester to battery terminal.
- 9 Measure the battery temperature around it.
- 9 Set the battery tester ampere values for 1/2 of the CCA rating (Circuit Current rating).
- 10 Compare the measured value with data sheet value.
- 11 If the values are out of the table value again recharge the battery and test it again.
- 12 If the battery fails in the load test twice, replace it.
- 13 Check the battery with voltmeter or multimeter.
- 14 Check the battery current with ampere meter.
- 15 Check the battery ohmic test by ohm meter.

- 16 Check the battery specific gravity with hydrometer.
- 17 Check the battery cell with cell tester and compare it with data sheet.

Note: Before the testing ensure the battery strength, rigidity and flammability, mould stress (temperature), venting, insulation electrolyte not under pressure, no leakage, no explosion or fire risk and protect from the battery short circuit over charge, over discharge, voltage reversal, high temperature, low temperature, misuse and abuse

- 18 Check the power out with ampere meter or multimeter
- 19 Check the battery cycle testing (temperature, charge, discharge rates and the depth of discharge.
- 20 Check the battery cycle testing cycle life is affecting by over charging and over discharging and it is vital to set the correct voltage and current limits check it with multi channel tester.
- 21 Check the battery load testing for verify that the battery can deliver its specified power when needed.
- 22 Use the calorimeter to quantify the total amount of heat generated by the battery, while it is cycled through its charge or discharge cycle.
- 23 Check the electro magnetic compatibility testing.
- 24 After conducting battery test process and audits with battery manufacturer's data sheet.
- 25 Use the battery analyzers to find the quick indication of the lithium batteries health.
- 26 Use the new tiny potential meter to check the failure analysis only they will have the detailed specifications of the cell mechanical and chemical components and its normally required access to expensive analytical equipment, such as electron microscopes and mass spectrometers which they should be expected to have more information.

Automotive Exercise 2.1.107

Mechanic Electric Vehicle - Traction Motor and Battery Managment System

Practice to measurement of BMS voltage, current and temperature

Objectives: At the end of this exercise you shall be able to

- measure the BMS conduct voltage
- measure the BMS conduct current
- measure the BMS temperature.

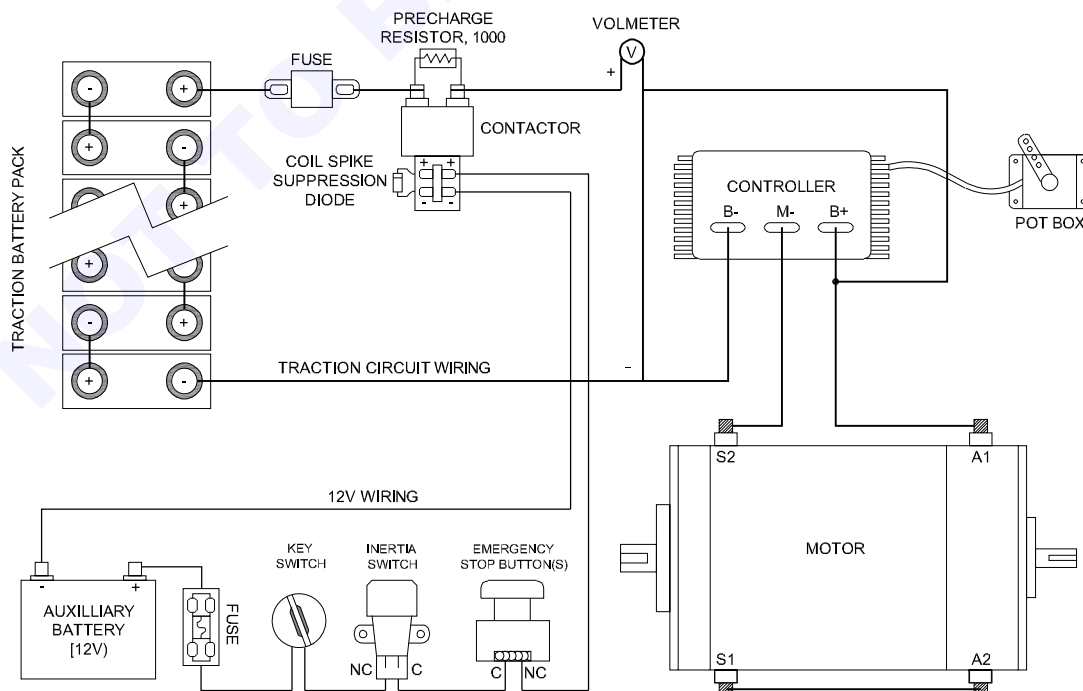
Requirement		
Tools/Instruments		Materials
• Trainee's tool kit	- 1 No.	• Soap oil - as reqd.
• Multimeter	- 1 No.	• Cotton waste - as reqd.
• Ampere meter	- 1 No.	
• Volt meter	- 1 No.	
• Thermistor	- 1 No.	
Equipments/Machineries		
• Electric vehicle	- 1 No.	

PROCEDURE

TASK 1: Measure the voltage of BMS in electric vehicle

- 1 Select the electric vehicle for measure the voltage of BMS.
- 2 Park the vehicle on the shop floor.
- 3 Study the vehicles manual for achieve the knowledge of BMS technical data.
- 4 Wear PPE before start work.
- 5 Trace the electric vehicles battery management system's wiring circuit.
- 6 Select the 12.48 V range volt meter to measure the voltage flow through the traction motor circuit.
- 7 Switch off the battery power.
- 8 Connect the voltmeter with electric vehicles traction motor circuit as shown in Fig 1.
- 9 Ensure voltmeter is properly connected with circuit wire (accordingly battery polarity).

Fig 1



EV20N21107H1

- 10 Switch 'ON' the battery power and note the voltage reading.
- 11 Measure the voltage reading in different place of wiring circuit.
- 12 Compare the measured voltage reading with manufacturers technical data.

- 13 If voltage reading is less than specified limit, check the battery charge or wire short circuit.

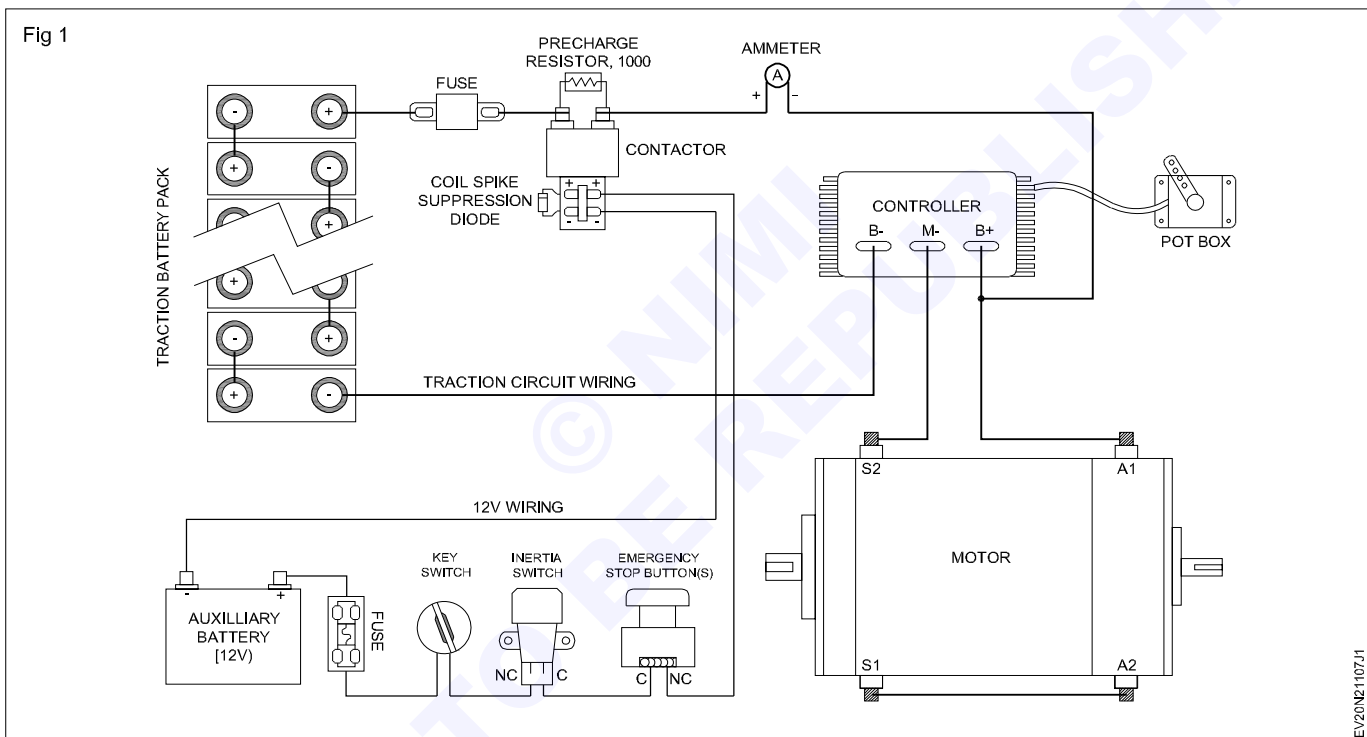
Note: You can measure the voltage by using multimeter also

TASK 2: Measure the current flow through the traction motor wiring circuit

- 1 Select the suitable ampere meter for measure the current flow in traction motor circuit or any other electrical circuit of electric vehicles.
- 2 Trace the electrical circuit to be measured current flow in a circuit.
- 3 Switch 'OFF' the battery power and connect the ampere meter in series connection of the circuit as per the polarity of battery and meter terminals. (Fig 1)

- 4 Switch 'ON' the battery power and note down the circuit ampere rating indicate on the meter dial.
- 5 Take reading in different places of the circuit and compare it with vehicle manufacturer's technical data.
- 6 If found any malfunction, check the circuit components or wire short circuits.

Note: You can measure the circuit current flow by using multimeter also



TASK 3: Measuring the temperature of battery management system components like battery, traction motor etc

- 1 Start the electric vehicle and run it for few minutes.
- 2 Select the sensor based temperature measurement gauge.

Note: Electric vehicles BMS has a sensor based temperature measurement system is provided in a vehicles

- 3 Check the temperature of battery and motor through the system provided in a vehicles in case failure of the gauge reading use the sensor based digital temperature gauge.

- 4 Power on the sensor based digital temperature gauge and touch the gauge where you want to measure the temperature like battery, motor etc.
- 5 Note the gauges reading and compare it with vehicles manufacturer's technical data, if temperature is higher than the specified limit, check the cause for high temperature.

Note: You can use sensor based hand held thermo couple thermometer. It is switchable °C/°F and maximum/minimum reading/display hold functions and low battery indicator it is range is -200° to 1370°C (-328° to 2498°F) it may be change mode to mode.

Practice on configuration of BMS with software application

Objectives: At the end of this exercise you shall be able to

- configuration of BMS with software application.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Battery manual	- 1 No.	• Soap oil	- as reqd.
• Battery cell testing instrument	- 1 No.	• distill water	- as reqd.
• Multimeter	- 1 No.		
• Hydrometer	- 1 No.		
Equipments/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

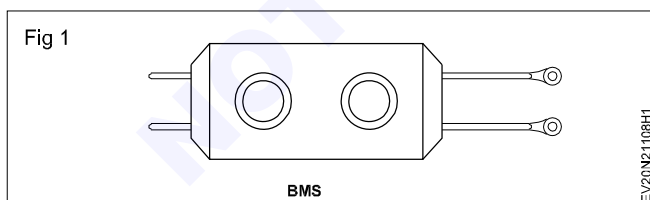
Configuration of BMS with software application

Note: A battery management system (BMS) is an electronic system that manages and monitors the performance and health of a rechargeable battery. The BMS is controlling the charging and discharging process, balancing the cells with in the battery pack and providing information about the battery performance and condition to the user

- 8 Check interface and communication protocols are in your place where you are testing BMS and IOT device.
- 9 Test the BMS and IOT separately and then testing the integrated system.

Note: While testing communication between BMS and IOT, must be secure to prevent unauthorized access. This can be achieved by using encryption and authentication protocols.

- 1 Select the electric vehicles and study the vehicles battery pack and charging methods.
- 2 Switch on the vehicle battery power and study the battery performance and condition of battery by providing information through BMS provided in a vehicle.
- 3 Connect the vehicle battery with battery charger for charging.
- 4 Check the vehicles BMS is connected with GSM-GPRS with IOT. (Fig 1)



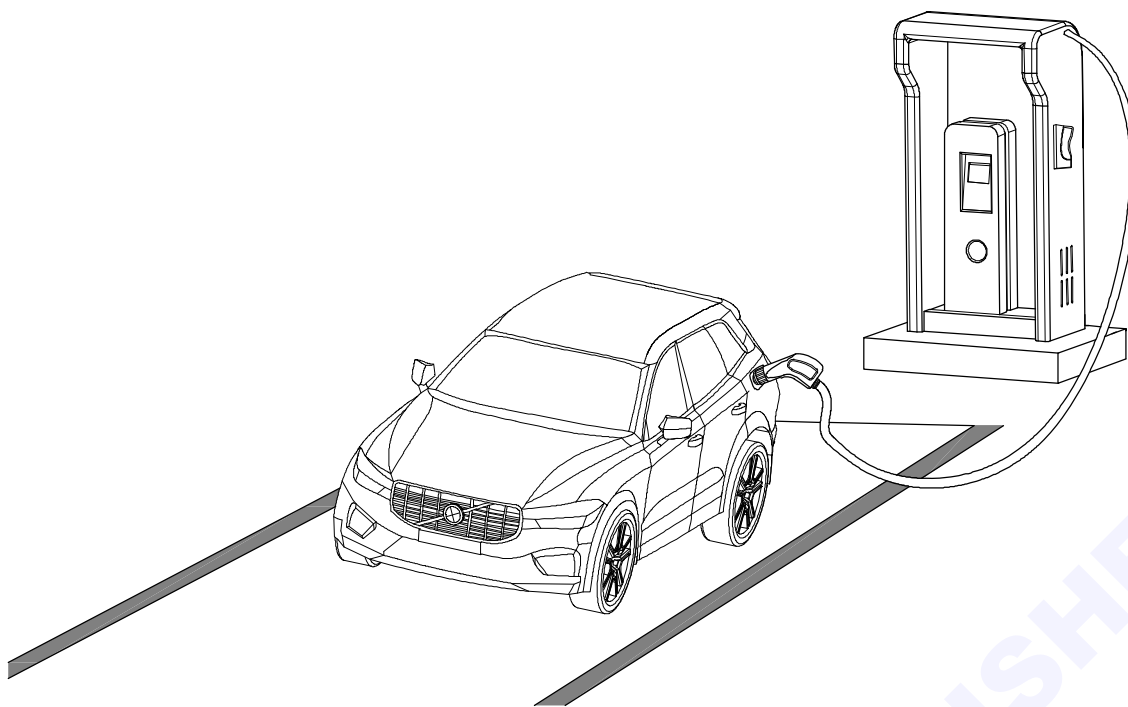
- 10 Ensure BMS is collect the data such as battery voltage, current, temperature and state of charge.
- 11 Ensure the above data of battery is send to IOT via GSM-GPRS and verify the data displayed in IOT device.
- 12 Ensure the IOT is analyzed the data and send commands to the BMS such as setting charging parameters or initiating a discharge cycle. (Fig 2)
- 13 Study the IOT is feedback report of BMS data, if maintenance is needed to do it (perform prevention maintenance of battery instead of waiting for a failure to occur).

Note: BMS software protects the battery from overcharging over discharging, overheating and battery damages

Note: BMS data terminal consists of hardware and software components that work together to manage the battery. The hardware components include sensors. The software components include algorithms and control systems, that analysis data of BMS data terminal.

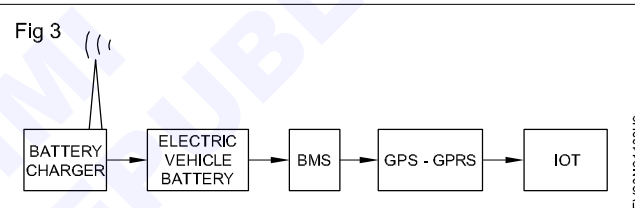
- 5 Check the vehicles BMS system is functioning properly and equipped with IOT (internet of things) technology.
- 6 Ensure the BMS unit is providing real time data of the battery performance and condition and allowing it to communicate and exchange data with other devices or system through the internet.
- 7 Check the BMS is send signal to remote monitoring and control of battery.

Fig 2



EV20N2108H2

- 14 If found any miscommunication or defects in BMS and GSM-GPRS and IOT system rectify the defects or replace the defective components and then check the functions of BMS, IOT and GPS-GPRS provided in electric vehicle and EV battery charging or battery bulk storing (Fig 3)



EV20N2108H3

Practice on check battery cells balance with external circuits

Objectives: At the end of this exercise you shall be able to

- check the battery cells balance with external circuit.

Requirements

Tools/Instrument

- Trainee's tool kit - 1 No.
- Multimeter - 1 No.
- Soldering iron (electric) - 1 No.
- Vehicle manual - 1 No.

Equipments/Machineries

- Electric vehicle - 1 No.

Materials

- Cotton waste - as reqd.
- Soap oil - as reqd.
- Resistor - as reqd.
- Soft solder - as reqd.
- Transistor - as reqd.
- Capacitor - as reqd.
- Wire - as reqd.
- Flux - as reqd.

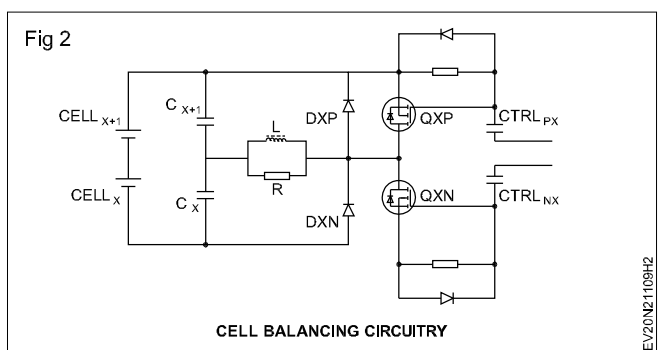
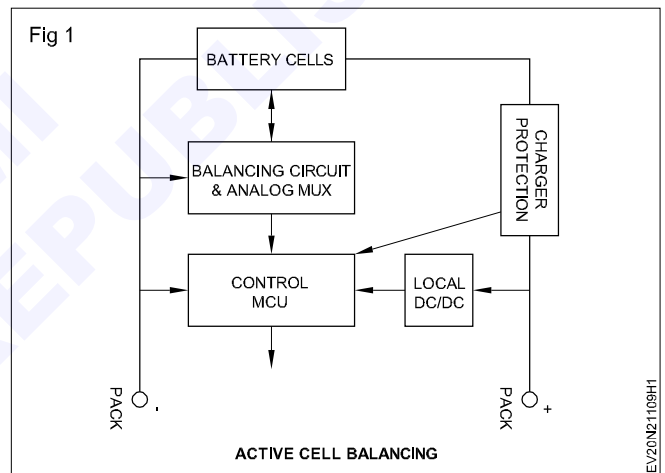
PROCEDURE

Checking a external circuit of battery cells balance.

- 1 Park the electric vehicle on the shop floor.
- 2 Use the personal and vehicle safety equipments to avoid electrical accidents.
- 3 Study the vehicle manual for achieve the knowledge of battery cells balancing external circuits.

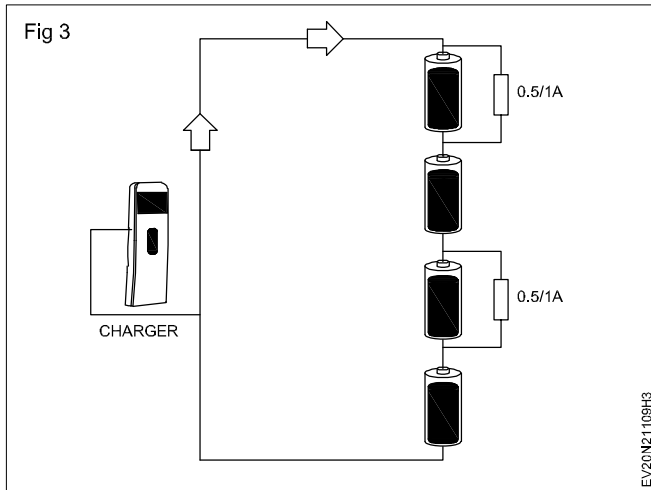
Note: Cell balancing is the process the equalizing the voltage and capacities of the individual cells in a series or parallel configuration, it is used to prevent overcharging, under charging or thermal run away

- 4 Cell balance circuit components like a switched resistor capacitors, inductors, transformers and converters. The circuit components selection based on their ratings, characteristics and compatibility with the circuit topology and battery cells.
- 5 Identify the location of battery pack provided in a electric vehicle.
- 6 Check which type of battery cell balancing system used in a vehicle (Active or Passive cell balancing).
- 7 Check the battery connection whether series connection or parallel connection.
- 8 Check the cell balance external circuits power resistors connected in series with a control MOSFET transistor. (Fig 1&2)
- 9 Open the battery pack cover and identify the cell balancing external circuit components.
- 10 Use the multimeter to check the condition of resistor, diodes, and transistors and relay switches.



- 11 If found the any defective components replace it with same rating and same size.

Note: When testing the cell balancing circuit components disconnect the battery power terminals



12 After verifying the components connect the battery terminal and plug the charger battery cable or give the load to the battery. (Fig 3)

13 Check the battery management system information whether cell balancing circuits are functioning properly.

Practice on verify SOC mapping of battery charging and discharging data

Objectives: At the end of this exercise you shall be able to

- verify the state of battery charging and discharging data map
- verify the state of battery health at charging and discharging data map.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• High voltage isolated tool	- 1 Set	• Soap oil	- as reqd.
• Voltage absence verifier	- 1 No.		
Equipments/Machineries			
• Electric vehicle	- 1 No.		
• Scissors lift	- 1 No.		

PROCEDURE**TASK 1: Verify the state of battery charge and discharge mapping**

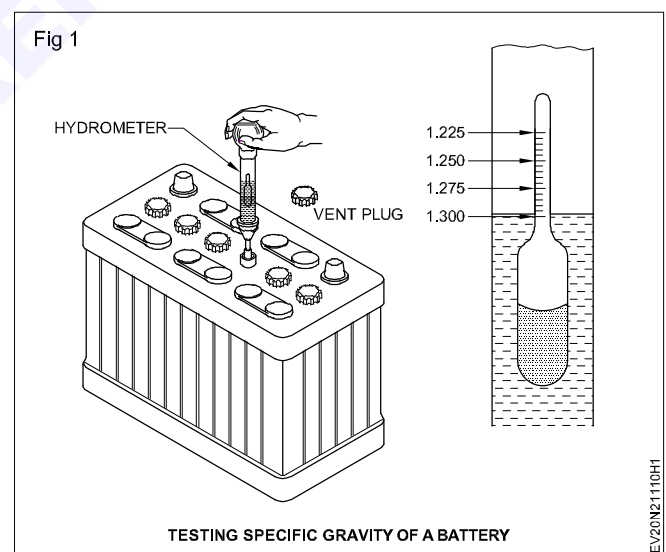
- 1 Park the electric vehicle on the shop floor.
- 2 Check the battery pack which types of battery used in the vehicle whether, lead acid battery or lithium ion battery.
- 3 Study the vehicles manual note the battery's technical data like charge, discharge and life cycle of battery.
- 4 Locate the battery pack and their connection in a vehicle.
- 5 Count the battery quantity packed in a battery pack.
- 6 Disconnect battery pack terminal connection charging and discharging cable.

Note: Before disconnecting the high voltage cable terminals, make sure that the voltage between the terminal is 0-Volt with suitable tool

- 7 Remove the battery cell balance circuit components from battery and keep it in safe place.
- 8 Use the scissors lift to transport the battery pack from vehicles to work place.
- 9 Support EV used the lead acid battery follow the following steps to check the charging and discharging condition of battery.
- 10 Clean the battery terminals with sand paper if corroded, if battery terminals sulphate, clean it with used cotton waste or with soda bicarbonate.
- 11 Unscrew all the vent plug and check the level of the electrolyte.
- 12 Top up the electrolyte to the marked level in all the cells with distilled water.

Note: No electrolyte to be used to top up battery

- 13 Keep the battery on a level wooden work bench.
- 14 Hold the hydrometer vertically as shown in Fig 1.



- 15 Place the nose of the hydrometer in the cell. Ensure that the nose is dipped in the electrolyte.
- 16 Press the rubber bulb of the hydrometer.
- 17 Release it to draw the electrolyte upwards.
- 18 Ensure that the electrolyte does not come into the bulb.
- 19 Note the float level which is floating in the electrolyte.
- 20 Record the reading of each cell in table -1 of each battery used in the battery pack.

Table 1

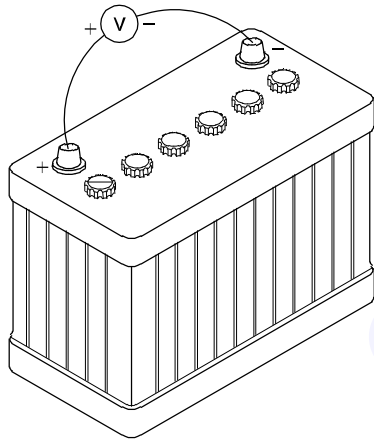
Battery	Cell-1	Cell-2	Cell-3	Cell-4	Cell-5	Cell-6	Battery capacity

Note: The above reading should not vary more than 25 points between cells.

Protect your hands and cloths from the battery acid.

- 21 Connect the leads of the DC voltmeter to the battery terminal as shown in Fig 2.

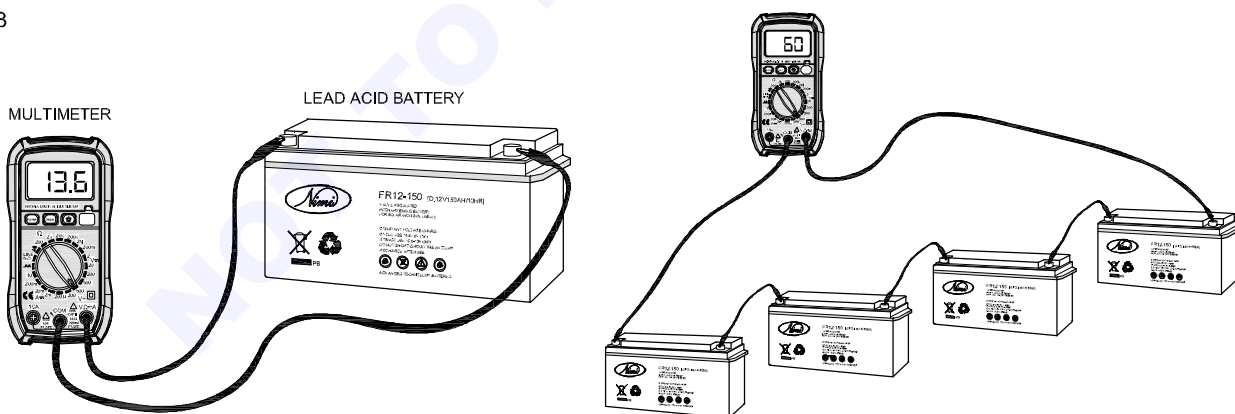
Fig 2



EV20N2110H2

- 22 Take the reading from the voltmeter and record the each battery charge condition.
- 23 The voltmeter should read at least 13.2 volts per battery (12V battery).
- 24 After completion of battery charge condition test, compare the readings with the manufacturer's specifications.
- 25 If need recharge the battery incase battery cell is defective replace the battery.
- 26 If the battery is maintenance free battery use the voltmeter or multimeter to test the battery voltage and use the multimeter to read the battery current. (Fig 3)
- 27 Suppose EV used the lithium ion battery, use the multimeter to check the each battery cells condition. If found any defective cells remove the cells and connect the new cell in series or parallel connections as earlier positioned the battery cells. (Fig 4)
- 28 After test the battery condition, if need charge the battery for full charge.
- 29 Connect the battery with bench load test equipment while check load test use the multimeter to measure the voltage drop.

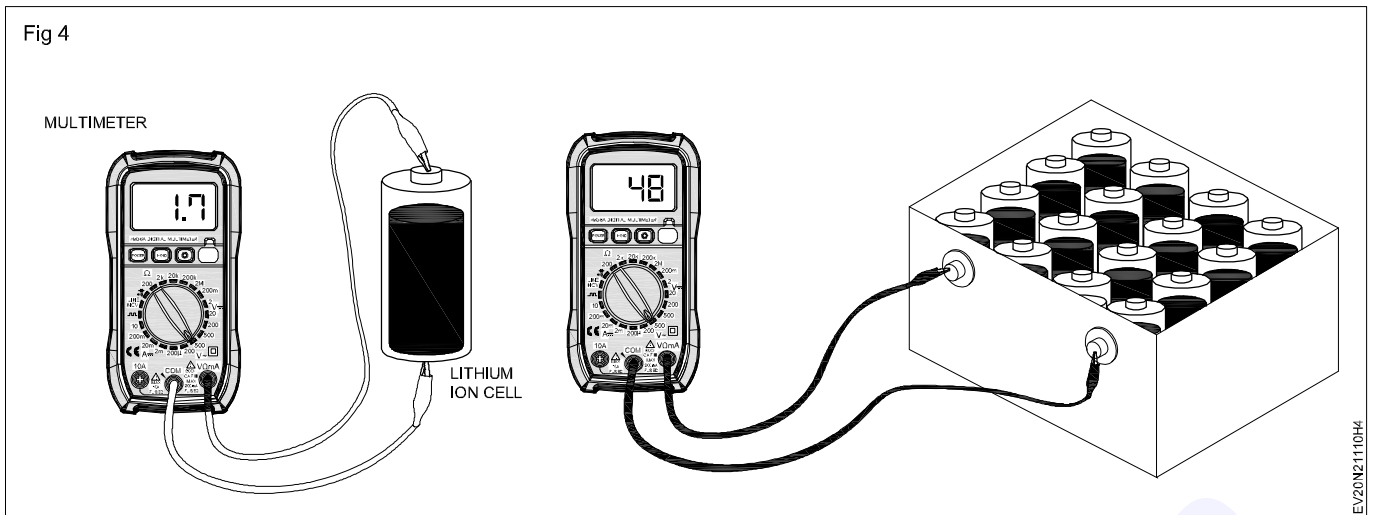
Fig 3



EV20N2110H3

- 30 Switch on the battery and drive the load for discharge test, now measure the current drop while load on battery current.
- 31 Note the reading and compare it with battery manufacturers technical data, if found battery is quickly discharged it means battery is defective and you replace it with new one.
- 32 Connect the new battery in battery pack connection and again test it with loads.
- 33 Ensure the battery charge and discharge rate is correct as per manufacturer's data.
- 34 Place the battery pack on the vehicle's battery pack location.

Fig 4



- 35 Ensure all cable connections are properly connected as per the vehicle manual circuit.
- 36 Once again check the wire connections, for electrical wire safety and then switch ON the power and study battery charge and discharge reading shown in panel board gauge.
- 37 If you are satisfied with safety measures, then you can start the EV.

Note: Multimeter can measure the 2V to 600V battery over charge the battery can be damaged the battery and reduce the life span of battery.

- 38 EV battery is heavy, use mechanical assistance during manipulation.
- 39 Avoid release of battery contents to the environments.
- 40 Always refer to additional instructions that may be given by the vehicle manufacturers.

Practice on connecting a battery for charging and testing

Objectives: At the end of this exercise you shall be able to

- connecting the battery for charging
- test the battery after charging.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Electric vehicle	- 1 No.		
• Battery charging	- 1 No.		

PROCEDURE

TASK 1: Connect the EV battery for charging

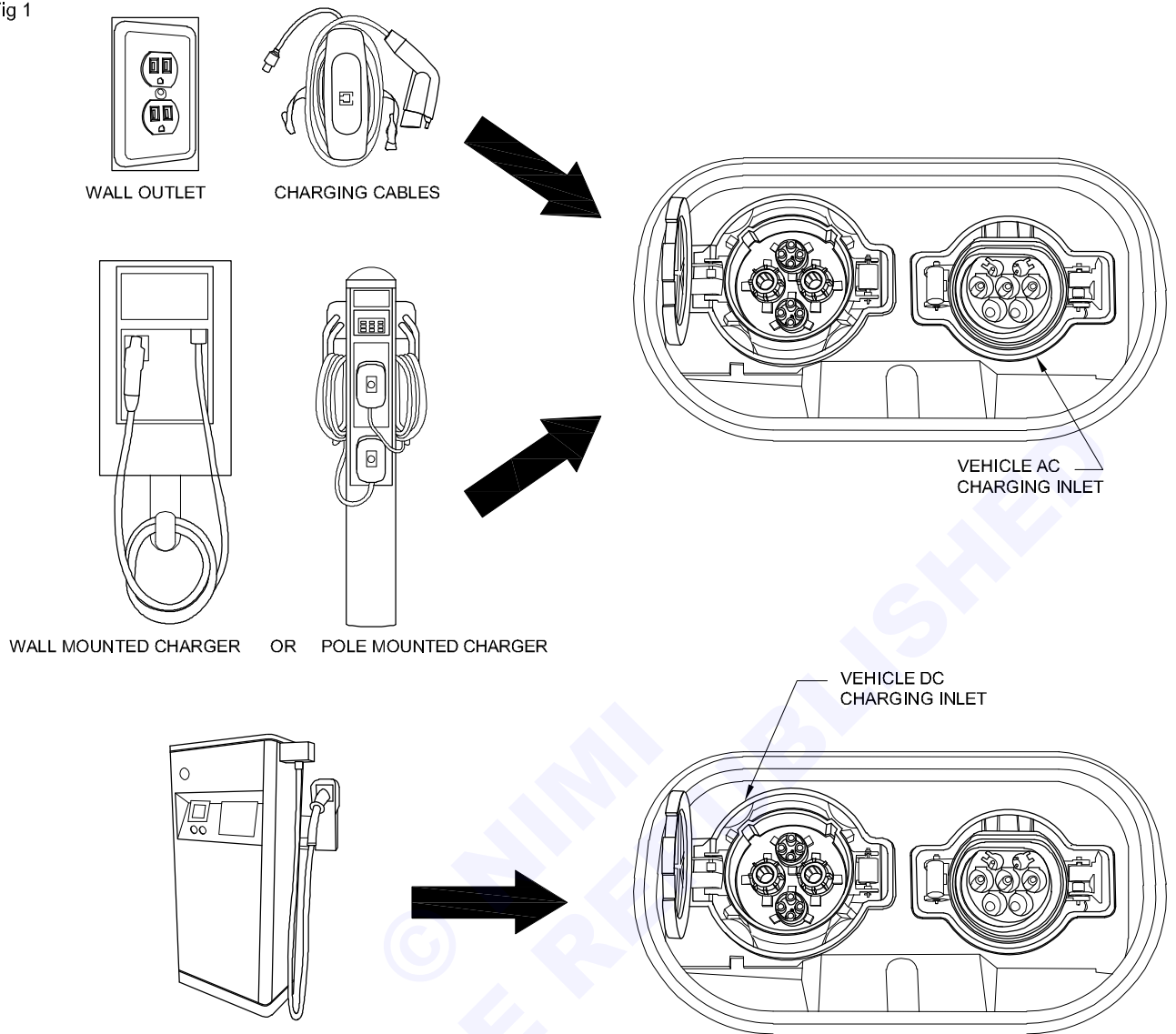
- 1 Select the electric vehicle for charging.
- 2 Park the vehicle in the shop floor near the battery charging station.(Fig 1)
- 3 Follow the electric vehicle safety and security standards.
- 4 Check the on board electrical energy.(Fig 2)
- 5 Follow the safety and protective against failure.
- 6 Wear the personal protection equipment against electrical accidents.
- 7 Park the vehicles near the battery charger.
- 8 Connect the charging cable with EV's charging inlet port as shown in Fig 3.
- 9 Switch on the power to the charger.
- 10 Ensure the rectification of AC voltage from grid to DC voltage.
- 11 Ensure the controls the current flowing into the battery pack by controlling the DC output voltage.
- 12 Ensure the bi-directional chargers allow energy transfer to the grid.
- 13 If the DC charging is a phrase that describes the use of an off-vehicle charger.

- 14 If the off vehicle charger, connect it directly to the battery by passing the on board charger and check the robust communication is connected between the vehicle and on-board charger.

Note: Different type of EV battery charger is used in battery charging station-you can use the charger as per the direction given by vehicle manufacturer (AC to DC or DC to DC)

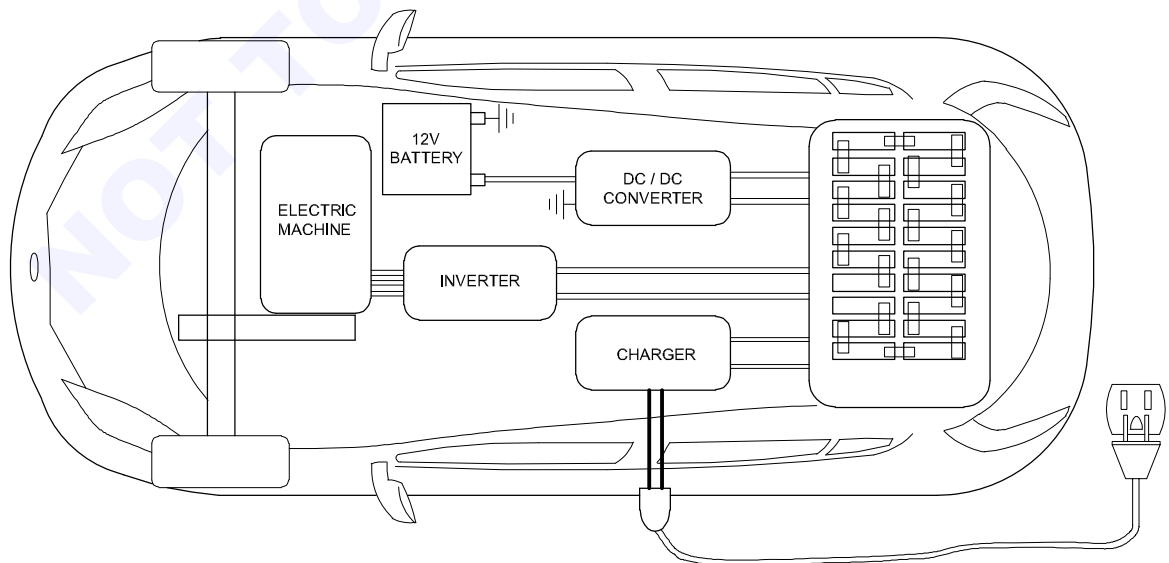
- 15 Allow the EV battery charger to charge the battery up to vehicle manufacturer's specified time limit.
- 16 After charging the battery switch off the charger power before remove the battery charger cable.
- 17 Remove the charger cable.
- 18 Check the vehicles battery power pack, whether it is fully charged or not.
- 19 Switch 'ON' the vehicles battery power and check the vehicles panel board information like voltage current and power storage etc.

Fig 1



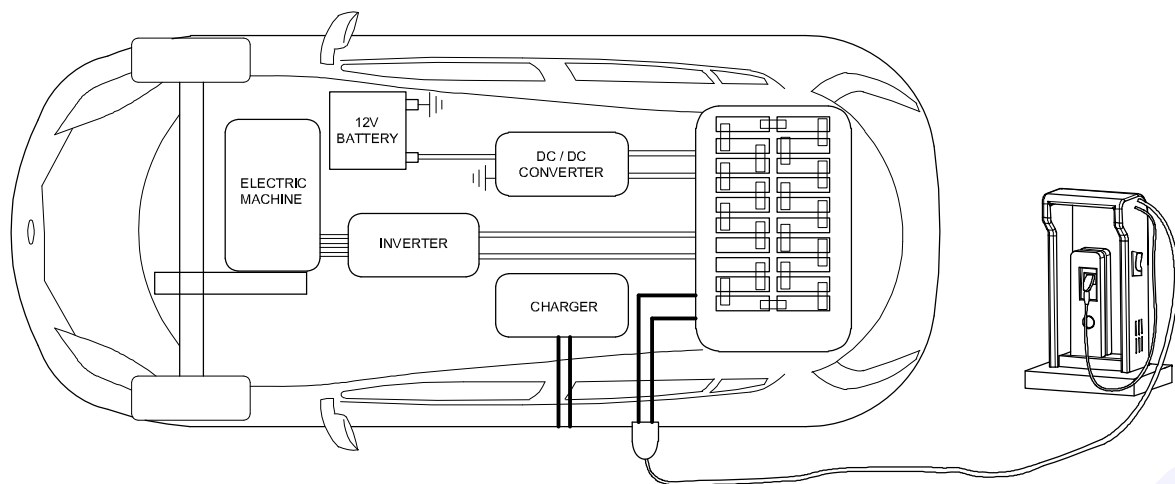
EV20N2111H1

Fig 2



EV20N2111H2

Fig 3



EV20N2111H3

Practice on safe storage, handle and dispose of high voltage battery system

Objectives: At the end of this exercise you shall be able to

- handle and safe storage of high voltage battery
- dispose of high voltage battery systems.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Electric vehicle	- 1 No.	• Battery gel	- as reqd.
• Battery charger	- 1 No.	• Distilled water	- as reqd.
• Scissor jack	- 1 No.	• Terminal cap	- as reqd.
• Battery storage rack	- 1 No.		

PROCEDURE**TASK 1: High voltage battery handling and safe storage**

Note: The instructor has to be explain and demonstrate electric vehicle's charging infrastructure safety, battery connectors, charging topology high voltage, battery handling, storage and battery disposal safety etc.

- 1 Select the vehicle for practical work.
- 2 Park the vehicle on the shop floor near the vehicle battery charging station.
- 3 Use the personal and vehicle protective equipments to avoid electrical accidents. while work with electrical vehicles high voltage battery.
- 4 Connect the vehicle charger cable with battery charger.
- 5 Ensure the charger cable in properly connected with vehicle manufacturer recommended charger.
- 6 Switch 'ON' the battery charger, let it allow to full charge.
- 7 Ensure electric vehicle battery is fully charged and then switch OFF the charger and unplug the charger cable.
- 8 Study the vehicle manufacturers information, safety and instruction materials provided in a vehicles manual.
- 9 Be aware of high voltage electricity storage components of electric vehicle like battery, electric motor, generator, compressor, inverter, heater and air conditioner etc.
- 10 Study the battery pack power storage and their cable connections.

Note: An electric or hybrid vehicle's high voltage systems are source of serious accidents, if precautions are not taken during certain operations.

- 11 Switch off the battery power from the high voltage battery.
- 12 Identify the battery high voltage cables are connected to the electric motor.
- 13 Deactivate and disconnect the high voltage system fitted with battery and insulate the vehicles high voltage battery connection cables by using electrical insulation tape and wrap the high voltage battery terminals with insulation tape.

Note: Never assumes that the EV is powered down because it is silent.

- 14 Never touch, cut or open any high voltage cable or high voltage components without using the personal protective equipment.
- 15 Avoid contact of battery contents with skin and eyes.
- 16 Before removal of the high voltage battery check the fire smoke, spark and heat damage, and leakage etc.
- 17 Check the manufacturers specific information, if it is necessary to open the vehicles bonnet and luggage compartment before disconnecting the starter battery.
- 18 Remove the service plug or turning off the isolation switch and secure the against reconnection.
- 19 Ensure that the high voltage system is at zero potential by using a voltage absence verifier.
- 20 Remove the battery pack from the vehicle.
- 21 Clean the battery external parts with cleaning tool.
- 22 Use the scissor jack to transport the battery to storage spot.

- 23 Store the battery in dry and not exposed to high temperature fires or direct sunlight.
- 24 Protect the battery from puncher or crushed.
- 25 Store the battery according to applicable legislation
- 26 Keep the battery away from water and rain
- 27 Never place the battery on the floor, lay high voltage rubber insulation ,mat underneath the battery
- 28 Always store the battery in its normally installed orientation never invert.
- 29 Store the battery in well ventilated areas in accordance with applicable legislation.

- 30 Only store the battery where sufficient insulated against short circuiting.
- 31 Cover the battery with a high voltage rubber insulation mat.
- 32 Mark the battery storage with a warning sign.

Note: Defective and damaged high voltage batteries must be stored in quarantine in a special place on the battery storage premises, monitored and marked as damaged/defective batteries.

TASK 2: Dispose of high voltage batteries

- 1 Identify the damaged or defective batteries for dispose.
- 2 Collect the batteries to dispose.
- 3 Identify the battery type (lead acid or lithium ion battery).
- 4 Classify the batteries whether it is send to repair or recycling.
- 5 If lead acid high voltage batteries send it for repair or renovate it.
- 6 If the lithium ion batteries send it for recycling specialist firm, there dismantle the packs and break them down into their different materials. The cells and circuits are crushed to separate and purity the various metals in them including nickel and lithium.
- 7 Safely collect and transport the high voltage batteries to hand over to recycling firm.

Automotive
Mechanic Electric Vehicle - Traction Motor and Battery Management System

Exercise 2.1.113

Practice on replace the defective battery module of 48V module system

Objectives: At the end of this exercise you shall be able to

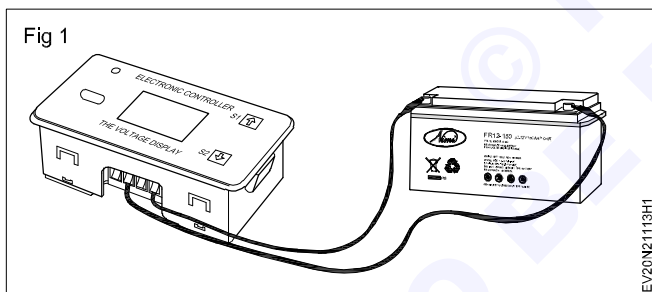
- replace the defective battery of 48V battery pack.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
• Voltmeter	- 1 No.	• Cable connector	- as reqd.
• Cell tester	- 1 No.	• Emery sheet	- as reqd.
		• Terminal cap	- as reqd.
Equipments/Machineries			
• Electric vehicle	- 1 No.		
• Work bench	- 1 No.		

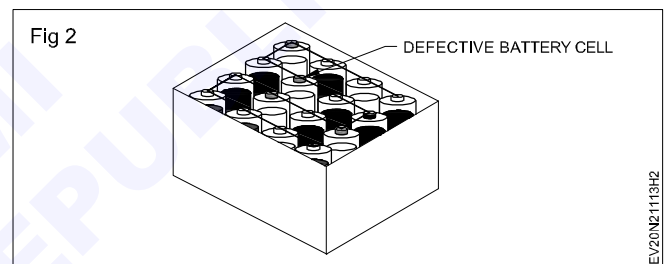
PROCEDURE

Replace the defective battery of 48V battery module system

- 1 Place the defective 48V electric vehicles (lithium) battery pack on work bench.
- 2 Disassemble the outside heat shrinkable film first. (Fig 1)



- 3 Identify the strings connections of the battery.
- 4 Test the each strings, by connecting multimeter or voltmeter test the batteries one by one to see which one is faulty.
- 5 Measure the each strings voltage one by one. There after compare the voltage reading of each strings and individual battery cells.
- 6 Select the low voltage bad batteries in a battery string.
- 7 Disconnect the scrap battery wire connection.
- 8 Replace the scrap batteries with the same capacity of new battery and then connect and spot weld them. (Fig 2)



- 9 Ensure new batteries are properly connected with strings.
- 10 Place the heat shrink film on the outside of battery and assemble it proper position as the instruction given by the vehicle manufacturers.
- 11 Measure the assembled battery output voltage.
- 12 Ensure the battery voltage is as recommended specified limit of vehicle manufacturer.
- 13 If the lead acid battery used in electric vehicle use the multimeter and voltmeter to check the voltage and continuity of the battery.
- 14 Use the hydrometer to check each cell charge condition.
- 15 If found any cell or battery defective replace the battery or repair the battery.
- 16 After repair re-assemble and fix the battery on the vehicle.

Practice to check the battery sensor's function

Objectives: At the end of this exercise you shall be able to

- check the functions of electric vehicle battery sensor.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
• Vehicle manual	- 1 No.	• Sensor	- as reqd.
Equipments/Machineries		• Battery terminal	- as reqd.
• Electric vehicle	- 1 No.		

PROCEDURE

Check the EV's battery sensor functions

Note: Many electric vehicles are equipped with diagnostic tools or software, that provide information about the battery condition.

- 1 Park the electric vehicle on the shop floor.
- 2 Study the vehicle manual.
- 3 Identify the battery sensor location.(Fig 1)
- 4 Trace the battery sensor's wire connections.
- 5 Check the battery terminal for loop connection or dirt fungy deposited on the terminal.

Note:

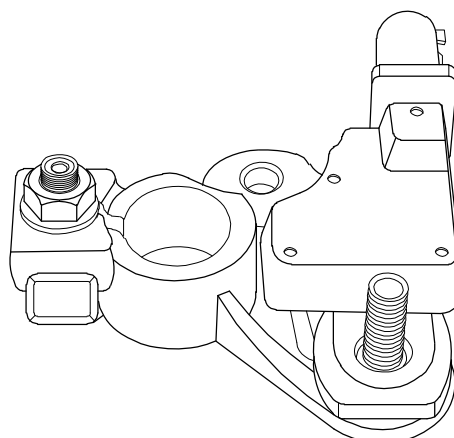
- 1 **Battery sensor measures the battery charge and discharge current flowing through battery. The battery sensor is provided on the battery terminal.**
- 2 **When the battery current sensor fails battery will not charge correctly it leads to dead battery.**

- 6 Check if batteries are in good condition even though battery is not charge properly then you check the following.
- 7 Check the battery charge rates if it is irregular it means battery current sensor is failure.
- 8 Check the battery voltage if it is low it means current sensor failure.

- 9 Check the corrosion on battery or sensor connection then clean it with cleaning materials.
- 10 Check the broken or bare sensor cabling - replace the broken cable.
- 11 Test the software of ECU and find the cause for failure if found any malpractice repair or replace component.
- 12 If found any type pf above said problems in battery current sensor circuits replace the battery current sensor and other faulty materials.
- 13 After replace the defective sensor check the sensor's function by operating vehicle.

Note: The instructor has to guide the trainees to check the function of battery current sensor.

Fig 1



EV20N2114H1

Practice on diagnose, repair and test the high voltage battery system

Objectives: At the end of this exercise you shall be able to

- **diagnose the defects in high voltage battery system**
- **repair the high voltage battery system fault**
- **test the function of high voltage battery systems.**

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
• Voltmeter	- 1 No.	• Emery sheet	- as reqd.
• Soldering iron	- 1 No.	• Lithium cell	- as reqd.
• PPE kit	- 1 No.	• Lead acid battery	- as reqd.
		• Converter	- as reqd.
Equipments/Machineries			
• Electric vehicle	- 1 No.		
• Work bench	- 1 No.		

PROCEDURE

TASK 1: Diagnose the defects in high voltage battery system

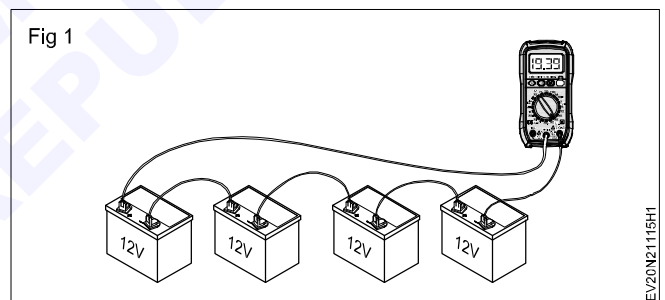
Note: The instructor has to explain and demonstrate the method of fault diagnose in on road electric vehicle's in high voltage battery system.

- 1 Park the electric vehicle on the vehicle repair bay.
- 2 Study the vehicle manual for achieve the knowledge of electric vehicle high voltage battery system and not the reel BMS date of EV.
- 3 Switch on the vehicle's battery power high voltage.
- 4 Note the dash board warning light signs of high voltage battery system.
- 5 If found any malfunctions in BMS, you can diagnose the fault in BMS.

Note: Use the personal protective equipments while working with electric vehicle.

- 6 Visually check the battery pack batteries internal and external connections.
- 7 If found any damaged cables replace batteries connections cables.
- 8 Check the battery pack voltage output the with help of multimeter or voltmeter. if found battery pack output is not as per specified limit. check the individual batteries connected within battery pack. (Fig 1)
- 9 Disconnect the battery cable connections.
- 10 Test the each battery for their condition.

Fig 1



- 11 If found the any batteries cell dead, replace the with new one at sum range of defective cell or battery (lead acid or lithium battery).
- 12 Connect the battery in series or parallel connections.
- 13 Apply charge to the battery through charging point.
- 14 If battery pack is not properly charged within specified time limit, check the current sensor if found faulty, replace it.
- 15 Check the cell balancer circuit resistors, if found any one damaged or faulty, replace it.
- 16 Check the battery on load condition, if found quick battery train the voltage, check the battery life if batteries nature aged in the series connection replace it.
- 17 Check the possible cause for collision and shock of lithium ion battery if found any loose connection of cells repair it for avoid electric shock or spark.
- 18 Check the battery vibration while vehicle running if found battery vibration correct it for a avoid battery damage and electric shock.

19 Check the battery terminals for find formation of dirt or funky layer and lithium dendrite, if found the defects rectify it.

20 Check the internal battery faults like overcharge, over discharge internal short circuit, external short circuit, over heating, accelerated degradation, thermal runaway, if found any one of the above defects in BMS rectify it (symptoms of fault voltage drop, state of charge drop, temperature raise, increase in internal resistance, swelling etc).

21 Check the batteries external defects like crack, leak, loose connection sensor fault, over heat (Cooling system fault) cell configuration fault if found above mention faults rectify it before use.

21 Write down the finding, fault, cause and their remedies in the table 1.

Table 1

High voltage battery common faults and their remedies

S.No	Fault	Cause	Remedies
1	Low battery charge/high discharge common battery faults and their remedies	Current sensor defective	Replace the current sensor
2	Battery cell imbalanced	Cell balance resistor defective	Replace the resistor
3	Battery over charge		
4	Battery over discharge		
5	battery over heat		
6	Battery cover damaged		
7	Slow charging speed		
8	No power output		
9	Battery charging failure		
10			

Practice on diagnose, repair and testing the EV battery controls

Objectives: At the end of this exercise you shall be able to

- diagnose the fault in EV battery controls
- repair the faulty components in EV battery controls
- test the EV battery controls.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
• Vehicle manual	- 1 No.	• insulation tape	- as reqd.
Equipments/Machineries		• EV battery controller	- as reqd.
• Electric vehicle	- 1 No.	• Emery sheet	- as reqd.
		• Battery terminal cap	- as reqd.

PROCEDURE

TASK 1: Diagnose the fault in Electric vehicles battery controls (Fig 1)

Note: The instructor has to demonstrate the Electric vehicle battery controller's fault diagnosing method.

- 1 Park the electric vehicle on the repair bay.
- 2 Study the vehicle manual and note the real data of the battery controller and high voltage battery.
- 3 EV's common charging controller problems are like faulty communication of vehicle over heating, power surge and software glitches are found through warning light indicating a problem in charging controller , replace the controller or check the charging cable and their connection if need replace the charging cable and charger plug.
- 4 Check the high voltage battery charger controller.
- 5 After replace the damaged charger cables, switch off the charger.
- 6 Wait for a few moments and then restart it.
- 7 Check the function of charge controller.
- 8 After repair the battery charge controller ensure the battery charge controller is functioning properly like a schedule charging remote monitoring and integration with energy management systems
- 9 Trace the battery DC/DC converters wire connections.
- 10 Check the DC/DC converters input and output if found low input recharge the battery incase DC/DC converter is defective replace it.
- 11 Check the DC/DC converters cable connections if need replace the cable connectors.
- 12 Trace the battery DC/DC converter's wire connections

- 13 Check the DC/DC converters input and output voltage, if found low input recharge the battery, incase DC/DC converter defective replace it
- 14 Check the auxiliary battery terminals and terminal connections.
- 15 Compare the DC/DC converter's input voltage and output voltage with vehicle manufacturer's real data.
- 16 Trace the battery controller wiring circuit in a EV.
- 17 Check the controller current output, if found phase loss, normally check the wire connections and motor hall effect sensor.

Note:

- 1 Use the multimeter to measure the voltage, current and continuity of the circuit.
- 2 The EV controller transforms the battery's direct current into alternating current and regulates the energy flow from the battery

- 18 If found fault replace the damaged wire and defective motor hall effect sensor.
- 19 If it is correct then check the controller internal parts, if need replace the controller.
- 20 While start the traction motor drive incase found thumping sound, check the motor wire internal short circuited due to the contact of the virtual connection. Then unplug current phase wires of motor.
- 21 Replace the controller and motor damaged wires.
 - After replacing the wire traction motor is not work it means motor coil is burnt so repair or replace the motor.

- If electric vehicle can start normally but it would not turn after a few meters, check the following

22 Check the battery voltage (low voltage).

23 Check the controllers wire connection for poor contact.

24 Check the vehicle under voltage value, if it goes down then under voltage limit the controller will stop power supply to traction motor. so you check the controller lock line voltage whether voltage is present in 5V power supply line of the hall effect sensor check the signal wire of the handle voltage of 3.5V-40V in normal, if it is less than find the cause and rectify it.

25 Note down the causes and remedies of fault in battery controls in Table 1

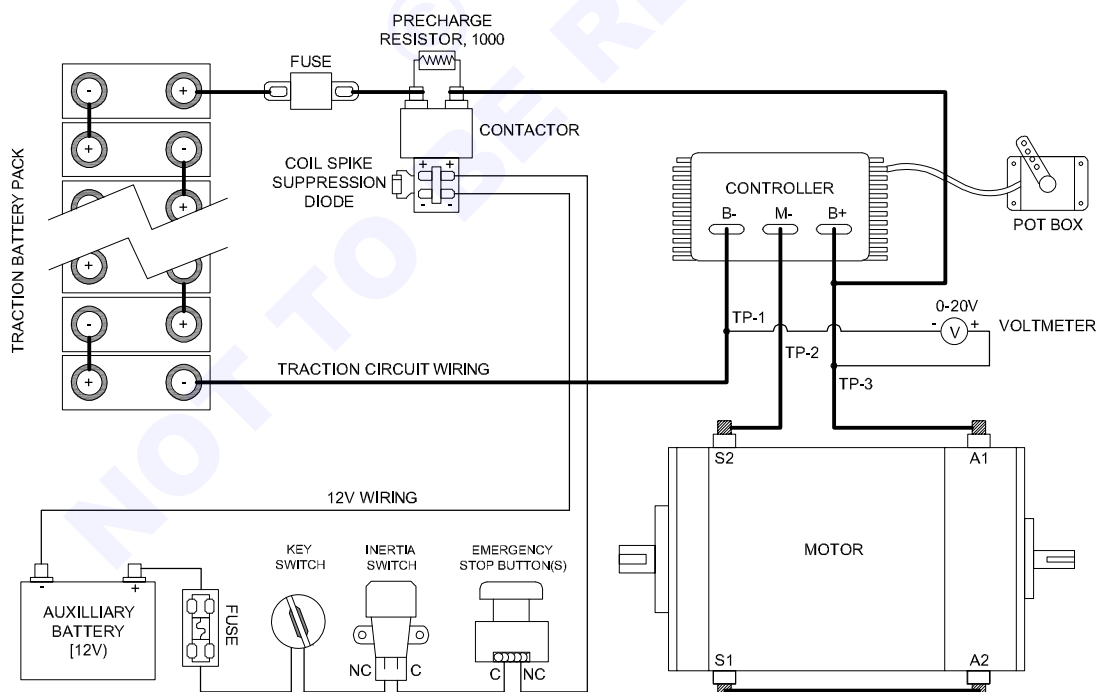
Note:

- 1 Ensure periodic inspection and cleaning of charging connectors and cables to prevent any potential issues.**
- 2 Ensure safety should always come first when working with any electrical issues.**

Table-1

S.No	Diagnosed Fault	Cause	Remedies
1	Motor Controller low output	Low battery power	Recharge the battery
2	Battery charge controller over heat		
3	Battery charge controller N/W		
4	Motor controller loose wire connections		
5	Battery over heat	Excess load	
6			
7			
8			

Fig 1



EV20N2116H1

Practice to measure and diagnose the cause of excessive battery drain

Objectives: At the end of this exercise you shall be able to

- measure the high voltage battery's terminal voltage
- diagnose the cause for excessive battery drain and its corrective action

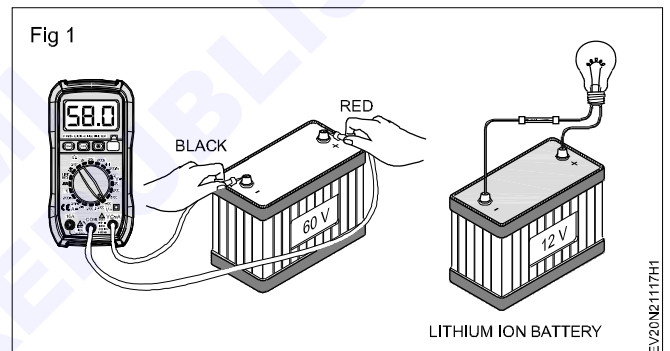
Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
• Voltmeter	- 1 No.	• Gel	- as reqd.
Equipments/Machineries		• Emery sheet	- as reqd.
• Electrical vehicle	- 1 No.	• Insulation tape	- as reqd.
		• Battery cable	- as reqd.

PROCEDURE

TASK 1: Measure the Electric vehicle battery terminal voltage

Note: The instructor has to demonstrate the EV battery terminal voltage measuring method by using voltmeter or digital multimeter.

- 1 Park the electric vehicle on the repair bay and adopt the vehicle safety measurement.
- 2 Study the vehicle service manual and note the battery's real data.
- 3 Identify the battery pack location and their wire connection.
- 4 Use the personal protective equipment before start the work in electric vehicle.
- 5 Identify the battery pack and its terminals.
- 6 Select the suitable digital multimeter or voltmeter.
- 7 Set the voltage reading range of multimeter to measure the battery terminal voltage. (Fig 1)



- 8 Connect the multimeter or voltmeter with batteries output terminal.
- 9 Note the reading shown in multimeter or voltmeter.
- 10 If found any batteries parasitic draw check cause for excessive key off battery drain.

TASK 2: Diagnose the cause of excessive key off batteries drain and its corrective action

Note: The instructor has to demonstrate the method of diagnose the cause of excessive battery drain and their remedies.

- 1 Check the battery quality and their age in service, if battery life is crossed over, replace the battery.
- 2 Check the battery terminals, if found fungies clean it.
- 3 Check the battery switch "ON" keys if it found defective replace it.
- 4 Check the vehicle interior electrical circuits, if any one circuit found short circuited rectify the fault and recheck the circuit.
- 5 Check the battery extreme temperature, humidity and exposur to water or moisture can also cause for key off battery power drain if found any type of defective the defect and recheck it for healthy battery power supply.
- 6 Check the any other electronic devices power "ON" and keep it with in vehicle cabin also cause for battery key of power drain if found any device ON condition remote it, when vehicles battery is switched to power off. Keep the ignition switch or remote key away from the other electronic devices to avoid interference and reduce the battery drain.

- 7 Check the vehicle ignition key fob, if found defective replace the faulty key fob.

Note: Use a test switch and digital ammeter for check the battery drain directly. Use the test switch between the negative battery terminal and negative battery cable.

- 8 Check the bad fuses or interior lights fail to shut off will continue to drain a car battery while it is idle.
- 9 Check the vehicles all electrical circuits, if found open circuit it also cause for battery power drain continue while your vehicle is idle.
- 10 To avoid the battery drain off, unplug the optional equipments such as cell phone charger, laptop charger, lights glowing of the vehicle while you park the vehicle at night and day.

- 11 When you parking the vehicle ensure the trunk, glove box and doors are all fully closed and latched before the leaving your vehicle.
- 12 When you are replacing a battery clean the corrosion, debris and oxidized metal on the battery terminal to avoid battery power drain off. Apply petroleum jelly all over the battery terminal and metal surfaces.
- 13 Clean the cable connector and connect it proper fitting to avoid short circuiting.
- 14 Over charge also can cause for battery power drain (due to high heat).
- 15 Excess load beyond battery capacity also cause for quick battery discharge.

Practice to check cooling requirements for EV components

Objectives: At the end of this exercise you shall be able to

- check cooling requirements for electric vehicle components.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cooling fan	- as reqd.
• User Manual	- 1 No.	• Cooling liquid	- as reqd.
• Work shop manual	- 1 No.	• Cotton waste	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Electric vehicle	- 1 No.	• Inverter	- as reqd.

PROCEDURE

Check the cooling system of electrical vehicle components

Note: The instructor has to demonstrate and explain the electric vehicle components cooling system requirements and their cooling function.

- 1 Park the electric vehicle on the shop floor.
- 2 Take safety precaution and use PPE before the start work in electric vehicle.
- 3 Study the electric vehicle work shop manual for identify the electric vehicle components cooling system.

Note: Cooling requirement of Electric vehicle components and their system is of battery pack traction motor electronic converter, inverter and HVAC.

- 4 EV working components required optimal temperature 15°C to 30°C normally, traction motor's temperature is up to 60°C (The optimal temperature neither warm or cold).

Note: The EV manufacturer provided components cooling system in their vehicle which that account for thermal efficiency, temperature uniformity, size, weight and cost, similar cooling needs ring true for traction motor. There are many types of cooling system used to cool the EV components like liquid cooling, air cooling and phase change materials in a electric vehicles artificial intelligence used to monitor the working components.

- 5 Check the battery location and battery cooling method used in your vehicle.
- 6 Check the EV's battery and electric components of a cooling system.

- 7 Check the battery liquid cooled heat sinks if found damaged replace it with new one.

Note: Vehicle manufacturers designing their equipment that can manage the heat produced during production process check the batteries air cooling system whether air is circulated through the battery pack properly if found improper cooling check the air supply of the vehicles (according seasonal climates) outside air supply or car inside air supply system used in a vehicle.

- 8 Check the air duct if found air block, clean it for free air flow.
- 9 Incase separate liquid cooling system used for battery pack cooling which only cools the battery pack.
- 10 The battery pack need to stay below the 60°C if it is more than as specified check the liquid cooling systems components like heat conducting pipe.
- 11 Incase battery pack used the submission cooling system check the liquid quantity and quality along with heat absorb material provided in the battery pack.
- 12 Check the air flow outside of fluid containing along this container housing if found any fault rectify it.
- 13 Incase used the micro channel heat sinks in battery pack check the battery temperature at charging and discharging condition, if battery pack temperature is more than specified limit replace the heat sinks used on the lithium ion battery pack.

Note:

- 1 Water, oil, mono fluid, liquid metal and boiling liquid are used in the cooling system of battery pack.

2 Battery cooling system are used the air cooling, liquid cooling, phase change material, cooling plates cooling pipes and immersion cooling (Container) method.

3 The electric motor used in different types of cooling system (1) Naturally ventilated (no fan) (2) Totally enclosed fan cooled (3) Totally enclosed force ventilated (axial fan or radial fan) (4) Totally enclosed air over (no fan) motor in air system (5) Jacket water cooled.

- 14 In case air cooling system is used in a motor check the fans and external fan if need clean the cooling fins and check the fan functionality for proper cooling of motor.
- 15 If integral fan to direct air through the motor winding cool the motor, check the fan blade for damage, fan alignment and lubricating bearings for smooth operation.
- 16 If water cooling check the coolant pipe, motor frame or motor housing water flow passages, check the water flow pressure and leaks and ensure the water quality meets specification.
- 17 Check the oil coolant pipe and immersed in the motor and check the quality of oil and oil level and oil pressure and oil leaks.
- 18 Check the forced ventilation external fans to circulate air inside the motor, motor bearings, air filter and unrestricted air flow through motor.

- 19 If self ventilated check the motor rotor, airflow, cooling the motor internally.
- 20 If found any defect in the motor air cooling system rectify it before start the EV.
- 21 A inverter cooling system of an electric vehicle inverter system including an inverter for converting electric power from the battery into alternating current and for supplying the current to a driving motor in this inverter heatsinks are provided vertically supported on a mounting base and heat generating parts of said inverter placed and fixed on at least one side of said sink.
- 22 Check the inverter's heat sink liquid flow vertical and outlet pipe converted to the other flow pipe for conducting a recirculating liquid coolant. Check the heat sink is covered with water proof cover, if found damage replace the water proof cover.
- 23 Check the switching parts are fixed on one surface of said heat sink and DC/DC converter is fixed on the opposite side surface of the heat sink.
- 24 If the inverter is IGBT based check the insulated gate bipolar transistor use as air cooling device, if found defective bipolar transistor replace it.
- 25 If the inverter and DC/DC converter is air cooled, check the blower fan and their function, if you are not satisfied repair or replace the blower unit.

Practice to check EV battery cooling fan function

Objectives: At the end of this exercise you shall be able to

- check the battery pack cooling fan function.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle user manual	- 1 No.	• Soap oil	- as reqd.
• Multimeters	- 1 No.	• Insulation tape	- as reqd.
• PPE kit	- 1 No.	• Wire	- as reqd.
		• Wire connector	- as reqd.
Equipments/Machineries			
• Electric vehicle	- 1 No.		
• Work bench	- 1 No.		

PROCEDURE

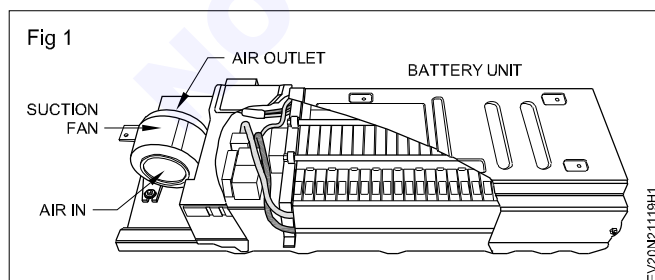
Check the EV's battery pack cooling fan function

Note: The instructor has to demonstrate the sequence of cooling fan function checking in live program.

- 1 Park the electric vehicle on the shop floor with safety measures.
- 2 Study the vehicles service manual for identify the battery cooling fan components and their connections.
- 3 Study the battery pack air flow circuit and cooling fan mounting and their power connections.
- 4 Identify the location of battery cooling fan.

Note: Use the personal protective equipment to avoid electric shock.

- 5 Check the fan wire connections and power supply to battery cooling fan.
- 6 Check the air suction motor fan and battery pack air inlet and air outlet.(Fig 1)



- 7 Check the battery pack air flow passages.

- 8 Switch on the battery pack air suction motor power and observe the motor running speed and air suction rate.
- 9 If air suction on motor running speed is slow then check the motor if need dismount and dismantle the motor, clean the parts, visually check the damages if found defective in any part of motor repair or replace the damaged part (Dismantling and assemble the motor).
- 10 Check the fan leaf if found any bend or damage replace the Fan blades or Fan.
- 11 Assemble the air suction motor and place it on test bench.
- 12 Connect the battery power to motor terminal and switch ON power.
- 13 Check the motor (speed) RPM and compare it with manufacturers specification. if found correct check the air velocity , if it is correct, mount the motor in that location of the vehicle.
- 14 Tighten the motor base mounting and connect the wire connection.
- 15 Power on the air suction motor and check the air inlet and air outlet of the battery pack.
- 16 If found the air leak in battery pack cover, rectify it and again check the inlet and out air flow.
- 17 Check the air is transfer the battery heat or no, when battery is on heavy load.
- 18 Ensure the air suction motor, air duct, air heat transfer function is functioning properly as specified the vehicle. manufacturer.

Practice to check the inverter cooling system

Objectives: At the end of this exercise you shall be able to

- check the cooling system of inverter assembly.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
• Vehicle manual	- 1 No.		
Equipments/Machineries			
• Electric vehicle	- 1 No.		
• Work bench	- 1 No.		

PROCEDURE

Check the Electric vehicle inverter's cooling system

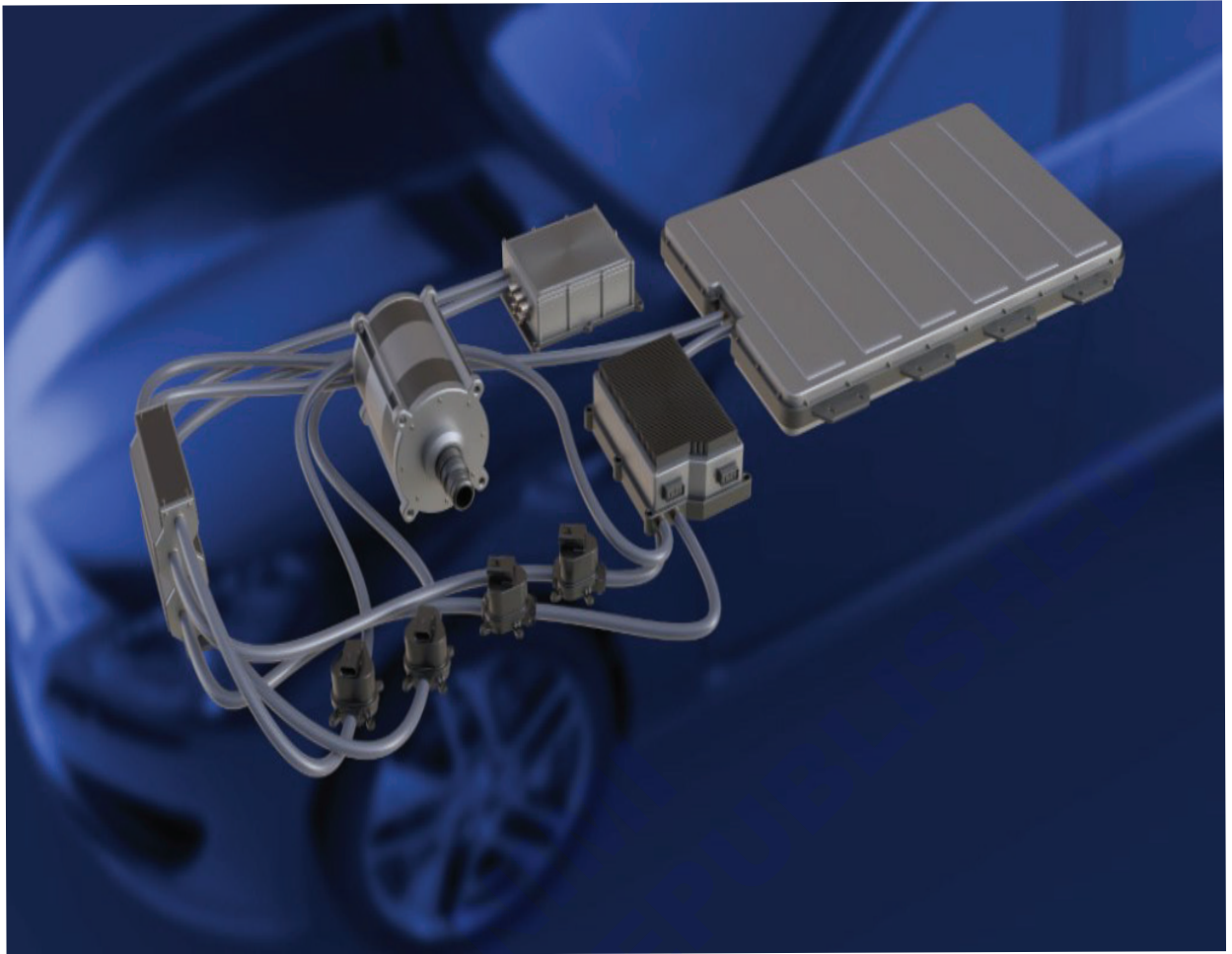
Note: The instructor has to demonstrate to check the optimal performance of a inverter's cooling system.

- 1 Park the electric vehicle on the shop floor with safety measure.
- 2 Study the vehicle manual for inverter's location and wire connections.
- 3 Study the inverters function and heat transfer method used in a vehicles. (Fig 1)
- 4 Physically check the inverter cooling method and their electrical wire and cooling system connections.
- 5 Check the inverters heat sink.
- 6 Check heat sink coolant flow passages for conducting a recirculating liquid coolant. if need clean the fluid flow passage.
- 7 Check the heat sink mounting position and their water proof cover if heat sink mounting or joints loose fitting, correct it.
- 8 Check the one side of heat sink is place near the IGBT, snubber resistors, an electrolyte capacitor and print board relatively positioned with respect to the heat sink, if found heat sink damaged replace it.

- 9 Check switching parts are fixed on one surface of heat sink and DC/DC converter is fixed on the opposite surface of the heat sink if found any misplace it properly change the defective switching parts.
- 10 Ensure the heat sink is composed of a pair of elements which are joined through a brazing material, if found brazing joint damaged repair it.
- 11 Ensure the liquid inlet pipe connected to one vertical flow passage and outlet pipe connected to other vertical flow passage.
- 12 Ensure the liquid flow pipe inclining angle is in the range between 10° to 15° if the pipe angle is incorrect, correct the pipe angle.
- 13 Check the flow pressure of the liquid if pressure is low check the cause for low pressure and rectify it.
- 14 After the repair verify the performance of inverter cooling.

Note: Different types of cooling systems are used for cool the electric vehicle's inverter and converter. So kindly refer the vehicle user manual for achieve the correct type of inverter's cooling system.

Fig 1



Practice to inspection of power steering control module circuit

Objectives: At the end of this exercise you shall be able to

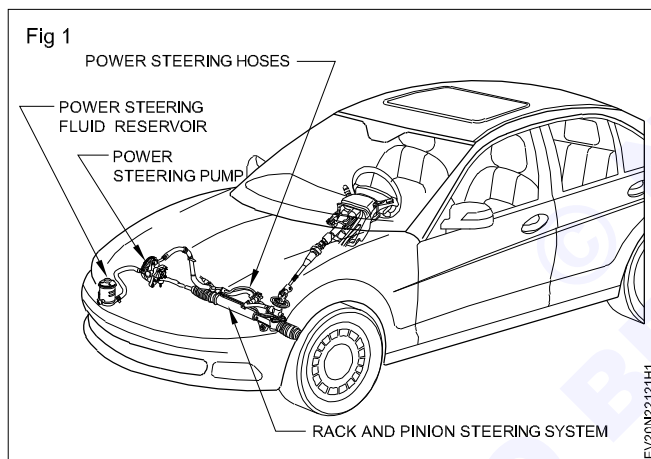
- identify and inspect the power steering control module circuit.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries		• Hydraulic oil	- as reqd.
• Electric vehicle	- 1 No.		

PROCEDURE

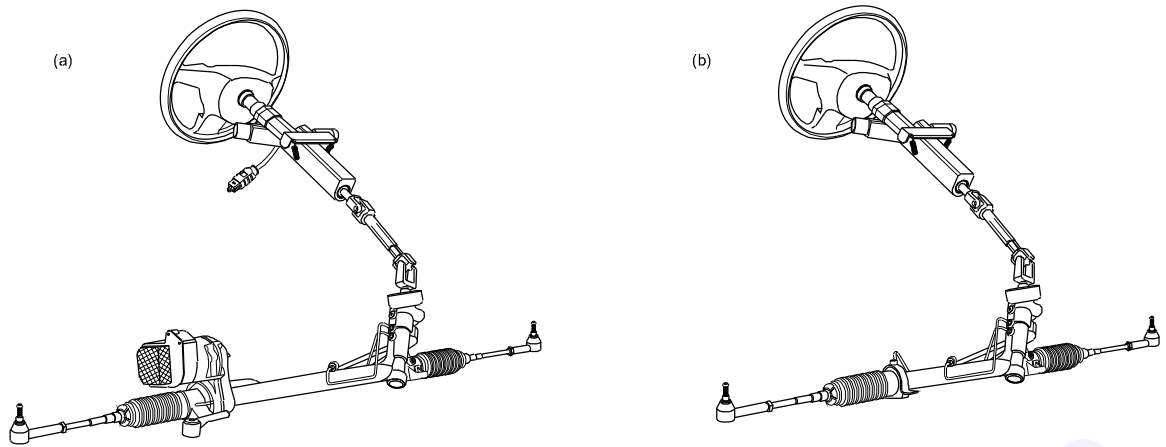
TASK 1: Identify the power steering parts and inspect the power steering control module circuit.

- 1 Park the electric vehicle on the shop floor service ram. (Fig1)



- 2 Study the electric vehicle manual.
- 3 Use the personal protective equipment, while work with electric vehicle.
- 4 Open the vehicle door and identify the which type of power steering system used in a vehicle (Integral type or booster type).
- 5 Inspect the steering wheel and steering column or forks and yoke in steering linkage.
- 6 Push and pull the steering wheel in line with column.
- 7 Push the steering wheel in various direction at right angles to the steering column.
- 8 Check visually and moving a steering wheel for steering wheel play.
- 9 Check the condition of flexible coupling or universal joints of steering.
- 10 Check the steering linkage condition.
- 11 Check the steering linkage operation.
- 12 Check the steering gear function by moving the steering wheel.
- 13 Check the condition of drag link ends (which is under the vehicle).
- 14 Check the tie rod end ball joints and their dust cover (Fig 2).
- 15 Check the power steering fluid level in reservoir.
- 16 Check the power steering fluid leaking or system malfunctioning.
- 17 Check the power steering wheel alignment.
- 18 Check the power steering fluid pipe, hose or wiring in case of Electric power assisted hydraulic power steering.
- 19 Check the function of power steering hydraulic fluid operating pump.
- 20 Check the steering geometry (camber, caster angle and king pin inclination by using turn gauge).
- 21 Check the King pin and Knuckle arm and bearing.
- 22 Check the front wheel toe in-toe out. (Fig 4)
- 23 Check the steering wheel sensor, torque sensor and electronic control unit.
- 24 If found any defects during inspection of steering (Fig 2,3) system, rectify it before move the vehicle.
- 25 Check the hydraulic pump drive belt, if hydraulic power steering pump driven by IC engine.

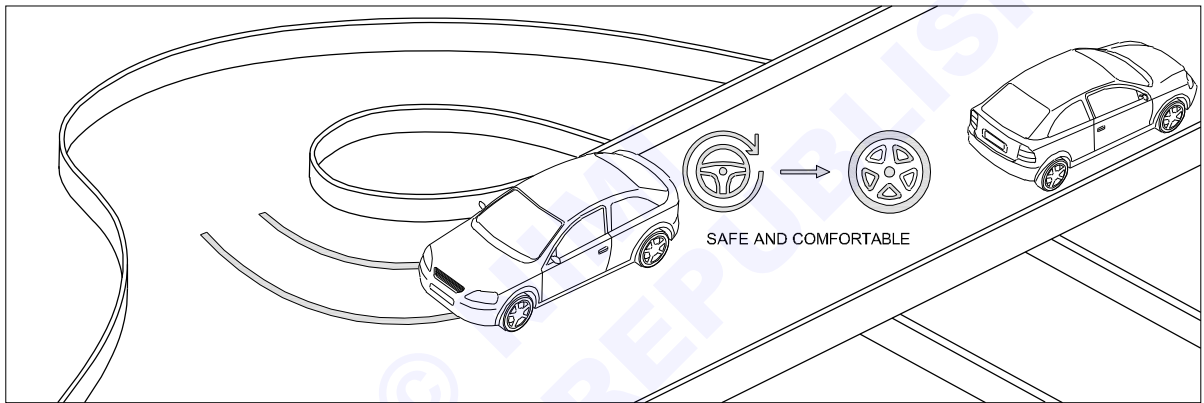
Fig 2



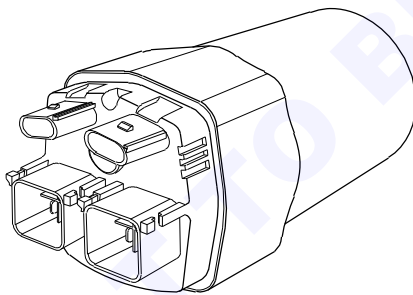
ELECTRIC POWER STEERING ON THE STEERING COLUMN

EV20N22121H2

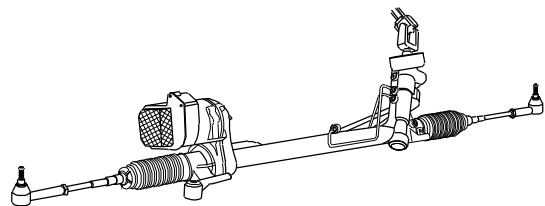
Fig 3



ELECTRIC POWER STEERING SYSTEM (EPS)



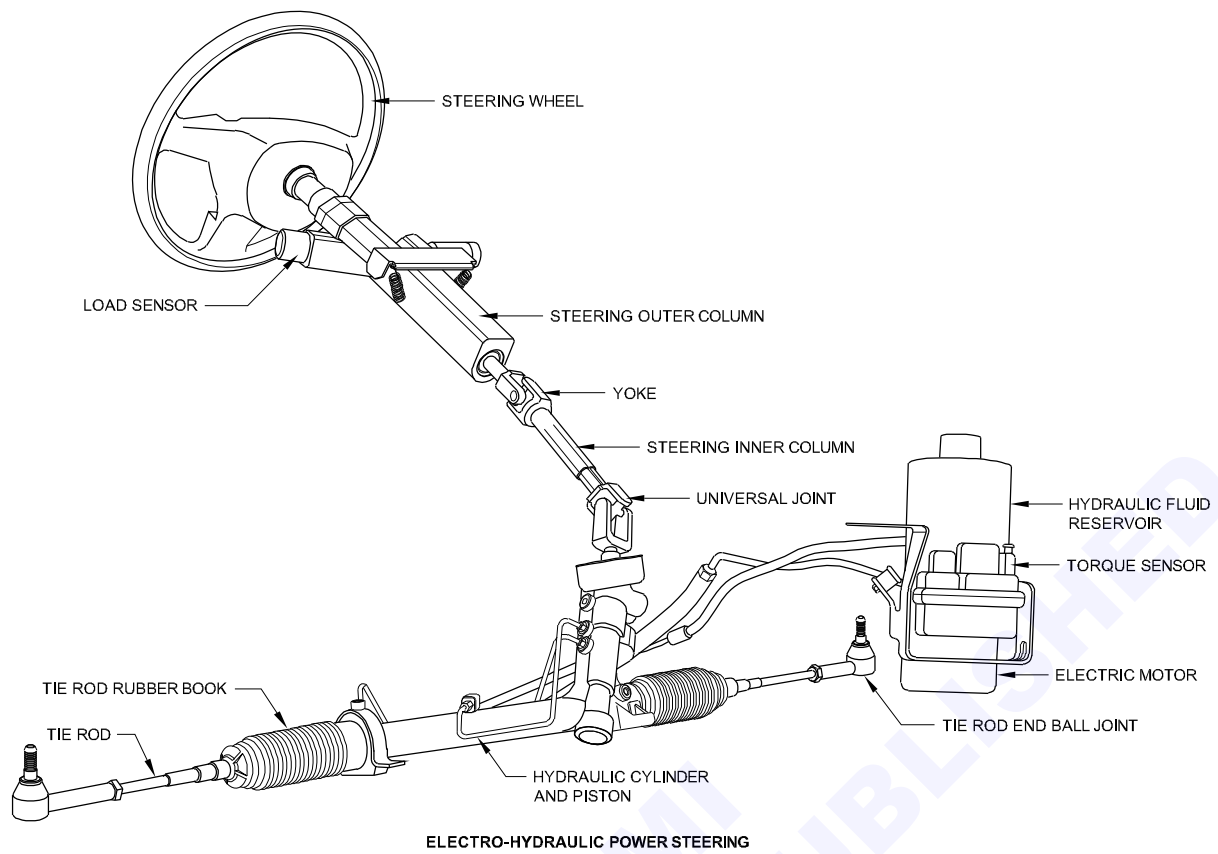
STEERING CONTROL UNIT



ELECTRIC POWER STEERING SINGLE PINION SERVO UNIT

EV20N22121H3

Fig 4



Practice on checking and adjusting power steering system

Objectives: At the end of this exercise you shall be able to

- check and adjust the power steering system
- check a power steering fluid pressure
- check and flush a power steering system
- fill and bleed the power steering system.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle service manual	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries		• Hydraulic oil	- as reqd.
• Electric vehicle	- 1 No.		
• Work bench	- 1 No.		

PROCEDURE

TASK 1: Checking a steering fluid level

- 1 Locate the power steering reservoir.
- 2 Remove the cap and observe the fluid level. Most of the power steering reservoir is made of clear plastic and the cap does not need to be removed to observe the fluid level.
- 3 If need top up the fluid
- 4 Replace the fluid, incase of fluid as following condition.
 - Discoloration
 - Burned odor

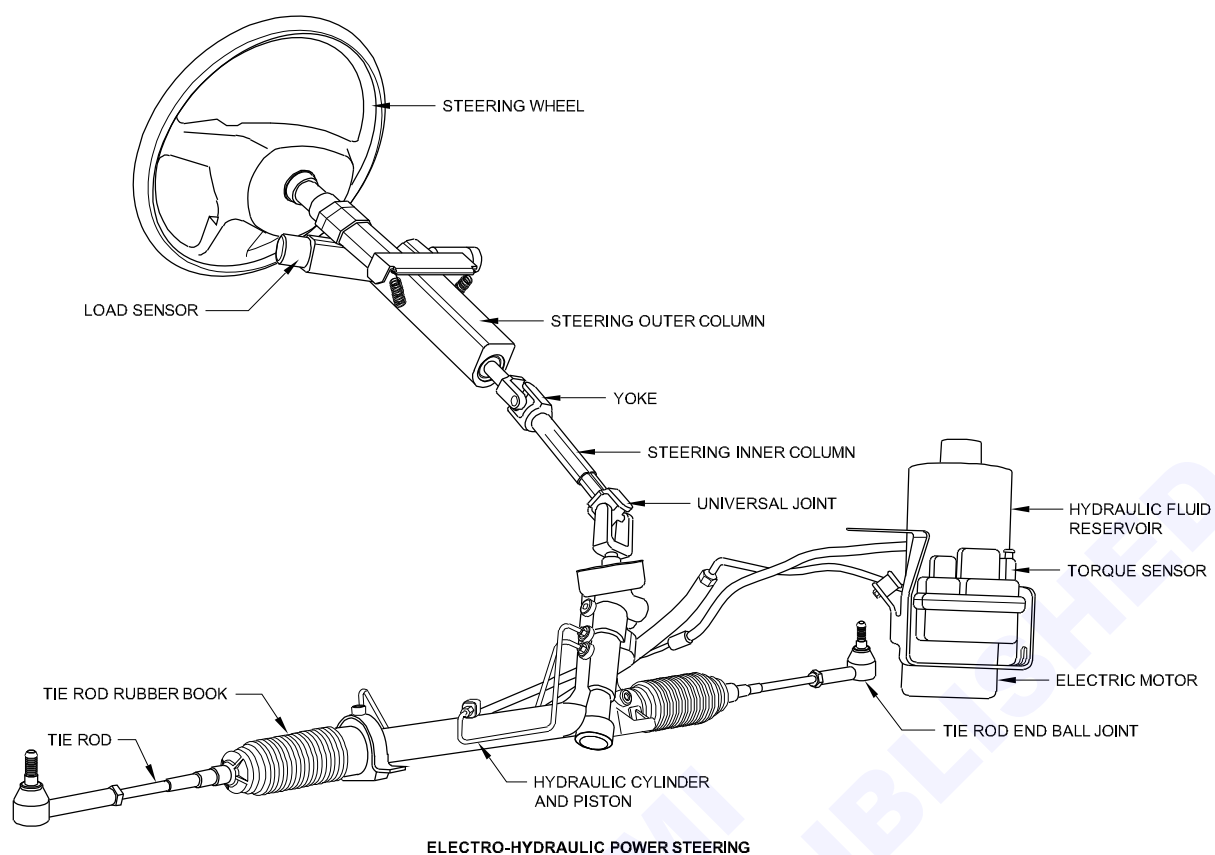
TASK 2: Flushing a power steering fluid (Fig 1)

- 1 Locate the power steering reservoir and confirm the power steering fluid by looking at the label on the reservoir cap.
- 2 Remove cap made by plastic or metal.
- 3 Check the fluid condition and fluid level.
- 4 Clean off all outside dirt from around fittings and hose connections before you remove the drain hose.
- 5 Disconnect the fluid hose connections to drain the fluid and place the tray under the drain hose.
- 6 Move the steering wheel left and right for move the piston to give the pressure on reservoir and line fluid to drain.
- 7 Ensure the complete fluid is drain from the reservoir and fluid hoses.
- 8 Reconnect the input and output hoses.
- 9 Fill the fluid in reservoir and switch on the ignition key.
- 10 Move the steering wheel to left and right and start the electric pump to purge system and increase speed to prime the pump.
- 11 Check the pump pressure by using pressure gauge like outlet pressure, boost pressure, port pressure and inlet pressure etc.
- 12 Turn of the pump power and check the fluid level in the reservoir. Add fluid as necessary.
- 13 Bleed the system if necessary by using instructions of steering gear box service manual.

Note:

- Always clean off around the reservoir filler cap before you remove it.
- Replace the reservoir filter according to requirements.
- Regularly check the fluid condition and fluid level in power steering reservoir.
- Never use high pressure wash or steam wash to clean on electric power steering pump while servicing a vehicle.

Fig 1



EV20N22122H1

Practice on identify the various sensors installed in steering system

Objectives: At the end of this exercise you shall be able to

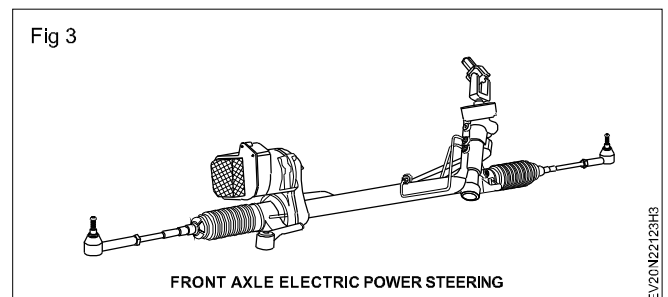
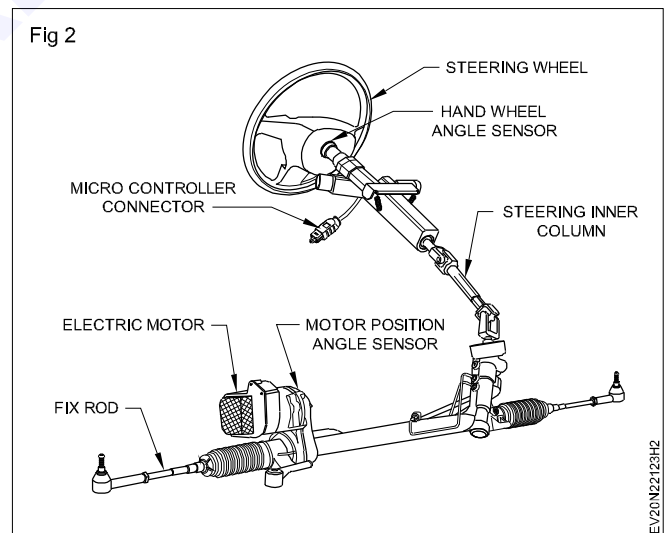
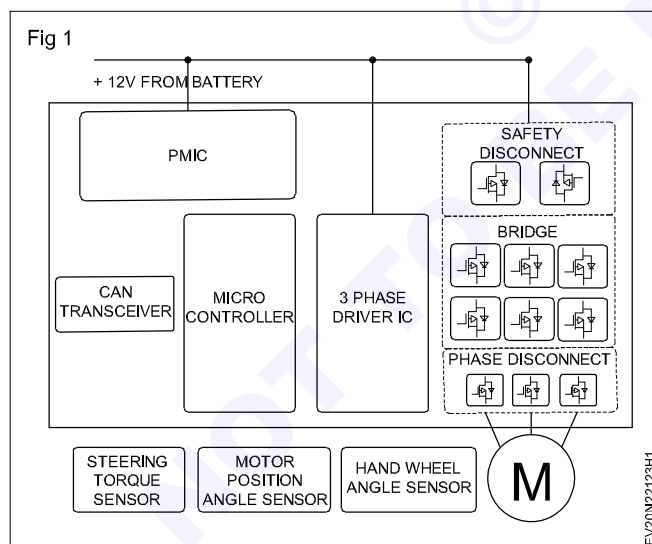
- identify the various sensors installed in power steering module circuit.

Requirement			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries		• Steering control unit	- as reqd.
		• Torque & index sensor	- as reqd.
• Electric vehicle	- 1 No.	• Steering wheel micro control	- as reqd.

PROCEDURE

TASK 1: Identify the various sensors installed in power steering system

- 1 Park the electric vehicle on the shop floor with following safety instructions.
- 2 Study the vehicle manual for find the location of various sensors installed in a steering module circuit.
- 3 Use the personal safety devices while work in electric vehicle.
- 4 Open the vehicle door and switch off the battery power. (Fig 1)
- 9 Identify the micro controller and steering electronic controller and their wire connections.
- 10 Identify can transceiver connected with sensor circuit board.
- 11 Identify the power steering electric motor and their motor position angle sensor.
- 12 Identify the steering torque sensor fitted on rack and pinion drive. (Fig 2, 3)



- 5 Identify the steering wheel and their fittings.
- 6 Dismantle the steering wheel and circuit board.
- 7 Identify the misfit circuit board fitted with steering wheel center place.
- 8 Identify the steering wheel angle sensor and their connections.

Practice on steering system trouble shooting

Objectives: At the end of this exercise you shall be able to

- trouble shooting of steering wheel, heavy at low speed
- rectify the poor recovery from turning
- rectify the vehicle pulls to one side during straight driving.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries			
• Electric vehicle	- 1 No.		
• Work bench	- 1 No.		

PROCEDURE

TASK 1: Trouble shooting of steering wheel feels heavy at low speed

S.No	Cause for trouble	Remedies
1	Dirty steering fluid	Replace the reservoir fluid
2	Under inflated tyres	Inflate the tyre as specified
3	Worn steering rack	Replace the rack rod
4	Bad function of steering pump	Overhaul or replace the pump
5	Bad function of steering wheel sensor	Replace the sensor
6	Bad function of torque sensor	Replace the sensor
7	Bad function of motor angle sensor	Replace the motor angle sensor
8	Low level power of steering fluid	Top up the hydraulic fluid
9	Poor wheel alignment	Align the wheel properly

TASK 2: Steering wheel poor recovery from turns

- 1 Check the front wheel tyre air pressure if found low air pressure, fill the air as specified limit.
- 2 Check the wheel alignment if need align the front wheels.
- 3 Check the steering rack if found bad steering rack replace it.
- 4 Check the power steering fluid leakage, if found leakage rectify the fluid leakage.
- 5 Check the steering hydraulic oil pump, if found malfunctioning overhaul the pump or replace the pump.
- 6 Check the hydraulic oil viscosity, if found the thick, replace the fluid of the power steering.
- 7 Check the steering gear if found improper adjusted readjust the steering gear for free movement.
- 8 Check the steering wheel play if found excess play adjust the pre-load.

TASK 3 : Vehicle pulls to one side during straight driving

S.No	Cause for vehicle pulls to one side	Remedies
1	Uneven brake adjustment	Adjust the front wheel brake evenly
2	Uneven tyre air pressure	Maintain the proper rise air pressure
3	Uneven tyre tread weariness	Use the even treaded tyres
4	Improper wheel alignment	Align the wheels properly
5	Improper size of tyre	Replace the tyre
6	Bad wheel bearing	Replace the bearing
7	Damaged brake pad or shoe	Replace the damaged part
8	Damaged suspensions	Replace the damaged part
9	Damage or worn steering linkages	Replace the damaged part

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Practice to identify and locate the components of AC system

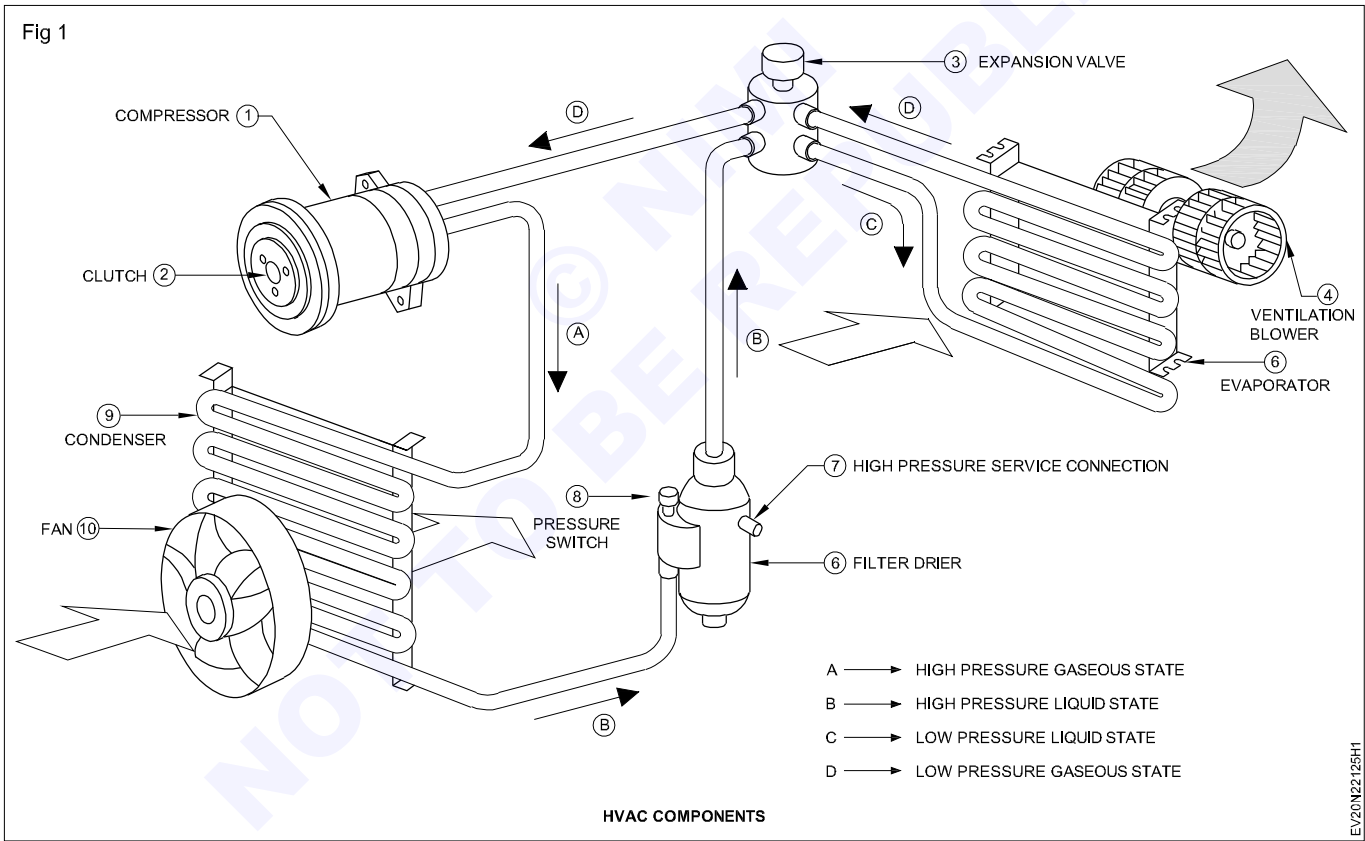
Objectives: At the end of this exercise you shall be able to

- identify the electric car air conditioner components.

Requirement			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle user manual	- 1 No.	• Soap oil	- as reqd.
• Training aid chart	- 1 No.		
Equipment/Machineries			
• Electric vehicle	- 1 No.		
• Demo car AC components	- 1 Set.		

PROCEDURE

Identify all HVAC components of a motor car (Fig 1)



- 1 Park the electric vehicle in shop floor with the emergency brake set.

2 Disconnect the negative battery cable.

3 Identify the compressor (1) and supporting device.

4 Identify the compressor magnetic clutch (2).

5 Identify the expansion valve (3) and its supporting device.
- 6 Identify ventilation blower (4) and its support system.

7 Identify filter drier (6).

8 Identify high pressure service connections (7).

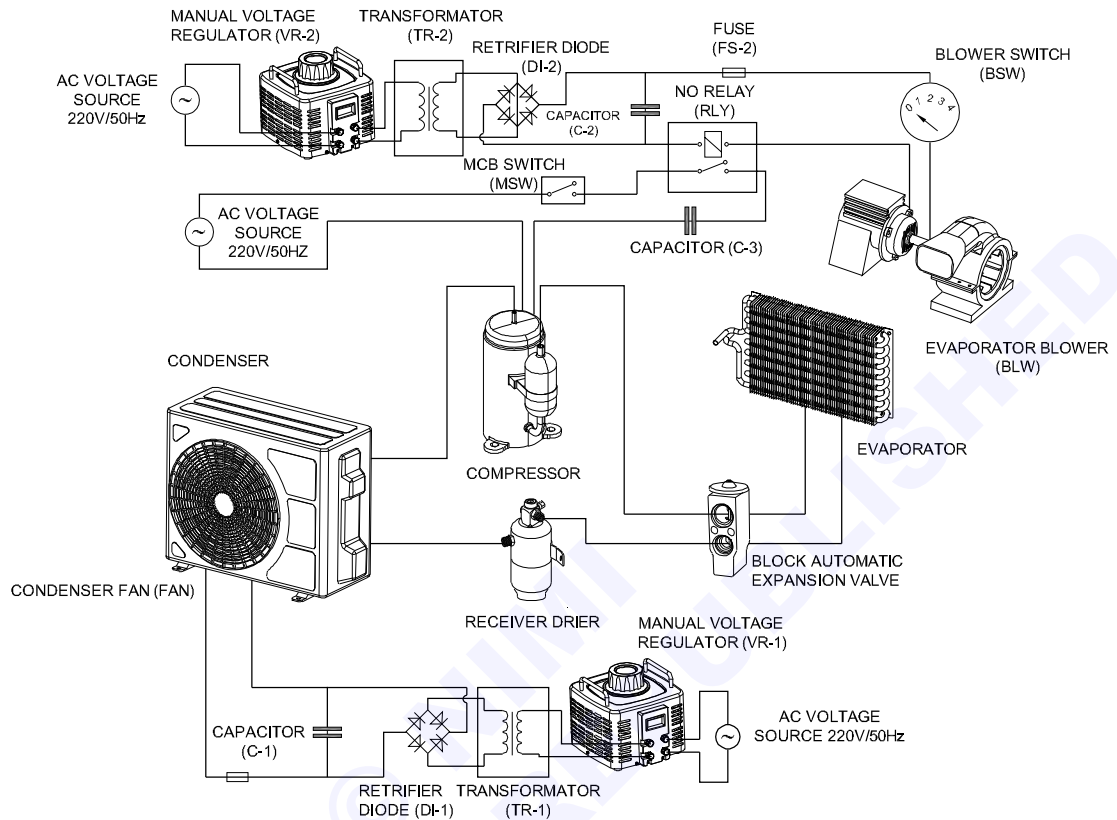
9 Identify the pressure switch (8).

10 Identify the condenser (9).

11 Identify blower fan (10).

- 12 Identify the high pressure pipe in gaseous state (A).
- 13 Identify the high pressure pipe connection in liquid state (B).
- 14 Identify the low pressure pipe connections (7) in liquid state (C).
- 15 Identify the low pressure pipe in gaseous state (D).
- 16 Identify the low pressure pipe in gaseous state (D).
- 17 Identify the manual voltage regulator fuse, MCB Rly etc. (Fig 2)

Fig 2



EV20N2125H2

Practice to check the performance of car AC system

Objectives: At the end of this exercise you shall be able to

- check the car AC heating system
- check the compressor rotation
- check the refrigerant recovery-evacuating charging of AC system.

Requirement			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Refrigerant	- as reqd.
• High pressure gauge	- 1 No.	• Cotton waste	- as reqd.
• Low pressure gauge	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries		• Pipe line seal	- as reqd.
• Electric car	- 1 No.	• AC pipe line	- as reqd.
• Recovery vacuum pump	- 1 No.	• Expansion valve	- as reqd.
• Recovery tank	- 1 No.		
• Manifold gauges	- 1 No.		

PROCEDURE

TASK 1: Checking the AC heating system

- 1 Check the battery condition.
- 2 Check the fuse connection.
- 3 Check the heater relay switch and wire connections.
- 4 Check the hot air circulation coil and blower rotation.
- 5 Check the blower motor mounting and wire connection.
- 6 Check the blower switch.
- 7 Check the heater coil and thermometer.
- 8 Malfunction of this heating system should be checked according to this diagram.



Cause for blower motor does not turn on

- 9 Broken wiring between battery positive terminals and blower unit.
- 10 Broken wire harmless.
- 11 Broken ignition switch circuit.
- 12 Broken heater relay circuit.
- 13 Loose or disconnected connectors
- 14 Blown out fuse.
- 15 Broken thermo switch circuit.
- 16 Broken heat mode switch circuit.
- 17 Broken blower resistor.
- 18 Broken power servo circuit.
- 19 Broken blower switch circuit.
- 20 Improper body grounding.
- 21 Defection blower resistor.

TASK 2 : Check the compressor rotation test

- 1 Check the compressor mountings.
- 2 Check the compressor driver belt tension and condition.
- 3 Check the magnetic clutch operation.
- 4 Check the compressor oil level and vacuum creation in compressor.
- 5 Start the engine and check the compressor rotation.
- 6 Check the noise from the compressor during compressor operating if found any noise rectify it.
- 7 Check the compressor inlet and outlet hose connections.

- 8 Check the compressor maximum refrigerant pressure at 100°C.
- 9 Check the compressor's rotation in idle and high speed of the engine.

- 10 Run the vehicle at 1500 RPM and record the cooling rate.

TASK 3 : Check the air gab

Clutch hub removal

- 1 Remove magnetic clutch retaining ring or nut.
- 2 Attach the tool to the end plate by threading the outer nut of the tool into the center hole of the clutch end plate.
- 3 Tighten the inner tool arbor against the end of the compressor shaft to increase the life of plate.

Tech Tip: Proper air gab between the clutch pulley and hub armature is critical to compressor overall performance failure to maintain the proper spacing as indicated in the service manual. Specification can lead to problems such as clutch burning or slippage.

Clutch hub installation

- 1 Position the shaft key in place.
- 2 Slide the clutch hub on the shaft of the compressor be careful not to damage the components by using excess force.
- 3 Thread the inner part of the tool into the shaft. Tighten the outer nut of the tool to push the shaft key.
- 4 Set the air by use of feeler gauge. Add or remove shims to obtain the manufacture's specification Always set at the minimum number and measure at multiple points around the circumference.
- 5 Reinstall the retaining or nut.
- 6 Check oil level and rotate the hub with the hose of the compressor down to help lubricate check the case of the compressor rotation.

TASK 4: Drain refrigerant in A/C system

- 1 Place the vehicle in parking area and neutral the gear with emergency brake set.
- 2 Raise the hood and disconnect the negative battery cable.
- 3 Place the recovery/recycle machine and plug it into a socket with machine in off condition.
- 4 Hang a manifold gauges from the hood in plain view. (Fig 1)

- 5 Connect the high pressure side hose of manifold gauges (normally blue in colour) to the low side on your A/C.
- 6 Connect the low pressure side hose of manifold gauge (normally red in colour) to the low side on your A/C line.

While connecting the hoses you must unscrew a small dust cap from the low/high side nozzle and push hoses on to the quick - release nozzle. (Fig 1)

Refer to your owner's manual for the proper location of your low/high side nozzle fitting if you cannot find it. The cap has an "L"/ "H" stamped on it, which stands for low side/high side.

- 7 Connect the centre hose of manifold gauge (normally in colour) to the proper fitting of machine. (as described by machine manufacturer). (Fig 1)
- 8 Turn on the recovery/recycling machine. (Fig 2)
- 9 Switch on the compressor on the recovery recycling machine.
- 10 Operate the compressor until the vacuum as indicated on the gauge of recovery/recycling machine.
- 11 Compressor may shut off it have automatic shut off feature otherwise switch off compressor manually.

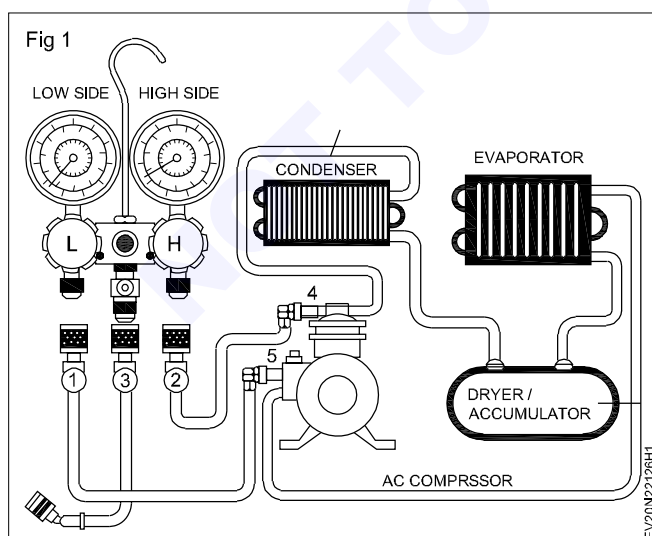
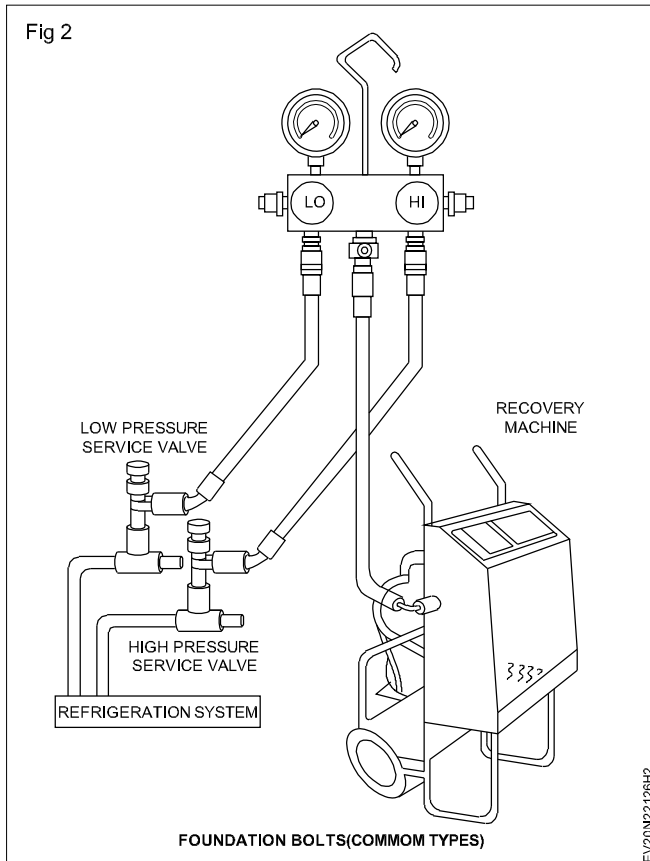


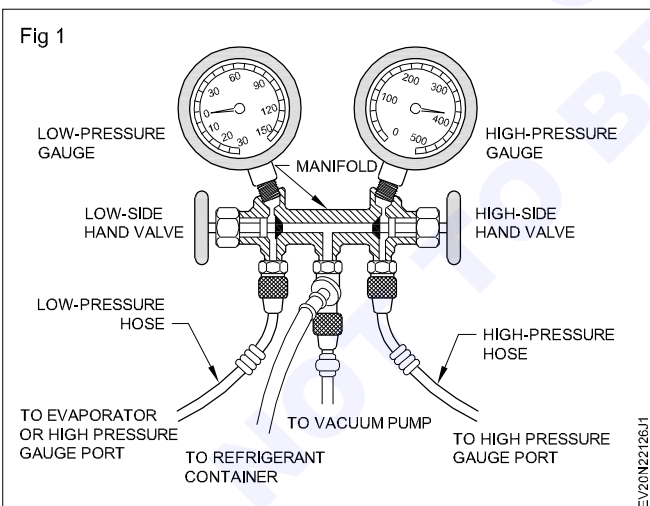
Fig 2



- 12 Observe the gauges on the machine for minimum of 5 min.
 - a If the vacuum rises but remains changes at 0 psi or below, the system is leaking, repair it after recovery process.
 - b If the vacuum reading changes to a pressure above 0 psi, the refrigerant was not completely removed from the system, then repeat steps above from 5 to 10.
 - c If the vacuum holds steady for a minimum 2 minutes, then the recovery is good.
- 13 Close all the manifold gauge hand valves, service hose valves and recovery system inlet valve.
- 14 Disconnect all the manifold gauge and cap all fittings.

TASK 5 : Evacuate refrigerant in A/C system

- 1 When the refrigerant in the system is discharged or recovered the system needs to be evacuated. Connect the vacuum pump to the system as shown in Fig 1.



- 2 Recommended refrigerant oil is to be added before evacuating the system (use mineral oil for R-12 and PAG oil for R-134 a system).
- 3 The oil circulates with the refrigerant through the system.
- 4 During discharge and recovery the refrigerant oil is trapped into oil separator during discharging.
- 5 Drain this oil into a measuring cup and add same amount of oil during evacuating.
- 6 Switch ON the vacuum pump. The vacuum pump pumps out air and creates vacuum thereby allowing moisture in the system to boil and vaporize.
- 7 Continued pumping action will remove moisture laden vapor.
- 8 The pump may also be attached to the manifold high pressure side fitting.
- 9 Close the centre hose fitting to which refrigerator container is attached.
- 10 Switch ON the vacuum pump and follow the instructions given in service manual.
- 11 After the pump has run for about 10 minutes make a quick check for leakage.
- 12 Then close both manifold valves (low and high side) Check the vacuum in the gauges it should not drop more than 2 psi in 5 minutes.
- 13 If no leak is detected continue the vacuum pump operation until the entire refrigerant in the system is completely evacuated and the vacuum gauge reads a vacuum of 30" of mercury.
- 14 Evacuate the system for about 20 minutes after the maximum vacuum is reached. Close the valves and switch off the pump.

- 15 The system is now ready for charging the refrigerant. The unit tank must contain a sufficient amount of R-134a refrigerant for charging. Check the amount of refrigerant in the tank. If there is less than 3.6 kg (8 pounds) of refrigerant, add new refrigerant to the tank. Refer to the manufacturer's instructions for adding refrigerant.
- 16 Verify that the high-side and the low-side hoses are connected to the A/C system. Open both the high-side and the low-side valves on the unit's control panel.
- 17 Open both the gas and the liquid valves on the tank.

Refer to the manufacturer's instructions for the charging station in use. It is necessary to evacuate the system before recharging it with new or recycled refrigerant.

- 18 Start the vacuum pump and begin the evacuation process. Non-condensable gases (mostly air) are vented from the tank automatically during the recycling process. You may hear the pressure being released.
- 19 Check for leaks in the system. Refer to the manufacturer's instructions for the charging station in use.

Change the vacuum pump oil frequently. Refer to the manufacturer's instructions for the charging station in use.

Once the system is evacuated, the system is ready for charging the refrigerant. Before charging pour recommended quantity of refrigerant oil through the suction port (refer service manual for quantity).

TASK 6: Charge the system with refrigerant

The system can be charged in many ways.

- Using portable service/charging station.
- Using manifold gauge set and a charging cylinder.

Using charging station

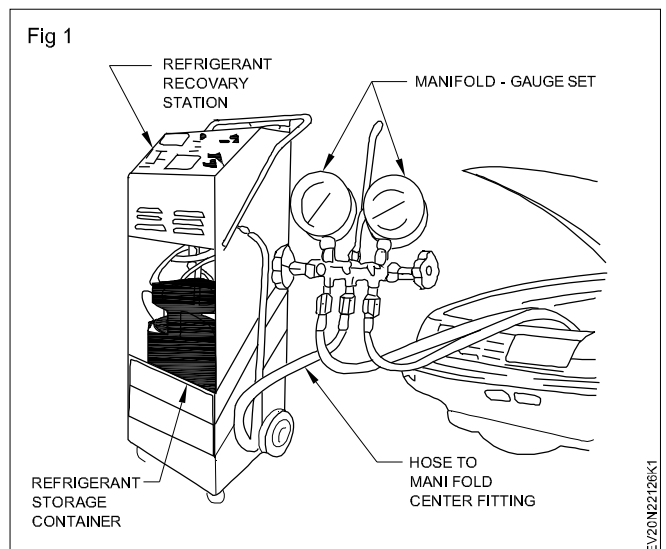
- 1 Connect the charging station vacuum pump to the middle service valve off the manifold gauge and switch on the pump.
- 2 The refrigerant from the cylinder will flow through the pump and into the compressor suction through the low pressure service valve in the manifold gauge set.
- 3 Before charging weigh the cylinder and switch OFF the charging station once the required quantity of refrigerant is charged. (refer service manual for proper quantity of refrigerant to be added).
- 4 Some charging station switch off automatically once the required amount of discharges done from the charging system.

Using manifold gauge set

- 1 Connect the charging cylinder with the manifold gauge as shown in Fig 1.
- 2 Open the valve from the charging cylinder and allow refrigerant to flow through the low pressure side of manifold gauge set.
- 3 The pressure gauge will show the rise in pressure once the refrigerant flows into the system.
- 4 The charging cylinder should be weighed before and after charging so that the net change in weight is equal to the quantity of refrigerant to be added.

- 5 Once charging is over close all the service valves with caps and disconnect the charging cylinder. The system is now charged with required quantity of refrigerant.
- 6 Start the vehicle and switch ON the A/C with blower speed minimum.
- 7 Note down the temperature readings after about 10 minutes time.
- 8 Ensure that there is sufficient cooling in the cabin and that all the components are working properly.
- 9 Take suitable correction action if there is any leak or malfunctioning.
- 10 Check the compressor running and battery voltage check the watch glass of receiver and drier for proper refrigerant flow.

Fig 1



A/C system oil charge replenishing

Any oil removed from the A/C system during the recovery process must be replenished at this time.

- 1 Use the correct graduated bottle of PAG oil for the R- 134a system.

Keep the oil bottles tightly capped at all times to protect the oil from moisture and contamination. You must have an accrued A/C vacuum for this operation. Never open the oil injection valve while there is positive pressure in the A/C system. This will result in oil blow back through the bottle vent. Never let the oil level drop below the pickup tube while charging or replenishing the system, as this will allow air into the A/C system.

- 2 Refer to the manufactures instructions for the charging station in use. Add the proper amount of PAG (polyalkylene glycol) oil to the system.
- 3 Close the valve when the required oil charge has been pulled into the system.

Charging

Evacuate the A/C system before charging

- 1 Close the low side valve on the control panel.
- 2 Open the high-side valve on the control panel.
- 3 Refer to the manufacturer's instruction for the charging station in use.
- 4 Enter the amount of refrigerant needed to charge the A/C, making sure to use the correct system of measurement, i.e kilogram (kg) or pound (lb).
- 5 Begin the charging process.

Practice to check car AC system and its components function

Objectives: At the end of this exercise you shall be able to

- check the charge state of refrigerant
- check car AC system and their components function.

Requirement			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Car AC manual	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries		• Refrigerant	- as reqd.
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1: Checking the charge state of refrigerant

- 1 Park the electric vehicle on the shop floor.
- 2 Locate the car AC components and electric power supply to compressor and condenser cooling fan.
- 3 Switch on the battery power to compressor and operate the manual regulator for maximum power output.
- 4 Operate air conditioner at maximum cooling for few minute.
- 5 Check the amount of refrigerant in sight glass as shown in Fig 1.
- 6 Observe the sight glass on the receiver (Fig 1) if you feel refrigerant is insufficient fill it as per specified limit by using portable charging station (gauge and charging cylinder) (Refer Ex. 2.2.126 TASK 6).
- 7 Refer the table-01 to rectify the refrigerator faults in car a/c systems

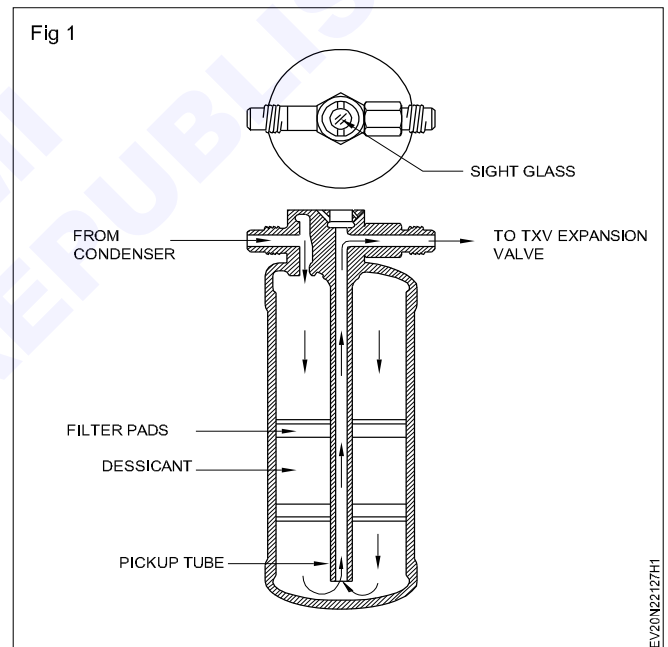


Table-1

Item	Symptom	Amount of refrigerant	Remedy
1	Bubbles present in sight glass	Insufficient	Check for leak with gas leak test Refer to items 3 and 4 evacuate and charge system. Then check for leak with gas leak tester. Refer to items 5 and 6
2	No bubbles present in sight glass	None, sufficient or too much	
3	No temperature difference between compressor inlet and outlet	Empty or nearly empty	
4	Temperature between compressor inlet & outlet is noticeably different.	Proper or too much	Discharge the excess refrigerant to specified amount.
5	Immediately after the air conditioner is turned off, refrigerant in sight glass stays clear.	Too much	
6	When the air conditioner is turned off, refrigerant foams and then stays clear.	Proper	

TASK 2 : Check the function of car AC components

Performance test on A/C unit

1 Install manifold gauge set

- a Close high pressure and low pressure valves.
- b Connect the high pressure hose to the discharge service valve of the compressor.
- c Connect the low pressure hose to the suction service valve of the compressor.
- d Run the engine and operate the car AC.
- e Set the blower switch at high speed in AC switch on temperature control at cool and air flow control at vent.
- f Keep all window glasses open.
- g Position the thermometer bulb in cool air outlet (supply grill outlet).
- h Place psychomotor close to the inlet of the cooling unit (place the psychomotor near the cool air outlet).

2 Wait until A/C system stabilizes (for about 20 to 30 minutes)

- a Check that the reading on high pressure gauge is 14.0 to 15.5 kg/cm² (200 to 230 PSI). If the reading is too high pour water on the condenser. If reading too low cover the front of the condenser.

- b Check that the reading on the dry bulb thermometer at the air inlet is 25-35°C (77-95°F).

3 Check the performance of the air conditioning system

- a Compare the dry bulb and wet bulb temperature with psychomotor chart and dry bulb readings of the psychomotor at the air inlet.

After measuring the temperature of the wet and dry bulb thermometer at the evaporator air inlet relative humidity percentage can be obtained Ex;- supporting dry and wet bulb temperature at the evaporator air inlets are 25°C (77°F) and 19.5°C (67°F) respectively. The point of intersection of the dotted lines in the graphic is 60%.

- b Measure the dry bulb temperature at cool air outlet and calculate the difference between inlet dry bulb and outlet bulb temperature.
- c Check the intersection of the relative humidity and temperature difference between two hatched lines.

- 4 If you found any defects in performance test, rectify the fault and retest the car AC performance as above steps 1-3.

Practice to check the electric-compressor defects

Objectives: At the end of this exercise you shall be able to

- check the e-compressor defects
- check the cause for car AC 'no cooling'.

Requirement			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Car AC manual	- 1 No.	• Soap oil	- as reqd.
• Car AC test kit	- 1 No.	• Magnetic clutch	- as reqd.
Equipment/Machineries		• Condenser	- as reqd.
• Electric vehicle	- 1 No.	• Blower	- as reqd.

PROCEDURE

TASK 1: Check abnormal noise from e-compressor

- 1 Switch on the battery power for car AC.
- 2 Check the e-compressor mountings for noise.(Fig 1)
- 3 Check the compressor for noise.
- 4 Check the compressor rotor bearing for noise.
- 5 Check the metallic sound from compressor Check oil level in compressor.

Check abnormal noise from magnetic clutch

- 1 Check the magnetic clutch plate.
- 2 Check the magnetic clutch bearing.
- 3 Check the magnetic clutch mountings
- 4 Check the magnetic coil power supply.
- 5 Check the puller.
- 6 Check the air gap between coil and pulley.
- 7 Check abnormal noise from condenser.

Check abnormal noise from condenser

- 1 Check the condenser fins for blockage or damage for noise.
- 2 Check the condenser mounting or lose fittings for noise.
- 3 Check the hose connection vibration and noise.
- 4 Check for bend/broken blades of fan.

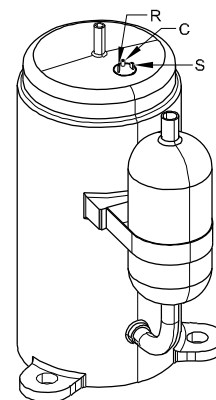
Check the abnormal noise from evaporator

- 1 Check the fins for damage and noise.
- 2 Check the mountings for lose fitting.
- 3 Check the hose vibration noise.
- 4 Check for tight fittings of blower coil unit.
- 5 Check for bend/loose end blower wheel from the shaft.

Check the abnormal noise from blower

- 1 Check the blower mountings.
- 2 Check the blower blade touch with body.
- 3 Check the blower (drive) motor mountings.

Fig 1



E - COMPRESSOR

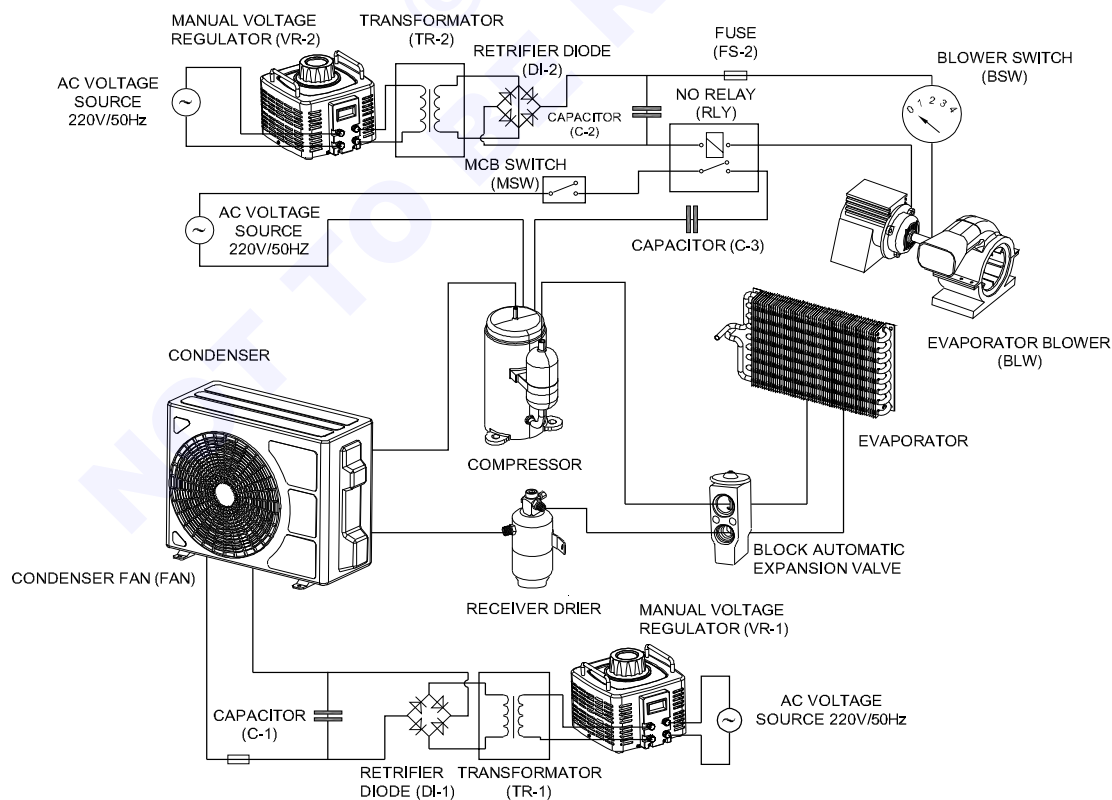
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TASK 2: Check the cause for car AC 'No Cooling' (Fig 1)

Trouble shooting in car in air conditioning system

S. No	Trouble	Causes for trouble	Remedies
1	No cooling	<ul style="list-style-type: none"> - Air ducts clogged - Compressor drive belt loose fitting. - Low refrigerant level in compressor - Defective condenser - Condenser fins damaged. - Air filter clogged. 	<ul style="list-style-type: none"> - clean the air dust - Tighten the belt - Charge refrigerant - Replace - Clean it - Replace it
2	No warm air	<ul style="list-style-type: none"> - Defective blower - Heater coil burnt - No power supply to heater coil - Blower resistor defective 	<ul style="list-style-type: none"> - Replace - Replace - Check wire connections - Replace
3	Cool air comes out only intermittently	<ul style="list-style-type: none"> - Slipping blower drive - Loose electrical connections to motor - Dust accumulated air filter 	<ul style="list-style-type: none"> - Check the motor shaft - Check for loose wiring - Clean the air filter
4	Insufficient cooling	<ul style="list-style-type: none"> - Compressor drive belt slip - Blower motor not work - Window glass open - Low refrigerant level in compressor 	<ul style="list-style-type: none"> - Replace/tighten the belt - Repair - Close the window glass - Charge refrigerant

Fig 1



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Practice on EV car AC trouble shooting

Objectives: At the end of this exercise you shall be able to

- trouble shooting in intermittent cooling, abnormal noise from compressor
- trouble shooting in magnetic clutch, condenser, evaporator and blower
- trouble shooting in presence gauge pressure low and high.

Requirement			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
Equipment/Machineries		• Soap oil	- as reqd.
• Electric vehicle	- 1 No.	• Refrigerant	- as reqd.
• Car AC portable charging station	- 1 No.	• Pipe seating ring	- as reqd.

PROCEDURE

Checking of refrigeration system with manifold high / low pressure gauge

Read the manifold gauge pressure with the following established conditions.

- Temperature at the air inlet 30-35°C (86-95°F).
- Engine running at 2000 rpm.
- Blower speed set at high.
- Temperature control lever set at cool.

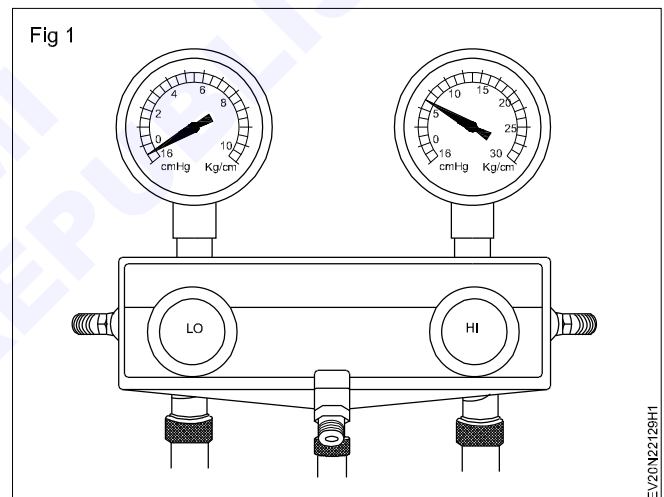
Note: It should be noted that the gauge indications may very slightly due to ambient temperature conditions.

1 Normally functions refrigeration system (Fig 1)

Low pressure side: 1.5-2.0 kg/cm² (21-28 psi, 147-196 KPa).

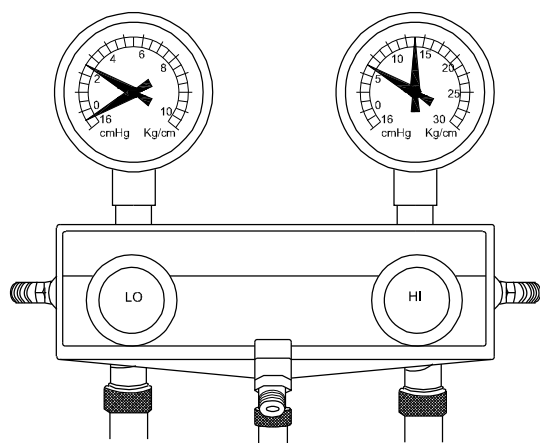
High pressure side: 14.5-15.0 kg/cm² (206-213 psi, 1422-1471 KPa).

2 Moisture functions refrigeration system (Fig 2)



Symptom seen in refrigeration system	Probable cause	Diagnosis	Remedy
During operation, pressure on low, pressure side sometimes becomes a vacuum and sometimes normal.	Moisture entered in refrigeration system freeze at expansion valve orifice and stops cycle, but normal state is restored after a time when the ice melts.	Drier in oversaturated state. Moisture in refrigeration system freezes at expansion valve orifice and blocks circulations of refrigerant.	1. Replace receiver & drier. 2. Remove moisture in cycle through repeated vacuum purging method. 3. Charge new refrigerant to proper amount.

Fig 2



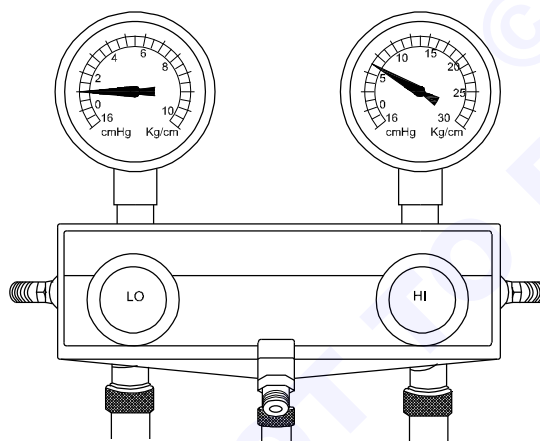
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3 Insufficient refrigerant (Fig 3)

Condition, periodically cools and then fills to cool

Symptom seen in refrigeration system	Probable cause	Diagnosis	Remedy
Pressure low on both low and high pressure sides.	Gas leakage at some place in refrigeration system.	Insufficient refrigeration in system.	Check with leak detector repair.
Bubbles seen in sight glass insufficient cooling performance.	Refrigeration system.	Refrigerant leaking.	Charge refrigerant to proper amount.

Fig 3



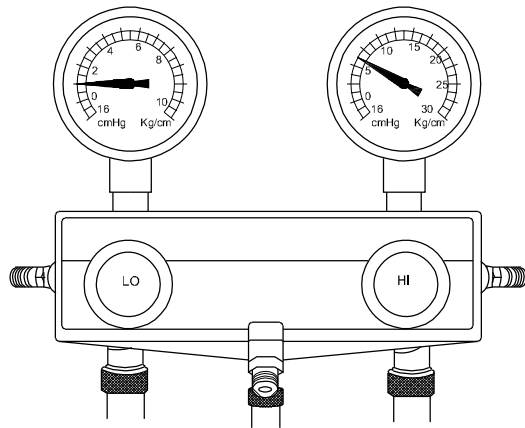
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4 Poor circulation of refrigerant (Fig 4)

Condition: Insufficient cooling

Symptom seen in refrigeration system	Probable cause	Diagnosis	Remedy
Pressure low on both low and high pressure sides.	Refrigerant flow obstructed by dirt in receiver.	Receiver clogged	Replace receiver
Frost on tubes from receiver to unit.			

Fig 4

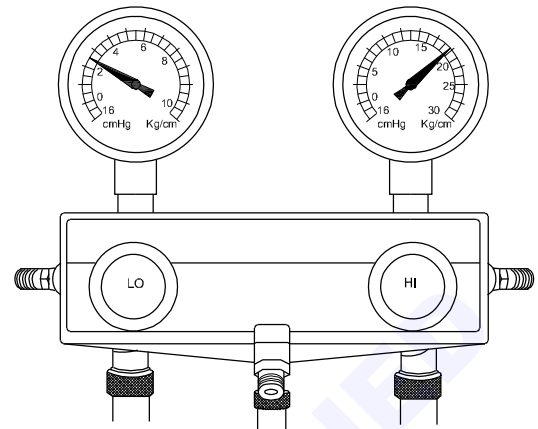


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5 Refrigerant overcharge or insufficient cooling of condenser (Fig 5)

Condition: Does not cool sufficiently

Fig 5



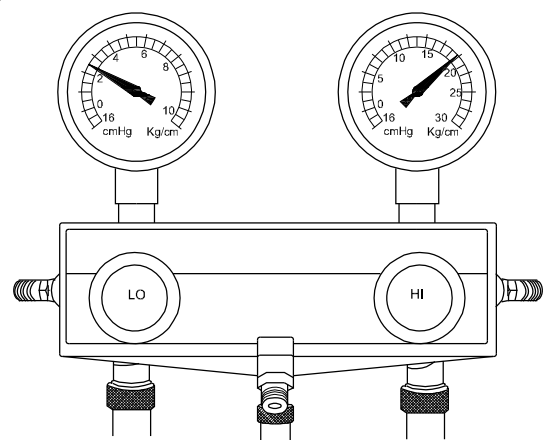
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Symptom seen in system	Probable cause	Diagnosis	Remedy
Pressure too high on both low and high pressure sides.	Unable to develop sufficient performance due to excessive refrigerant in system condenser cooling insufficient.	Excessive refrigerant in cycle refrigerant overcharged Condenser cooling in sufficient condenser fins clogged or fan motor faulty.	<ol style="list-style-type: none"> 1. Clean condenser 2. Check fan motor operation 3. If (1) and (2) are in normal state check amount of refrigerant. <p>Note. Vent out refrigerant through gauge manifold low pressure side by gradually opening.</p>

6 Expansion valve improperly mounted/Heat sensing tube defective (opens too wide) (Fig 6)

Condition: Insufficient cooling

Fig 6



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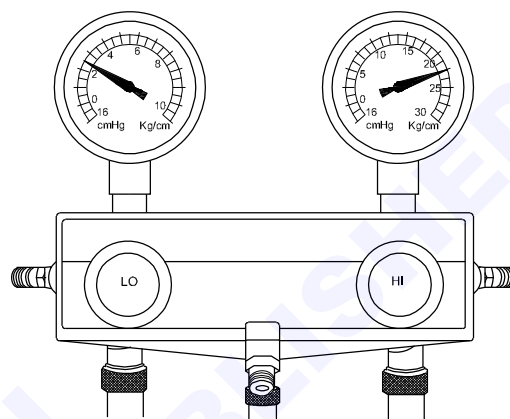
Symptom seen in refrigeration system	Probable cause	Diagnosis	Remedy
Pressure too high or both low and high pressure sides.	Trouble in expansion valve or heat sensing tube not installed correctly. Refrigerant flow out of adjustment.	Excessive refrigerant in low pressure piping. Expansion valve opened too wide.	1. Check heat sensing tube installed condition. 2. If (1) is normal, test expansion valve is unit form. Replace if defective

7 Air present in refrigeration system (Fig 7)

Condition: Does not cool down sufficiently

Note: These gauge indications are shown when the refrigeration system has been opened and the refrigerant charged without vacuum purging.

Fig 7



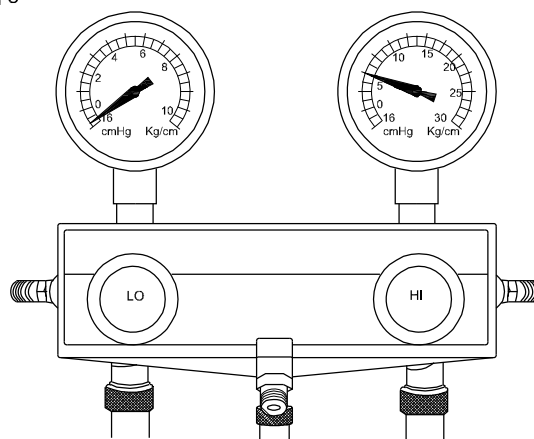
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Symptom seen in refrigeration system	Probable cause	Diagnosis	Remedy
Pressure too high on both low and high pressure sides.	Air entered in refrigeration system	Air present refrigeration system. Insufficient vacuum purging.	1. Replace receiver & drier 2. Check compressor oil to see if dirty or insufficient. 3. Vacuum purge and charge new refrigerant.

8 Refrigerant does not circulate: (Fig 8)

Condition: Does not cool (Cools from to time in some cases)

Fig 8



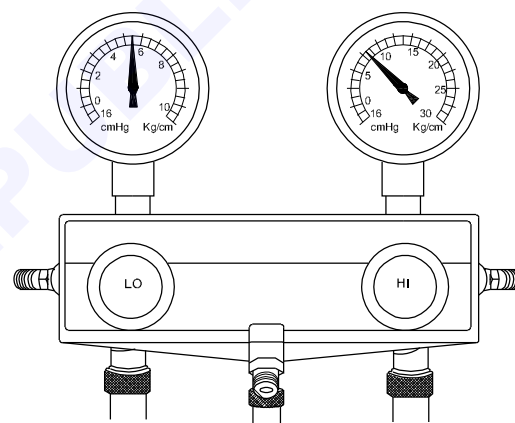
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Symptom seen in refrigeration system	Probable cause	Diagnosis	Remedy
Vacuum indicated on low pressure side, very low pressure indicated on high pressure side. Frost or dew seen on piping before and after receiver and drier or expansion valve.	Refrigerant flow obstructed by moisture or dirt in refrigerant freezing or adhering to expansion valve orifice Refrigerant flow obstructed by gas, leakage from expansion valve heat sensing tube.	Expansion valve orifice clogged Refrigerant does not flow.	Allow to stand for some time and then restart operation to determine if trouble is caused by moisture or dirt. If caused by moisture refer to procedure step 2. If caused by dirt, remove expansion valve and clean off dirt by blowing with air. If unable to remove dirt, replace valve. Vacuum purge and charge new refrigerant to proper amount. For gas leakage from heat sensing tube. Replace expansion valve.

9 Defective compression compressor: (Fig 9)

Condition: Does not cool

Fig 9



Symptom seen in refrigeration system	Probable cause	Diagnosis	Remedy
Pressure too high or low pressure side. Pressure too low at high pressure side.	Internal leak in compressor.	Compression defective Valve leaking or broken. Sliding parts (piston, cylinder, gasket, connecting rod, etc.,)	Replace compressor

Diagnosis test for high pressure and low pressure with pressure gauge.

Normal operating pressure ranges of car AC using HFC-134 a at an ambient conditions of 32°C to 35°C are

- a Low pressure side: 1-3 kg/cm²
- b High pressure side 12-22 kg/cm²

- 1 Clamp the gauge manifold of testing station to observe pressure conditions of car AC system.
- 2 Connect low side and high side hoses to service ports of car AC system.

- 3 Start the car and switch on AC, accelerate the engine shaft (Gear in Neutral) the RPM of the engine/compressor shaft should be around 2600 for about 15 to 20 minutes.
- 4 If the high side of car AC system is higher than normal, check for:-
 - A Dirty condenser
→ Clean the condenser
 - B Air in the system condenser
→ Recover and recharge the refrigerant

- C Excess refrigerant charge.
→ Purge out and reduce the refrigerant and check for normal cabinet temperature conditions.
- 5 If high side of car AC system is lower than normal, check for
- A Leakage of refrigerant
→ use soap solution to detect the leakage points of all fitting joints. If any leakage point is observed with soap bubbles, tighten the flare-fitting joint. If there is no leakage.
- B Check for under charge of refrigerant in such case, the low pressure side gauge reads lower than normal.
→ Refrigerant may be charged if the system does not have leakage.
→ If there is leakage of refrigerant, arrest the leak, and reprocess the refrigerant charging.
- 6 If the low side of car AC system is lower than normal, check for
- A Leakage points, arrest the leakage and reprocess the system for refrigerant charging.
- B If the compressor has poor pumping, check the performance of compressor. The symptom in car cabinet is either poor or no cooling effect.
- 7 If the low side of car AC system is higher than normal, check for
- A Over charge of refrigerant and the high side pressure also becomes higher than normal.

- B If compressor has poor pumping, check the performance of compressor.

E-compressor problems and remedies

- 1 Low refrigerant in the AC system - refill the refrigerant if you suspect there is leak when refilling the AC refrigerant arrest the car AC refrigerant leakage and then fill the refrigerant as specified limit.
- 2 Faulty car AC pressure sensor switch - replace it.
- 3 Relay or fuse probe - replace the defective fuse or relay.
- 4 Compressor dead action - replace the compressor.
- 5 E compressor not get in power - recharge the battery.
- 6 Wire connection issue - check and rectify the wire fault ensure all wire connections are tight.

Note: Usually inspect the AC wiring going to and from the AC components (Fan, magnetic clutch, condenser fan, fuse relay, ECU/ECM and climate control sensor etc.

- 7 Compressor clutch is not engaging - replace the magnetic clutch.
- 8 Rusted clutch plate - replace the clutch plate.
- 9 After rectify the car AC faults ensure car AC is functioning as specified limit.

Practice on identify and checking the function of ABS components

Objectives: At the end of this exercise you shall be able to

- identify the components ABS brake system
- check the ABS warning lamp
- check the electronic brake distribution system.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- EV manual - 1 No.

Equipments/Machineries

- Electric vehicle - 1 No.

Materials

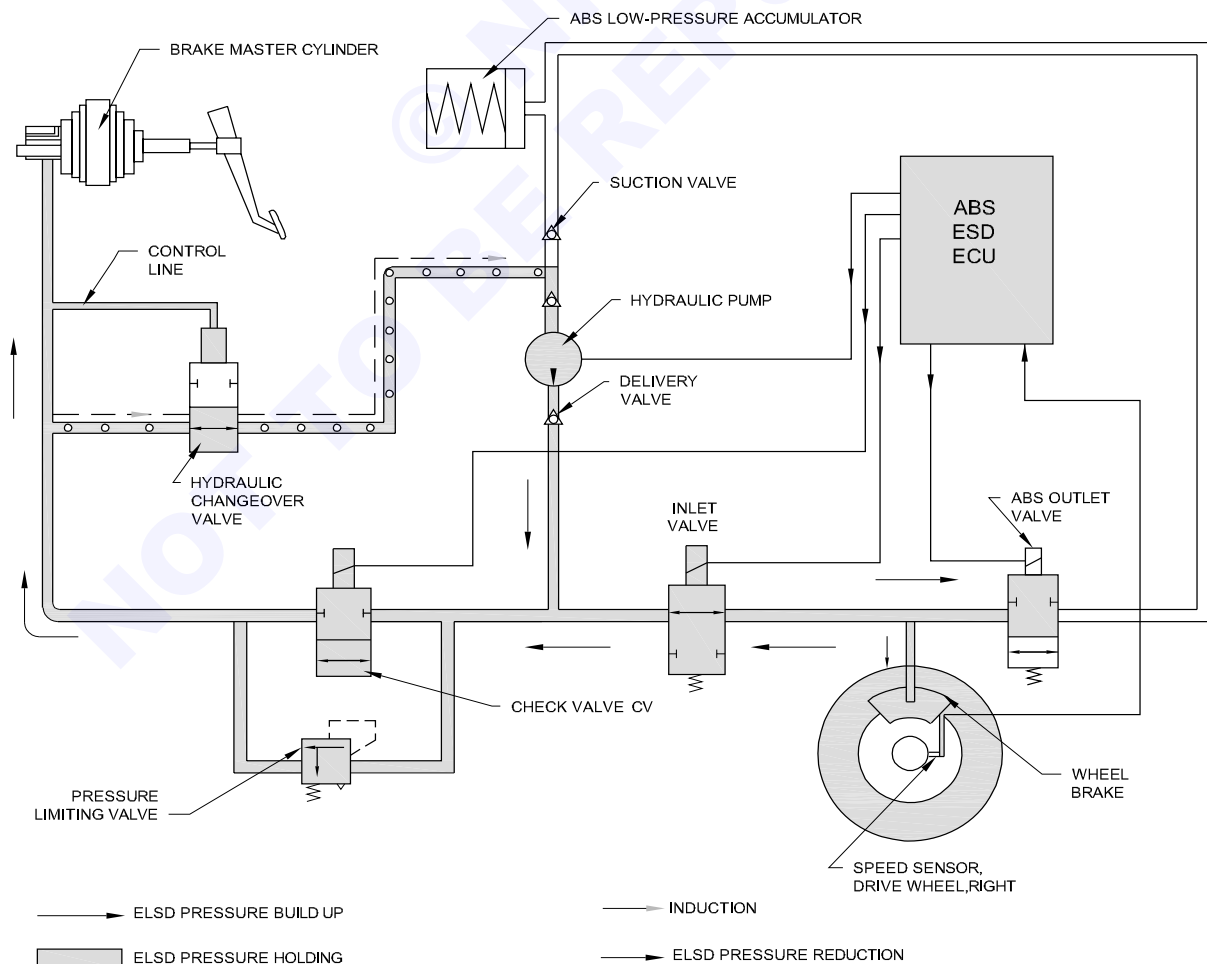
- Cotton waste - as reqd.
- Soap oil - as reqd.
- Hydraulic oil - as reqd.

PROCEDURE

TASK 1: Identify the components of ABS brake system of electric vehicle

- 1 Park the vehicle on the shop floor service ram with safety measures.
- 2 Study the vehicle manual and note the brake components used in ABS brake system.
- 3 Open the vehicle door and identify the brake pedal and their connection. (Fig 1)
- 4 Identify the master cylinder and trace the brake fluid line to all wheels. (Fig 1)

Fig 1



- 5 Identify the hydraulic change over valve. (Fig 1)
- 6 Identify the pressure limiting valve and check valve. (Fig 1)
- 7 Identify the location of inlet valve. (Fig 1)
- 8 Identify the delivery valve. (Fig 1)
- 9 Identify the hydraulic pump and suction valve. (Fig 1)
- 10 Identify the low pressure accumulator. (Fig 1)

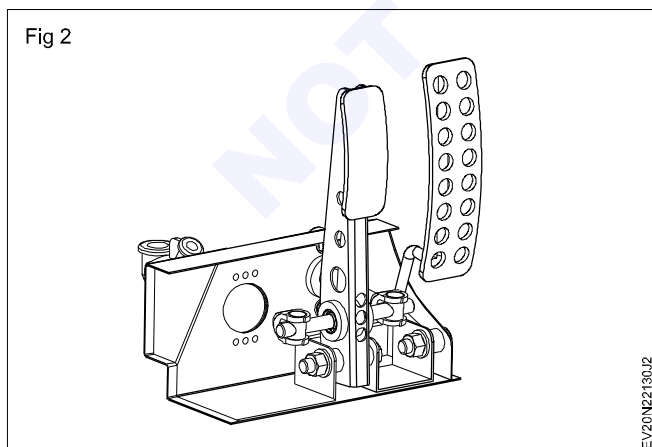
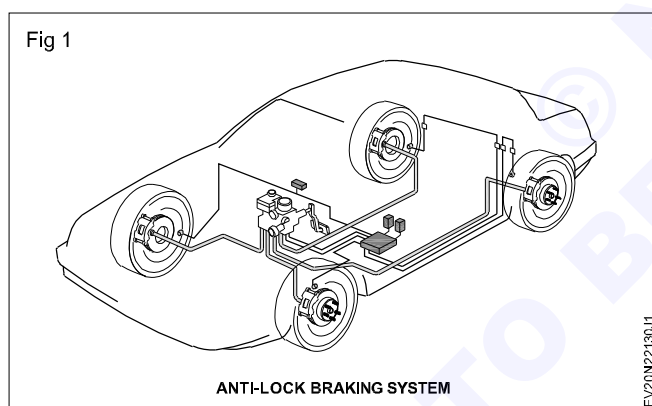
- 11 Identify the ECU ABS sensors and their wire connections. (Fig 1)
- 12 Identify the ABS outlet valve. (Fig 1)
- 13 Identify the wheel speed sensor and wheel brake compare it.
- 14 Identify the hand brake and ensure the proper spring action of hand lever of hand brake.

TASK 2: Check the ABS warning lamp

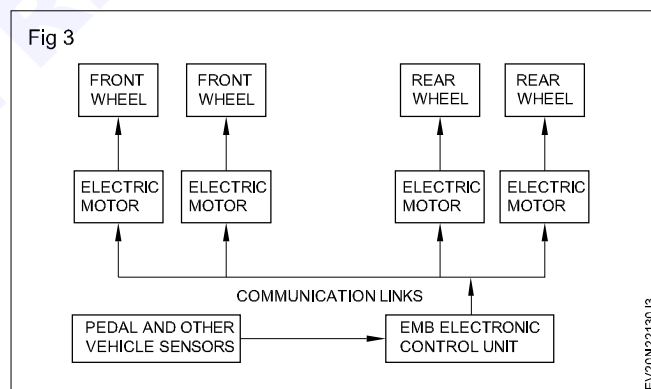
- 1 Study the electric vehicle manual for achieve the knowledge of ABS brake wiring circuit.
- 2 Inspect the fluid line fittings and their wire connections.
- 3 Inspect the brake light and their wire connections.
- 4 Switch ON the ignition power and apply foot brake.
- 5 Check the brake light for glowing when brake pedal is in engage position.
- 6 Disengage the brake pedal and check the brake light for light OFF.
- 7 If it is glowing continuously, check the brake light wire connections and brake light switch, if need replace the brake light switch or rectify the wire short circuited.
- 8 If you use the OBD scan tool for trace out a fault in brake line circuit components. Identify the fault then rectify it as per instructions given by the service manual.

TASK 3: Identification of electronic brake distribution system components (EBD)

- 1 Identify the vehicle brake pedal and their mechanical connections. (Fig 1) (Fig 2)
- 3 Identify the ECU and their wire connections with electric brake distribution system components.
- 4 Identify the wheel sensors.
- 5 Identify the brake fluid distribution unit. (Fig 3)

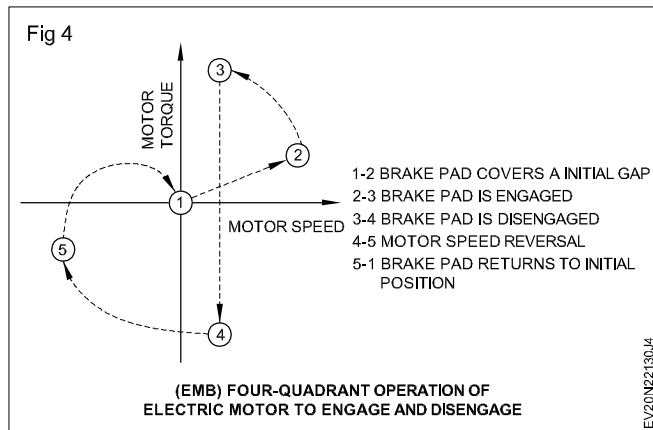


- 2 Identify the master cylinder and wheel cylinder or caliper unit.



- 6 Identify the brake pedal travel sensor .
- 7 Identify the electromechanical hydraulic actuator.
- 8 Check the brake performance by pressing the brake pedal just as for traditional hydraulic system.
- 9 Ensure the brake pedal travel sensor detects the pedal position and send the information to the control unit at the exact time the pedal returns the braking feel of a traditional hydraulic system.
- 10 Ensure the electronic control unit processes the signal it has received from the pedal sensor and it send the command to the actuators (Fig 4).

Electro mechanical brake system



- 11 Ensure the electromechanical hydraulic actuator converts the electrical impulse received from the control unit into the calipers hydraulic pressure/Clamping force to slow or stop the vehicle.

Note: The caliper unit is operated by the actuator and electro mechanical caliper managed directly by the control unit that converts the electrical energy and it receives into braking force to the disc wheel.

Practice to identify the battery charger type and voltage levels

Objectives: At the end of this exercise you shall be able to

- **identify the different type of EV battery charger and their voltage levels.**

Requirement			
Tools/Instruments		Material	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
• Battery charger manual	- 1 No each.		
Equipment/Machineries			
• Electric vehicle	- 1No.		
• Battery charger (different type)	- 1 No.		

PROCEDURE

TASK 1 : Identify the type of electric vehicle battery charger and their voltage levels (Fig 1)

Note: The instructor has to display the wall chart of different type of electric vehicle battery charger and display the different type of battery charger in shop floor. Ask the trainee to identify the EV battery charger type.

- 1 Inspect the different type of the battery charger layout in your section.
- 2 Study the chargers type and their capacity (AC,DC charger, trickle charger).
- 3 Identify the fast charging station (Lever 2).
- 4 Identify the slow charging station (Level 1).
- 5 Identify the rapid charger (Level 3).
- 6 Study the battery charger capacity.
- 7 Identify the level four charger.
- 8 Identify the slowest method of EV charging through 3 prong 220V plug.
- 9 Identify the faster way of AC charger 3-4 times faster using house hold and public charging.
- 10 Identify the fastest charging station with power of 50KW.
- 11 Identify charger type.
- 12 Identify and study the voltage output of each charger.
- 13 Identify the charger and their maximum output.

- 14 Identify the charging capacity of charger.
- 15 Identify the voltage rating of each charger slow speed charger voltage up to 18 V.
- 16 High speed charger voltage upto 43 V.
- 17 AC charger – 50V.
- 18 DC charger – 45V.
- 19 Identify and measure the current rating slow speed up to 32A, high speed upto 63 A AC charger upto 12.5 A, DC charger – 12.5A.

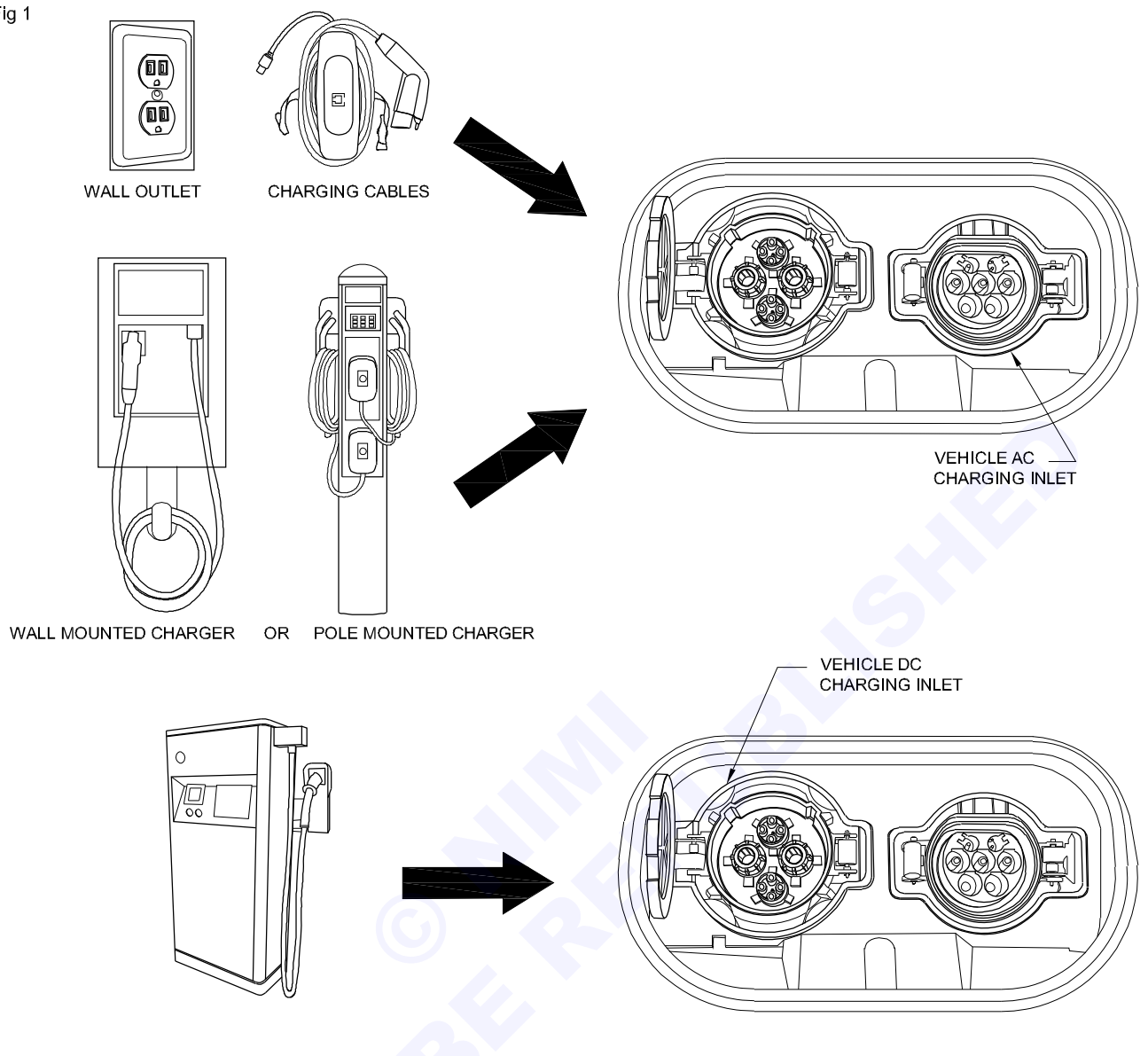
Note: The Indian market mostly has two types of EV chargers

- 1 AC charger
- 2 DC charger

Electrical output of charger levels compared level L1,L2,L3









- 1 Check the level-1 charger output is 1.3 KW to 2.4 KW AC current, charging hours – 24.
- 2 Check the level-2 chargers output is 3 KW to under 20KW AC current range of charging hours over night for full battery charging
- 3 Check the level 3 charger output is 50 KW to 350 KW DC current range of battery charge for full battery is an hour.

Fig 1



EV20N23131H1

Permanently wired off vehicle charger

		Max. Voltage (Volts)	Max. Current (Amps)	Power (kW)	Range Gain (miles/hr) ^a	Fueling Time (%Drive Time) ^b
AC Level I		120 ^c (1Φ)	16	1.9	5.5	1280%
AC Level II		240 ^c (1Φ)	80	19	55	130%
DC Level I		500 DC ^c	80	40	80 ^d	88%
DC Level II		500 DC	200	100	200 ^d	35%
Mode 1		250 (1Φ) or 480 (3Φ)	16	7.7	22	320%
Mode 2		250 (1Φ) or 480 (3Φ)	32	15	44	160%
Mode 3		500 (3Φ)	250	125	360 ^d	20%
Mode 4		600 DC	400	240	400 ^d	18%

Practice to operate the standard chargers and determine the battery pack charging time

Objectives: At the end of this exercise you shall be able to

- operate the various types of battery charger
- determine the battery charging time under various condition.

Requirement			
Tools/Instruments		Material	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
Equipment/Machineries		• Soap oil	- as reqd.
• Electric vehicle	- 1 No.		
• Battery charger (different types)	- 1 No each.		

PROCEDURE

TASK 1 : Operate the various types of EV battery charger

Note: The instructor has to demonstrate the EV battery charger cable connect and disconnect with battery pack.

- 1 Locate the different type battery charger provided in your shop floor (level 1, level 2, AC charger DC fast charger).
- 2 Select the different type of electric vehicle for battery pack charging.

Note: There are 3 standard charging levels used to charge electric cars. All electric cars can be charged with level 1 and level 2 stations. These types of chargers offer the same charging power as the ones you can install at home. Level 3 chargers-also called DCFC or fast charging stations-are much more powerful than level 1 and 2 stations, meaning you can charge an EV much faster with them. that being said, some vehicles cannot charge at level 3 chargers. Knowing your vehicle's capabilities is therefore very important.

- 3 Check the battery charger, case connectors, charging port, charging outlet plug.
- 4 Select the type of charger and connect the charger cable with vehicle charging port.

Note: EV battery charging comes down two main consideration where you decide to charge and how fast you decide to charge.

- 5 These are interconnected with the charging speed and EV battery capacity and which type of charging system is using with your vehicle battery charging.




- 6 Switch 'ON' the battery charger and ensure the vehicle battery pack start charge indication shown in battery charger light indication or digital display.
- 7 Note the battery charging start time and battery fully charged time.
- 8 Ensure the battery charging time taken by battery is as specified limit. If it is taken more time check the battery condition or plug and cable connectors pins.

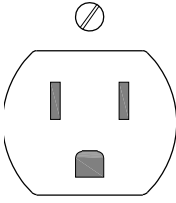
Note: Use the trickle charge method for EV by using a standard 220 V plug at your home. It is recommended in urgent cases only with caution and consultation with electricity providers.

- 9 Use the public charging wall box installed for 3 to 4 time faster.
- 10 Use the DC charger station for DC fast charging with power from 50KW and above with this method you can top up EV battery from 20% to 80% in approximately with is 40 minutes.
- 11 Use the ultra-fast charging station provide more than 150 KW DC power for charging of EV battery.
- 12 Refer the EV manual for a particular vehicle type of battery, recommended type of charging station charging outlet, type of charging plug, charging port, charger and electric vehicle supply equipment etc.
- 13 Level 1 charger takes full charge (standard wall outlet-120V).
- 14 Level 2 charger takes 8-10 hours for battery full charger (240V outlet dryer plug).
- 15 DC fast charging takes 20 to 30 minutes for charge upto 80% charge of battery.

TASK 2: Determine the battery charging time

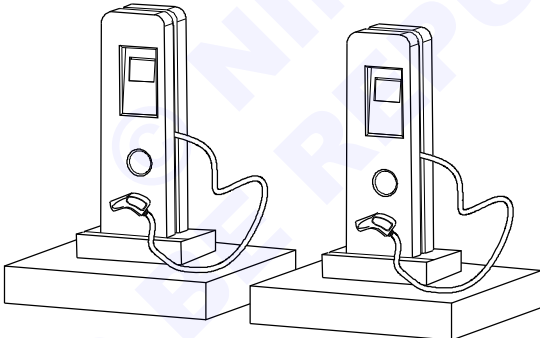
- 1 Select the EV battery charger as per recommended by the vehicle manufactures.
- 2 Connect the battery charger cable with vehicle battery charging port.
- 3 Note the total time taken for battery charging and compare it with specified time as shown in below table data.

Level	Charge Hub Markers	Power(kW)	Approximate Charging time (Empty Battery)
1		1	200km (124 miles): +/- 20 Hours 400 km (249 miles): +/- 43 hours
2		3 to 20, typically 6	200 km (124 miles): +/- 5 hours 400 km (249 miles): +/- 11 hours
3(DCFC)		Typically 50,	80% of 200km (124 miles): +/- 30 min 80% of occasionally 20 400 km (249 miles): +/- 1 hour



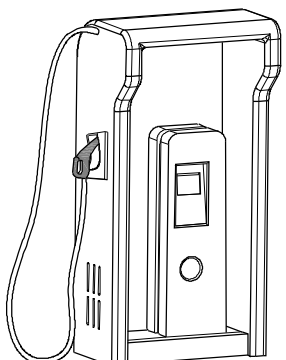
Level 1 Public chargers

Level 1 is the standard wall outlet of 120 volts. It is the slowest charge level and requires tens of hours to fully charge a 100% electric vehicle and several hours for a plug-in hybrid.



Level 2 Public chargers

Level 2 is the typical EV plug found in homes and garages. Most public charging stations are level 2. RV plugs (14-50) are also considered level 2 chargers.



Level 3 Public chargers

Level 3 Public chargers Lastly, some public stations are level 3 chargers, also known as DCFC or DC fast chargers. These charging stations are the quickest way to charge a vehicle. Note that not every EV can charge at level 3 chargers.

Practice to check the inputs for different types of chargers

Objectives: At the end of this exercise you shall be able to

- **check the requirement of charging inputs for different types of chargers.**

Requirement			
Tools/Instruments		Material	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
• Charger manual	- 1 No each.		
Equipment/Machineries			
• Electric vehicle	- 1 No.		
• Different types of battery charger	- 1 No.		

PROCEDURE

TASK 1 : Check the EV battery chargers input

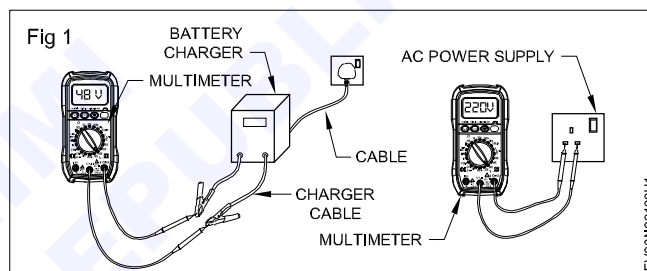
- 1 Locate the different types of battery charger and their power connections.
- 2 Study the battery chargers user guide.
- 3 Note the each type of battery charger power input and output voltage.
- 4 Select any one type of battery charger for test the input voltage of battery charger.
- 5 Plug the battery into a wall outlet.
- 6 Use the multimeter to measure the EV battery chargers charging input voltage and ampere rating.

Note: You can use the voltmeter and ampere meter (AC and DC) to measure the current

- 7 Prepare the multimeter to measure the input voltage of battery charger.
- 8 Attach the test probes of your multimeter to their corresponding ports.
- 9 Insert the end of black probe into the port on the multimeter labeled "COM". Then insert the red probe into the port labeled "V".
- 10 Set the multimeter to AC range of voltage as specified by the charger manufacturers.

Note: If you operating your multimeter on the wrong settings could over load it or even result in more serious damage such as an explosion.

- 11 Touch the black probe to the battery chargers negative contact point on the charger input point.(Fig 1)



- 12 Hold the red test probe against the chargers positive input contact point.

Note: If you accidentally mix up the test probes, the multimeter may display a negative reading. Switch the probe position in correct point.

- 13 Check the number displayed on the multimeters display screen. (Fig 1)

Note: If you are not sure exactly how much, consult to the battery chargers instruction booklet for the information, some where on the charger information plate itself.

- 14 As it is check the battery chargers output DC voltage after resetting the multimeter reading as per booklet information.
- 15 Same above said method and steps followed to check the other all types of battery charger input.

Note: If found any error in input AC voltage reading of battery charger check the main power supply AC voltage.

Practice to trouble shooting in EV battery charger

Objectives: At the end of this exercise you shall be able to

- **fault diagnose and rectify the fault of charger not responding**
- **rectify the fault of battery charger not delivering expected current.**

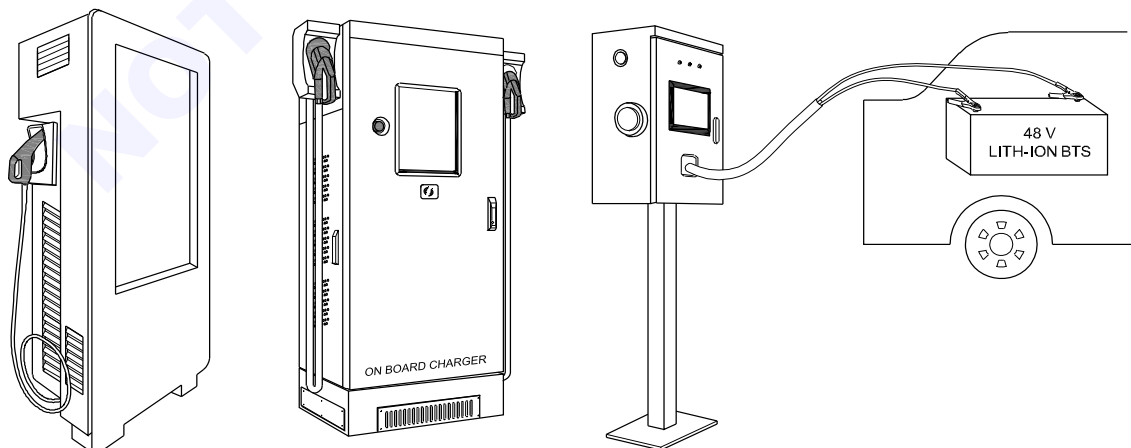
Requirement			
Tools/Instruments		Material	
• Trainee's tool kit	- 1 No.	• Cotton waste	- 1 No.
• Multimeter	- 1 No.	• Soap oil	- 1 No.
• Volt meter	- 1 No.		
Equipment/Machineries			
• Battery charger	- 1 No.		
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1 : Diagnose the cause and remedies of battery charger not responding

- 1 Select the any one type of EV battery charger.
- 2 Check the battery charger cable connection and ON/OFF switches.
- 3 Check the battery charger's input power cable plug pins.
- 4 Check the battery charger out put cable and the plug pins.
- 5 Check the battery chargers power supply switch and fuses.
- 6 Use the multimeter to check the continuity of any thing.
- 7 Check the power supply to the battery charger by using tester. If power is not available check the fuse and main supply switch.
- 8 Check the power supply cable and connector's if found any damage or defect, replace the damaged park.
- 9 Again check the power supply input of battery charger.
- 10 If power supply is correct as per specified power rating, then check the battery charger's out put DC voltage and ampere reading by using multimeter.
- 11 If found battery charger's power out is low or nil, check the battery charger's transformer or electric circuit components.
- 12 If found transformer weak or electronic board circuit components are damaged, replace it with suitable value components.
- 13 Check the battery charger output cable, socket, plug loose fitting etc., if found any type of defects rectify it by replacing/repair or tighten the cable and socket etc.,
- 14 Ensure the battery charger is functioning properly as per given technical data by the manufacturers. (Fig 1)

Fig 1



TASK 2 : Causes and remedies for battery charger not delivering expected current**Battery charger does not delivering expected current**

S.No	Causes	Remedies	Remarks
1	Low input current to charger	Provide proper power supply	
2	Excess heat of battery	Reduce EV battery temperature	
3	Failure of BMS	Rectify by the fault of BMS	
4	Other loads in use while battery charger	Remove battery loads while in battery Charging	
5	Battery deterioration	Replace the battery	
6	Excess current and voltage limit of battery	Use the proper power charger	
7	Fullness of battery	Disconnect the battery charger cable	
8	Reach maximum charging rate of battery	Disconnect the battery charger cable	
9	Bad environment	Provide recommended environment while Battery charging	
10	Large size of battery	Use the proper size and proper voltage Battery	
11	Low level of charger	Rectify the charger defects	
12	Cable loose connection	Tighten the cable connection	
13	Charger digital gauge defect	Replace the gauge	

After rectifying the above faults check the charge out put voltage for Proper functioning.

Practice on carry out drive by wire architecture

Objectives: At the end of this exercise you shall be able to
 • identify the EV wire architecture systems.

Requirement			
Tools/Instruments		Material	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1 : Identify the Electric vehicle drive by wire architecture Systems

Note: The instructor has to demonstrate to identify the EV drive by wire architecture systems through wall EV wall chart

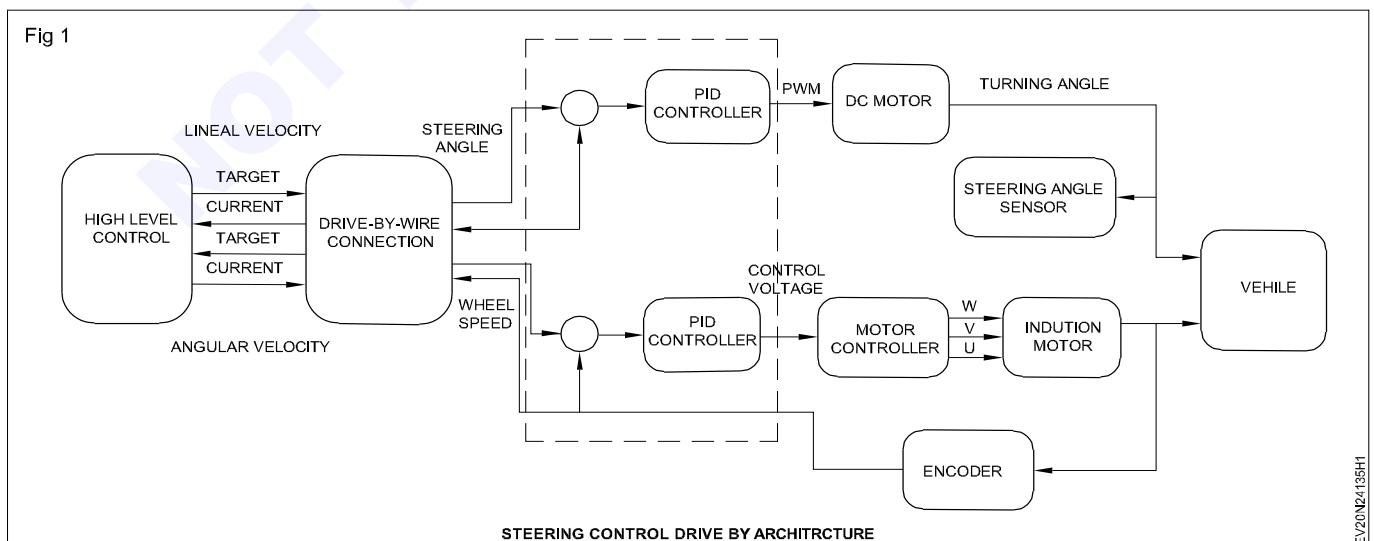
- 1 Park the Electric vehicle on the shop floor.
- 2 Study the electric vehicle manual for identify the drive by wire architecture.
- 3 Identify steering control drive by architectures. (Fig 1)
- 4 Identify ADAS interface PC, cameras, onboard control computer different drive commands high angle unit.
- 5 Identify the EV power drain components like main CPU, Front CPU, DPW Dash board gauges, camera, inventor, converter liar, rack CPU, controller, router, battery pack, battery management system, battery charger, encoder, rear CPU, traction motor wire connections.
- 6 Identify the steering motor drive by wire system.
- 7 Identify the brakes by wire system like drive by wire throttle pedal drive by wire throttle body, throttle position

sensor 1 AC and brake signal sensor fluid distribution unit, wheel sensor wire connections.

- 8 Identify the rear drive motor system or front drive motor system wire connections.

Note: Which vehicle equipped with technology that one basically run on electronically controls various range of operations including braking, throttle, steering and acceleration and power transmission etc.,

- 9 Identify the navigation architecture and mapping planning modules wire connections.
- 10 Identify the car hardware architecture, like power modules localization module, power circuit board wire connections.
- 11 Identify the perception modules. Like detecting and recognizing the object sensors wire circuits.
- 12 Identify the human-machine interface module (HMI) wire circuit.



Practice to identify the function of accelerator pedal to torque

Objectives: At the end of this exercise you shall be able to

- identify the operating components of accelerator pedal to torque.

Requirement			
Tools/Instruments		Material	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1 : Identify the operating components of accelerator pedal to traction motor torque

- 1 Park the electric vehicle on the shop floor.

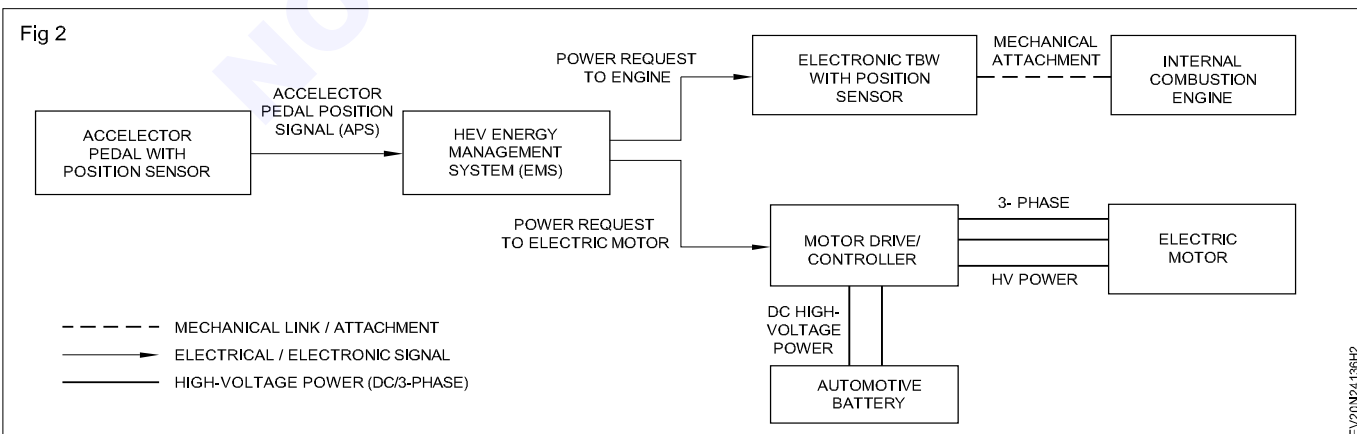
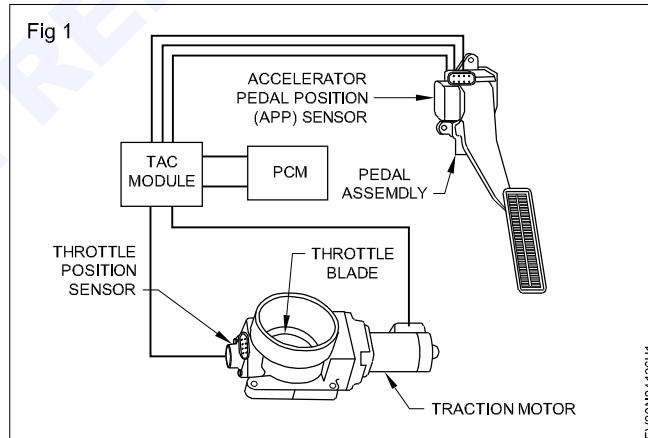
Note: The instructor has to be demonstrate and explain the function of accelerator pedal to traction motor torque components

- 2 Study the accelerator pedal power flow diagram and their components between accelerator pedal to wheel drive.
- 3 Identify the accelerator pedal sensor and their power supply system.
- 4 Identify the ECU to accelerator pedal sensor wire connection. (Fig 1)
- 5 Identify the motor controller and their wire connections. (Fig 1)
- 6 Identify the traction motor and their wire connections.
- 7 Identify the method of motor torque transmission to wheels.

Note: The torque output of the motor is directly proportional to the current flowing through it.

- 8 Identify the hybrid electric vehicle accelerator pedal wire connections as shown in Fig 2.

- 9 Switch 'ON' the battery power to traction motor drive system.
- 10 Press the accelerator pedal and check the function of pedal sensor and throttle position sensor.
- 11 Check the function of traction motor torque to wheels.
- 12 Ensure accelerator pedal drive by wire system is functioning properly.



Practice on fault diagnose and repair of accelerator pedal not working

Objectives: At the end of this exercise you shall be able to

- **diagnose fault of accelerator pedal not working**
- **repair the fault of accelerator pedal not working.**

Requirement			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
• Multimeter	- 1 No.	• Pedal sensor	- as reqd.
Equipment/Machineries		• Throttle body sensor	- as reqd.
• Electric vehicle	- 1 No.	• Controller	- as reqd.
• Work bench	- 1 No.		

PROCEDURE

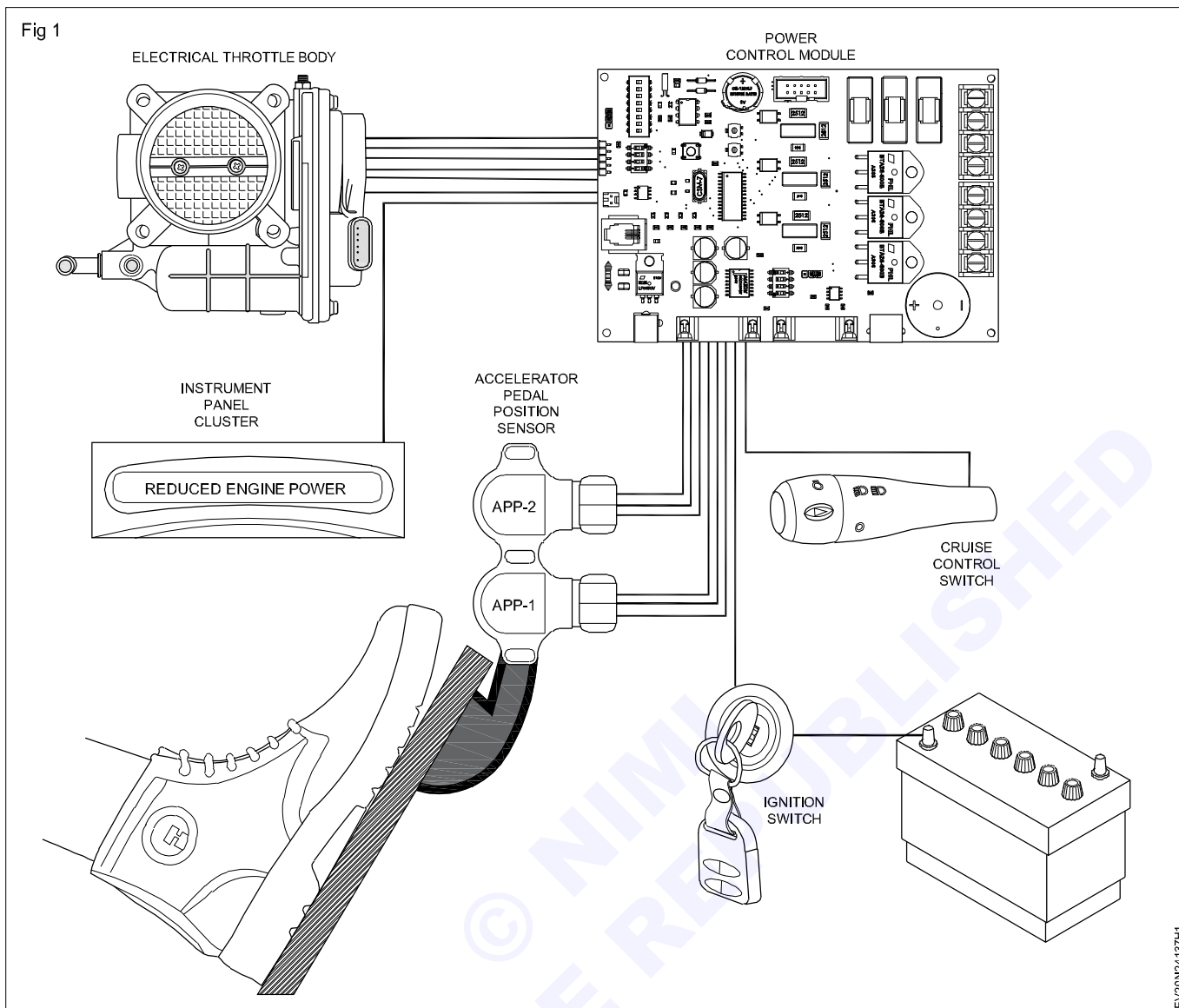
TASK 1 : Cause and remedies of accelerator pedal not working

Note: The instructor has to instruct the trainees to follow the EV safety instructions while work with EV.

- 1 Park the electric vehicle on the repair bay with following vehicle safety instructions.
- 2 Study the vehicle manual for accelerator pedal wire connection.
- 3 Trace the accelerator pedal drive by wire system.
- 4 Identify the components of accelerator pedal to traction motor torque drive system.
- 5 Switch on the vehicle battery power and operate the pedal.
- 6 Check the traction motor speed according to pedal movement.
- 7 If found motor is not running or not increased the speed, then you check accelerator pedal sensors wire connection.
- 8 If sensors are faulty, replace it with same size and same power rating.
- 9 Check the ECU wire connection for loose connection or connection damaged.
- 10 If found loose connection, tighten it or if found damaged wire, replace the same size wire.
- 11 Check the controller to throttle position sensor wire connection if found disconnected, connect the wire.
- 12 Check the battery power supply to accelerator pedal sensor ECU controller and traction motor by using multimeter.
- 13 Check the fuse in between the circuit of accelerator pedal drive wire system, if found fuse blown out replace the fuse and then check the battery power flow to remain accelerator pedal sensor to traction motor wire circuit.
- 14 Ensure the electric vehicle accelerator pedal acceleration movement and pedal sensor functions are functioning properly as per vehicle manufacturers technical data Fig 1. (Battery power supply, accelerator pedal movement, traction motor torque etc)

Note: Use the personal protective equipments while working electric vehicle to avoid electrical accident / damage.

Fig 1



EV20N24137H1

Practice on fault diagnose and remedies of brake not working

Objectives: At the end of this exercise you shall be able to

- **diagnose the cause for brake not working**
- **rectify the fault of brake not working.**

Requirement			
Tools/Instruments		Material	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
• Multimeter	- 1 No.	• Hydraulic oil	- as reqd.
Equipment/Machineries		• Wheel sensor	- as reqd.
• Electric vehicle	- 1 No.	• Fluid distribution work	- as reqd.
		• Brake shoe/pad	- as reqd.
		• Caliper unit	- as reqd.
		• Master cylinder	- as reqd.

PROCEDURE

TASK 1 : Fault diagnose and rectify the fault of brake not working

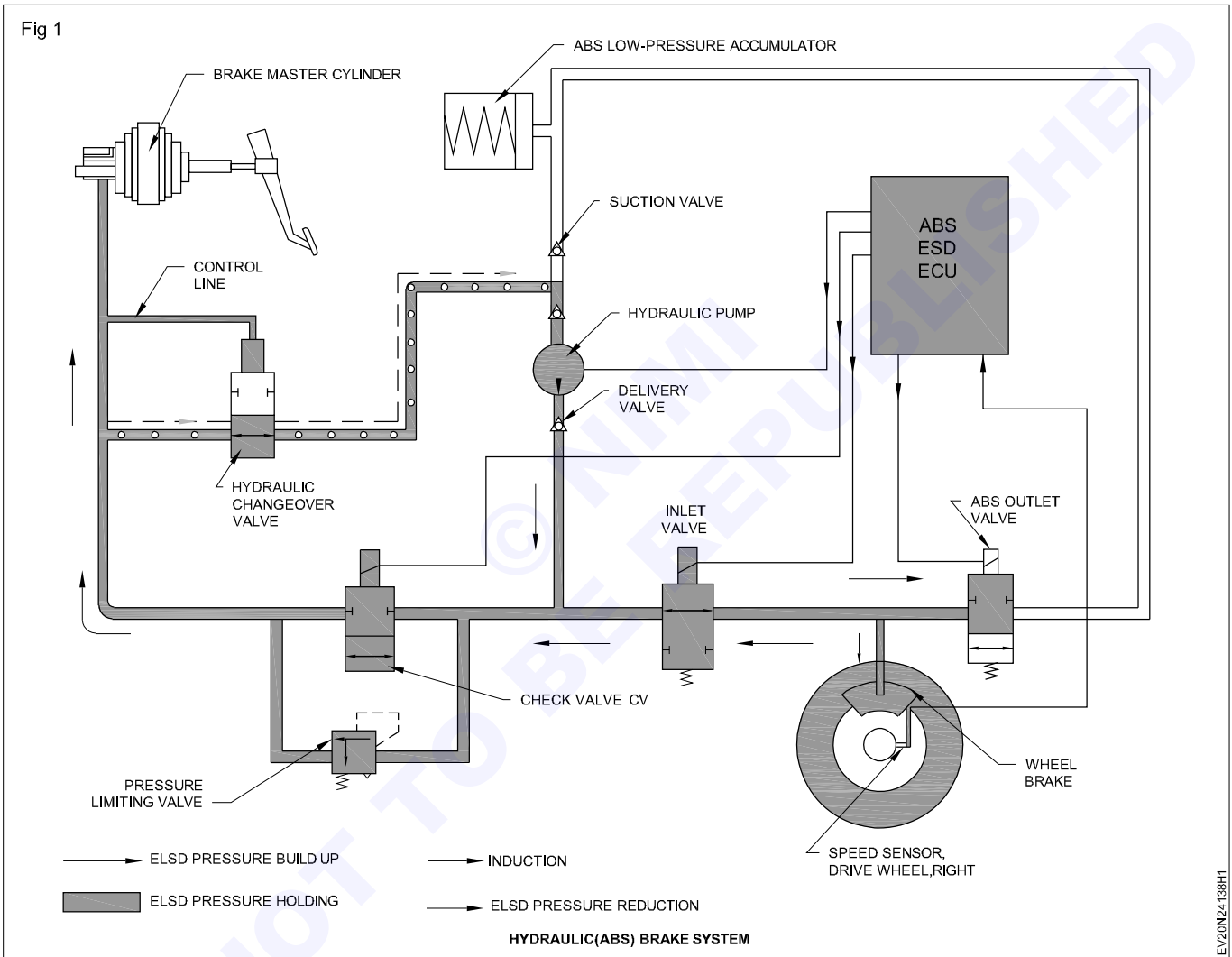
- 1 Park the electric vehicle on the shop floor.
- 2 Identify the which type brake used with a vehicle (drum brake or disc brake or electric brakes).
- 3 Trace the brake circuit from brake pedal to wheel (Fig1).
- 4 Follow the defects and remedies as shown in table - 1.
- 5 After rectify brake defects, check the vehicle brake by operating on the road.
- 6 Ensure the vehicle brake is working property.

Note: Incase of ABS brake use the scan tool to trace the defects in ABS brake system

Brake not work – Table 1

S.No.	Causes for brake not work	Remedies	Remarks
1	No fluid in master cylinder	Top up fluid	
2	Damaged rotor disc	Replace	
3	worn brake pads	Replace	
4	hydraulic fluid leaking	Arrest the fluid leaking and top the fluid	
5	Water or oil grease on rotor disc	Clean the disc	
6	Low hydraulic fluid pressure	Overhaul the master cylinder	
7	Over loading vehicle	Reduce the vehicle load	
8	Air lock in fluid circuit	Bleed the system	
9	Excess brake in fluid circuit	Adjust the brake pedal play	
10	Master cylinder vent hole block	Clean the vent hole	
11	Defective brake sensor	Replace the sensor	

12	Damaged sensor wiring	Replace the wiring	
13	Defective fluid controller	Replace the controller	
14	Defective hydraulic changeover valve	Replace the valve	
15	Defective pressure limiting valve	Replace the valve	
16	Defective hydraulic pump	Replace the pump	
17	Defective ABS inlet and outlet valve	Replace the valve	
18	Defective hydraulic changeover valve	Replace the valve	



Practice to drive a electric vehicle on the road

Objectives: At the end of this exercise you shall be able to
 • **drive a electric vehicle on the road.**

Requirement			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle tool kit	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1 : Electric vehicle driving practice a on the road

- 1 Park the electric vehicle on the plain surface.
- 2 Inspect the vehicle tools and equipment.

Note: The instructor has to be demonstrate to drive the electric vehicle with safety measures.

Before start the vehicle

- 1 Check the vehicle type air pressure and other vehicle fittings.
- 2 Check the vehicle battery charge condition.
- 3 Check dash board information gauge function by switch on the ignition key.
- 4 Check the brake and accelerators pedal sensor functions.
- 5 Check the indicator light and other lights of a EV.
- 6 Check the vehicles electrical network when battery power is powered up.
- 7 Check the brake fluid leakage.
- 8 Check the battery electrolyte leakage.
- 9 Check the steering linkages.
- 10 Check the suspension fittings.

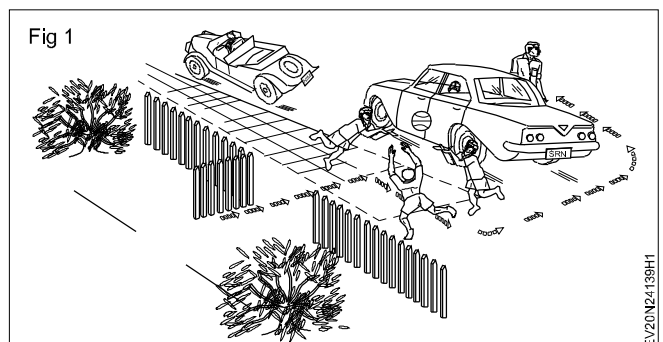
After start the vehicle

- 1 Check the dash board warning system.
- 2 Select the driving route.
- 3 Set the driver seat comparability.
- 4 Wear seat belt and other safety measures.

During vehicle driving

- 1 Simply put load on accelerator pedal.
- 2 Drive slowly.
- 3 Try to keep your speed limit under 60 km ph.
- 4 Maximize regenerative braking function as you come to a stop and use the brakes only when necessary.

- 5 Set regenerating setting to send extra power back to the vehicle batteries while decelerating.
- 6 Use the heater or car AC as on your requirement.
- 7 Use the proper inflated tyres or maintain the proper tyre air pressure.
- 8 Don't overload the vehicle.
- 9 Avoid installation exterior accessories like roof and cargo carries on your EV.
- 10 Use a very efficient route.
- 11 Don't apply brake frequently.
- 12 Follow the road traffic rules and regulations.
- 13 Follow the road traffic signals.
- 14 Control the vehicle speed according to road condition.
- 15 Use the hand signal where ever need.
- 16 Don't overtake on left side of road lane.
- 17 Don't overtake the vehicle on the road curve.
- 18 Use the dipper light at night time overtake the front of your vehicle.
- 19 Don't sound horn near school, hospital and sensitive zone.
- 20 Always keep a sharp look out for pedestrian crossing the road. (Fig 1)



- 21 Slow down before approaching curves/narrow roads.
- 22 Decrease the vehicle speed and drive on the road curves.
- 23 Make sure that you keep control of the wheels at all the times by keeping both hands in place on the steering wheel.

Safe drive through slopes, hills and narrow bridges

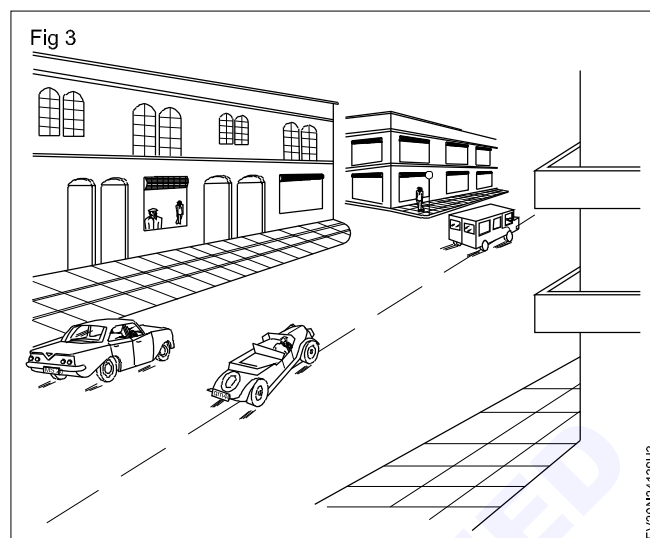
- 1 Decrease the vehicle speed and don't overtake on the narrow bridge.
- 2 Use the more torque is required to go up hill so better drive at slow speed.
- 3 When going down the hill gravity increases the vehicle speed so that safer to change into a lower speed of vehicle where ever apply brake partially.
- 4 Don't drive the vehicle into neutral position, while going down a hill.
- 5 Avoid constant use of brakes when you drive a vehicle in down hill.
- 6 Never cross a centre line of the hill road.
- 7 While encountering water on the road, you should ensure the water does not enter into the traction motor and battery pack.

Precautions while overtaking

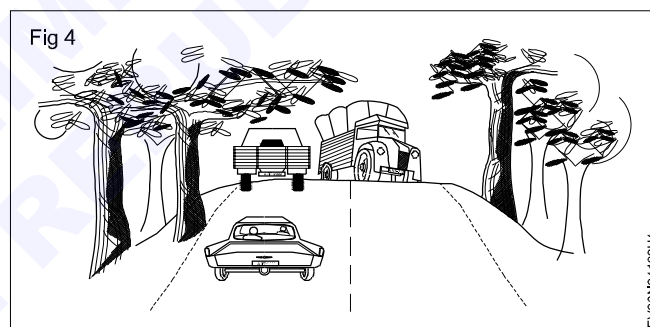
- 1 Overtake only on the right side of the front going vehicles.
- 2 Don't over take if any vehicles coming from the front in tends to turn right.
- 3 Do not over take any vehicle across the road.
- 4 Give horn sound and light signal, while you are overtaking a vehicle. (Fig 2)



- 5 Get clearance from the vehicle in front with the hand signal for overtaking. (Fig 3)



- 6 Make sure that sufficient and appropriate space is available for overtaking on the road.
- 7 Don't cut sharply to the left of the vehicle going in front immediately on overtaking.
- 8 Don't try to overtake on hill roads in fog, mist or heavy rainfall. (Fig 4)



- 9 Never drink and drive and never use the cell phone while drive the vehicle.
- 10 Never use the TV and other distracting gad gets in the ear during driving.
- 11 One way traffic rules has to be strictly followed.
- 12 Use fog light in fog area for better visibility.
- 13 Follow the table for vehicle speed and braking distance.

S.No	Vehicle speed km/hr (a)	Braking distance (metres) (b)	Reaction distance (metres) (c)	Total distance (metres) (d)	Deceleration (m/sec ²) (e)	Remarks (f)
1	30	6.9	12.5	19.4	5	Uniform deceleration is assumed for all speeds.
2	60	27.8	25.0	52.8	5	
3	90	62.5	37.5	100	5	

Practice on trace the light circuit of electric vehicle

Objectives: At the end of this exercise you shall be able to

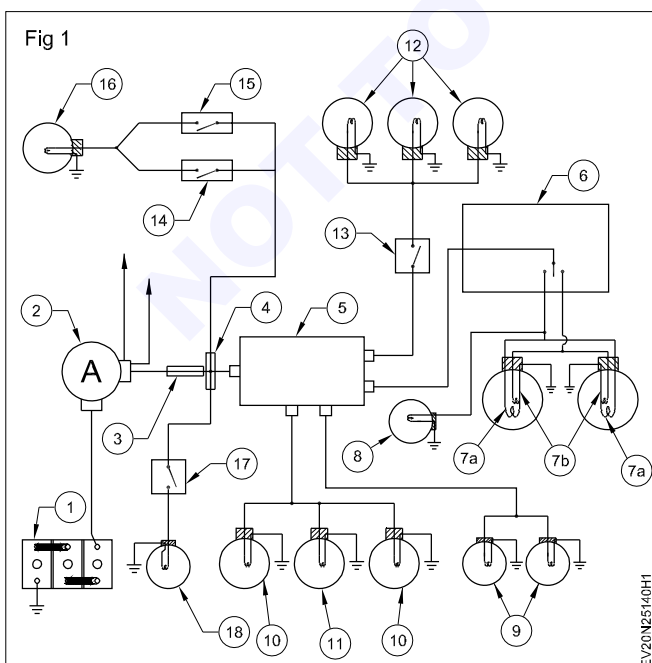
- trace the all lighting circuit
- test the bulbs
- align the head light lamps
- aiming adjustments of head light.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Multimeter	- 1 No.	• Soap oil	- as reqd.
• Test lamp	- 1 No.	• Insulation tape	- as reqd.
Equipments/Machineries		• Bulb	- as reqd.
• Electric vehicle	- 1 No.	• Wire clip	- as reqd.
• Battery	- 1 No.	• Wire (different colour)	- as reqd.
• Test bench	- 1 No.	• Emery sheet	- as reqd.
		• Switches	- as reqd.

PROCEDURE

TASK 1: Tracing a lighting circuits of Electric vehicle

- 1 Select the vehicle for tracing lighting circuit.
- 2 Park the vehicle on the shop floor
- 3 Study the vehicle manual for lighting circuits.
- 4 Switch off the battery power.
- 5 Trace the lighting circuits one by one with refer the vehicle lighting circuit diagram.
- 6 Trace the battery cable from the battery (1) to the ammeter (2) and check for proper connections. (Fig 1)
- 7 Trace the wire from ammeter (2) to the fuse unit (3) (or circuit) breaker) and check for proper connections.
- 8 Trace the wire from the fuse unit (3) to the junction box (4) and check for proper connections.
- 9 Trace the wire from the fuse unit (4) to the headlamp switch (5) and check for proper connections.
- 10 Trace the wire from headlamp switch (5) and to the dipper switch (6) and check for proper connections.
- 11 Trace the wire from the dipper switch (6) to the connection of the headlamp's high beam (7a) and low beams (7b) and check for proper connections.
- 12 Trace the wire from high beam (7a) circuit to the beam indicator lamp (8) in the instrumental panel.
- 13 Trace the wire from the headlamp switch (5) to the parking lamp (9) and tail-lamp (10) and check for proper connections.
- 14 Trace the wire from the headlamp switch (5) to the number-plate lamp (11) and check for proper connections.
- 15 Trace the wire from headlamp switch (5) to the instrument panel lamps (12) via the instrument panel switch (13) and check for proper connections.
- 16 Trace the wire from the junction box (4) to the dome light pillar switch (14) and automatic door switch (15) and to the roof light (16) and check for proper connections.

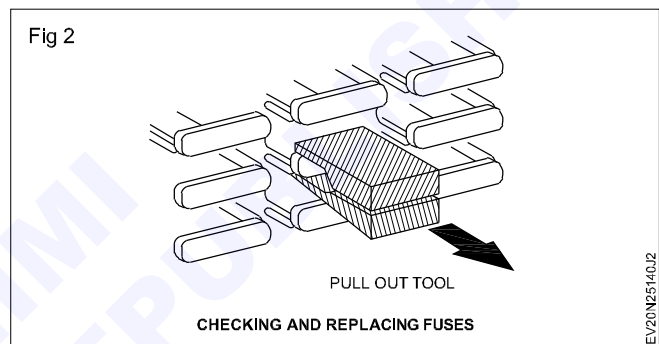
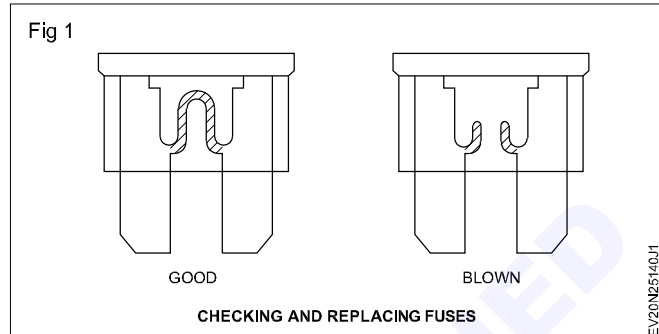


The roof light pillar switch and the automatic door switch are connected in pillar. Trace the wire from the junction box (4) to the stop-light (warning light) switch (17) to the stop-light (18) and check for proper connections.

17 Replace deflection bulbs, where they are fused.

TASK 2: Check the fuses of all the lighting units

- 1 Check the battery charge.
- 2 Connect the test lamp clip to a good ground. Touch the probe of the test lamp on either end of the fuse. If the test lamp lights, the fuse is in good condition. If the test lamp lights out only while touching one side that means the fuse is defective. If the test lamp does not light even on touching both sides that means the power source is not on or ground connection is bad.
- 3 Remove the fuse from its spring clip. Check whether it is blown or not. If blown replace it using pull out tool. (Fig 1 & Fig 2)



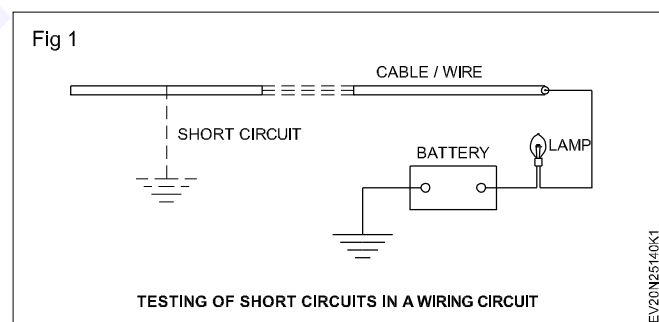
TASK 3: To find out open and short circuit in the lighting circuit

- 1 Check the wiring for open circuit by connecting an ohmmeter between the two terminals.

If there is an open circuit the ohmmeter reading will be more.

If there is a short circuit the test lamp will glow before the circuit is completed and also the fuse will be blown off.

- 2 Trace the open circuit and rectify.
- 3 Check the wiring for short circuit with the test lamp. (Fig 1)



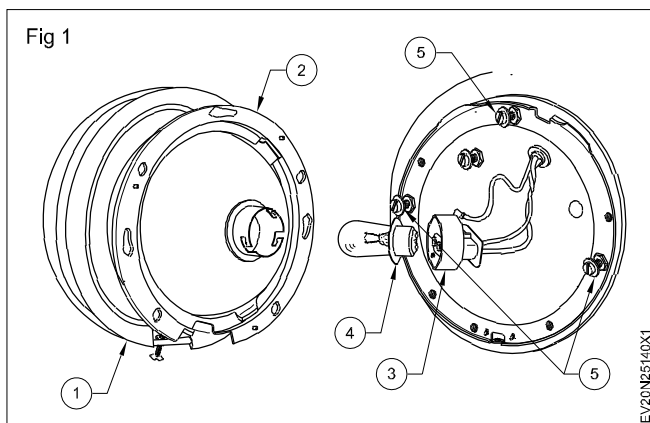
TASK 4: Remove the lighting units and check the bulb and its holder and fused bulb

a Headlamp

- 1 Unscrew the screw securing the rim.
- 2 Take out the rim along with rubber dust excluder (1).
- 3 Press the light unit and turn it in the anticlockwise direction so that the light unit (2) will come out.

While removing the light unit ensure that the adjusting screws (5) are not disturbed.

- 4 Turn the bulb holder (3) in the anticlockwise direction to take it out.
- 5 Remove the bulb (4). (Fig 1)



b All other lamps

- 6 Unscrew the screws.
- 7 Remove the lock-rings according to the model.
- 8 Remove the light lenses.
- 9 Remove the bulbs.
- 10 Check the bulbs
- 11 While removing the bulbs check for loose fitting.
- 12 Check the bulbs for fuse by connecting wires from the battery.
- 13 If the bulb is fused replace it.

TASK 5: Assemble the light units and test for proper work

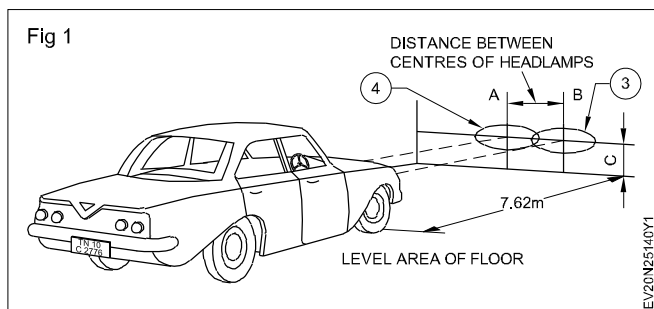
- 1 Check the front lens and reflector and replace, if found damaged.
- 2 Position the new light unit on the rim.
- 3 Ensure that the locating tabs at the edge of the light unit fit into the slots in the rim.
- 4 Ensure that the unit retaining ring is correctly positioned.
- 5 Engage the projections on the bulb holder with the slots or flanges in the bulb sleeve.
- 6 Press and twist the clockwise to fit the light assembly with the rim on the vehicle by the rim securing screws. Assemble all other the light units by securing the screw/lock rings.
- 7 Test all the lights by operating all the switches, after completing all the checking, by connecting a battery of proper voltage.

Trouble shooting

Sl. No	Trouble	Causes	Remedies
1	Head light do not glow	<ul style="list-style-type: none"> -Bulb fuse -Wire loose connection -Open circuit in wiring -Head light bulb fuse /burned out -Head light switch defective 	<ul style="list-style-type: none"> -Replace -Tighten it -Connect open wire connection -Replace the bulb -Replace the switch
2	One head light does not glow	<ul style="list-style-type: none"> -Loose wire connection -Bulb burned out -Open wire circuit -Damaged wire -Rust formed in earth wire connection 	<ul style="list-style-type: none"> -Tighten the wire -Replace the bulb -Repair it. -Replace the wire junction box. -Clean it
3	High or low beam does not work	<ul style="list-style-type: none"> -Head light bulb one filament burned out -Wire loose connections in bulb holder -Dim and bright switch defective -Defective head light bulb holder 	<ul style="list-style-type: none"> -Replace the bulb -Tighten -Replace the switch -Replace the bulb holder

TASK 6: Do preliminary checks

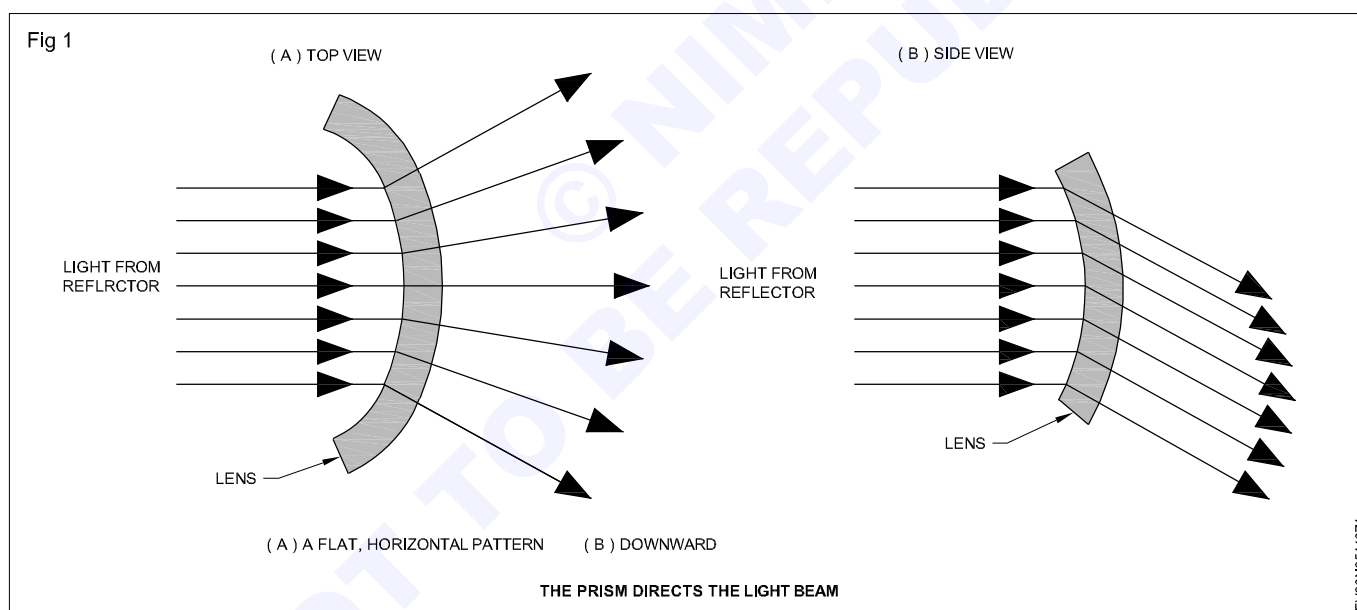
- 1 Check the air pressure in the tyres and inflate them to the correct pressure.
- 2 Check the headlamp mountings. (Fig 1)



- 3 Position the car 7.62 meters away in front of a white screen or a plain wall.

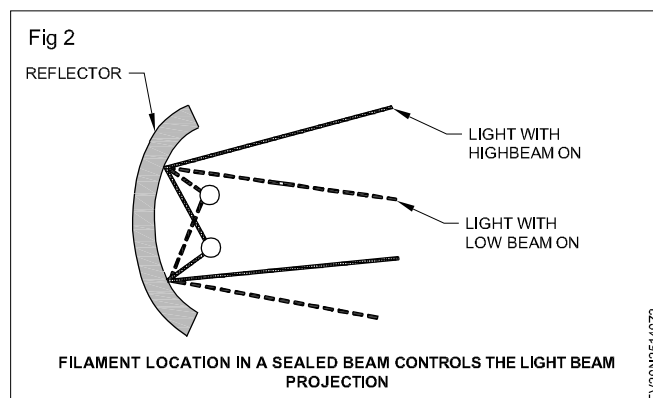
TASK 7: Setting the beams (long and short) and test the beams

- 1 Adjust the headlamp beams by the vertical adjusting screw or the horizontal adjusting screw of head light.
- 2 Assembly ensure that the main beam's high intensity zone falls as shown Fig 1.
- 3 Ensure the upper beam is adjusted separately after throwing it separately on the white screen.
- 4 Observe the headlamp main beam directed straight ahead and parallel to the road when the vehicle is fully loaded. (Refer to the diagram)



Adjustment of headlamps

- 1 Adjust the head light upper/lower beam if required.
- 2 Operate the dip switch by foot switch or hand operated switch. Observe the dipped beam dipping downwards and towards the kerb. (Fig 2)
- 3 Ensure head light's upper and lower beam is functioning as required limit.



Practice to change head light bulb and switch

Objectives: At the end of this exercise you shall be able to

- check the head light bulb
- check and replace the head light switch.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Multimeter - 1 No.
- Test lamp - 1 No.

Equipments/Machineries

- Electric vehicle - 1 No.

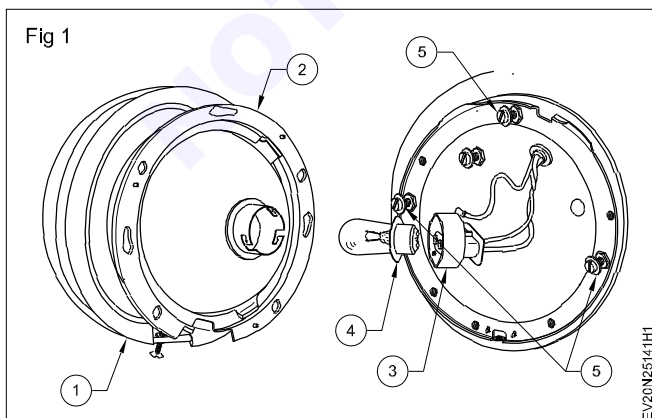
Materials

- Cotton waste - as reqd.
- Soap oil - as reqd.
- Head bulb - as reqd.
- Head light switch - as reqd.
- Insulation tape - as reqd.
- Wire - as reqd.
- Head light bulb holder - as reqd.

PROCEDURE

TASK 1: Checking and replacing the head light bulb

- 1 Park the electric vehicle on the shop floor with applying safety devices to the vehicle.
- 2 Study the vehicle manual for electrical head light bulb power range and switching type.
- 3 Identify the head light switch and head light location on the vehicle.
- 4 Switch on the main ignition switch.
- 5 Operate the head light switch and check the head light glowing.
- 6 If found any one of the head light is not glowing check the wire loose connection.
- 7 If found every thing is correct, ensure the head light bulb or headbulb holder is probe.
- 8 Switch off the ignition switch and then follow the steps to remove the headlight bulb.
- 9 Unscrew the screws securing the rim.(Fig 1)

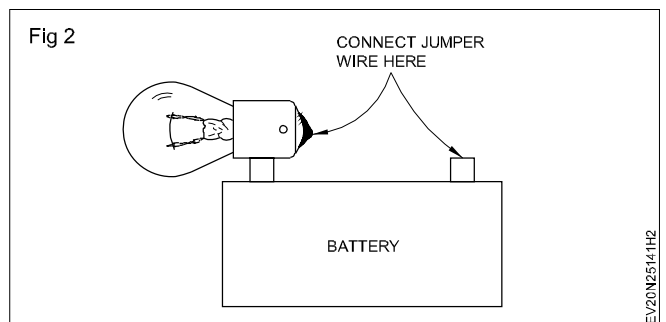


- 10 Take out the rim along with the rubber dust excluder (1).

- 11 Press the light unit and turn it in the anticlockwise direction so that the light unit (2) will come out.

While removing the light unit ensure that the adjusting screws (5) are not disturbed.

- 12 Turn the bulb holder (3) in the anticlockwise direction to take it out.
- 13 Remove the bulb (4).
- 14 Unscrew the screws.
- 15 Remove the lock-rings according to the model.
- 15 Remove the light lenses.
- 16 Remove the bulbs.
- 17 Check the bulbs. (Fig 2)
- 18 While removing the bulbs check for loose fittings.
- 19 Check the bulbs for fuse by connecting wires from the battery shown as in the figure. (Fig 2)
- 20 If the bulb is fused replace it.

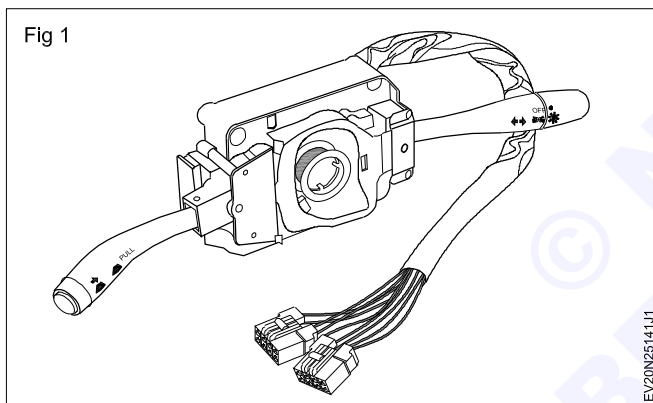


TASK 2: Assemble the light units and test for proper work

- 1 Check the front lens and reflector and replace, if found damaged.
- 2 Position the new light unit on the rim.
- 3 Ensure that the locating tabs at the edge of the light unit fit into the slots in the rim.
- 4 Ensure that the unit retaining ring is correctly positioned.
- 5 Engage the projections on the bulb holder with the slots or flanges in the bulb sleeves.
- 6 Press and twist clockwise to fit the light assembly with the rim on the vehicle by the rim securing screw. Assemble all other light units by securing the screws/lock rings.
- 7 Test all the lights by operating all the switches, after completing all the checking by connecting to a battery of proper voltage.

TASK 3: Checking and replacing the head light switch

- 1 Identify the location of head light switch in the vehicle.
- 2 Check the head light circuit wire connections.
- 3 Check the head light fuse and relay.
- 4 Switch 'ON' the ignition key and ensure battery power is supply to the head light switch.
- 5 Suppose your vehicle positioned with combination car switch. (Fig 1)
- 16 Dismount the combination switch mounting screws.
- 17 Remove the combination switch mounting screws.
- 18 Carefully remove the combination switch.
- 19 Select the new combination switch with same power rating and same in size.
- 20 Mount the new combination switch on the steering column with new mounting screw.
- 21 Ensure the new combination switch is positioned properly.
- 22 Connect the wire connectors with combination switch wire connectors.
- 23 Ensure wire connector's male and female are properly seated.
- 24 Switch on the battery power by operating ignition switch.
- 25 Check the head lights function by operating head light switch.
- 26 Ensure the head light, gauges light, head light high and low beam, head light sign lights are functioning properly.
- 27 Ensure vehicle turn indicator and wiper also functioning properly.



- 6 Switch 'ON' the head light switch by turning roller switch position-1.
- 7 Ensure the gauges light and parking lights are glowing.
- 8 Turn the head light switch to position-2.
- 9 Ensure the head light glow sign light is glowing at the same time head light also glowing.
- 10 Operate the dip and dim light by moving up and down movement of lever switch.
- 11 If not functioning the switch, ensure head light switch is defective.
- 12 Switch off the ignition power to head light switch.
- 13 Switch off the ignition switch.
- 14 Ensure battery power is cut off to head light switch.
- 15 Disconnect combination switch wire connectors of head light, wiper motor and indicator light.

Note:

- 1 Ensure there is no any loose wire connection in a lighting and other electrical circuit.
- 2 Use insulation tape on wire joints to avoid electrical short circuit.
- 3 Use the multimeter or test lamp to check continuity.
- 4 Always follow the electric vehicle safety rules while work on the electric vehicle.

Practice to trace the wiring circuit of lighting system

Objectives: At the end of this exercise you shall be able to

- trace the wiring circuit of lighting system.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• User manual	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1: Tracing various wiring circuits of EV lighting circuits

- 1 Park the vehicle on the shop floor.
- 2 Study the vehicle user manual for lighting circuits.
- 3 Take one print out of EV lighting circuit wiring diagram.
- 4 Identify the wire's colour code of each lighting circuit.
- 5 Identify and trace the head light wiring circuit as wire colour code.
- 6 Identify and trace the turn indicator wiring circuit.
- 7 Identify and trace the parking light wiring circuit.
- 8 Identify and trace brake light wiring circuit.
- 9 Identify and trace the fog light wiring circuit.
- 10 Identify and trace the car interior light wiring circuit.
- 11 Identify and trace the wire from dipper switch to wire connection to head light (High and Low beam).
- 12 Identify and trace the panel light wiring circuit end to end.
- 13 Identify and trace the reverse light wiring circuit.
- 14 Write down the light wiring colour code in table 1.

Table 1

S.No	Lighting Circuit	Cable colour code	Bulb power rate	Remarks
1	Head light			
2	Tail light			
3	Indicator light			
4	Fog light			
5	Interior light			
6	Number plate light			
7	Reverse light			
8	Parking light			
9	Gauges light			
10	Reading lamp			
11				

Practice to remove and re-install wiper motor and switch

Objectives: At the end of this exercise you shall be able to

- remove and reinstall the wiper motor and wiper switch.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• User manual	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries		• Wiper motor	- as reqd.
• Electric vehicle	- 1 No.	• Grease	- as reqd.
• Work bench	- 1 No.	• Emery sheet	- as reqd.

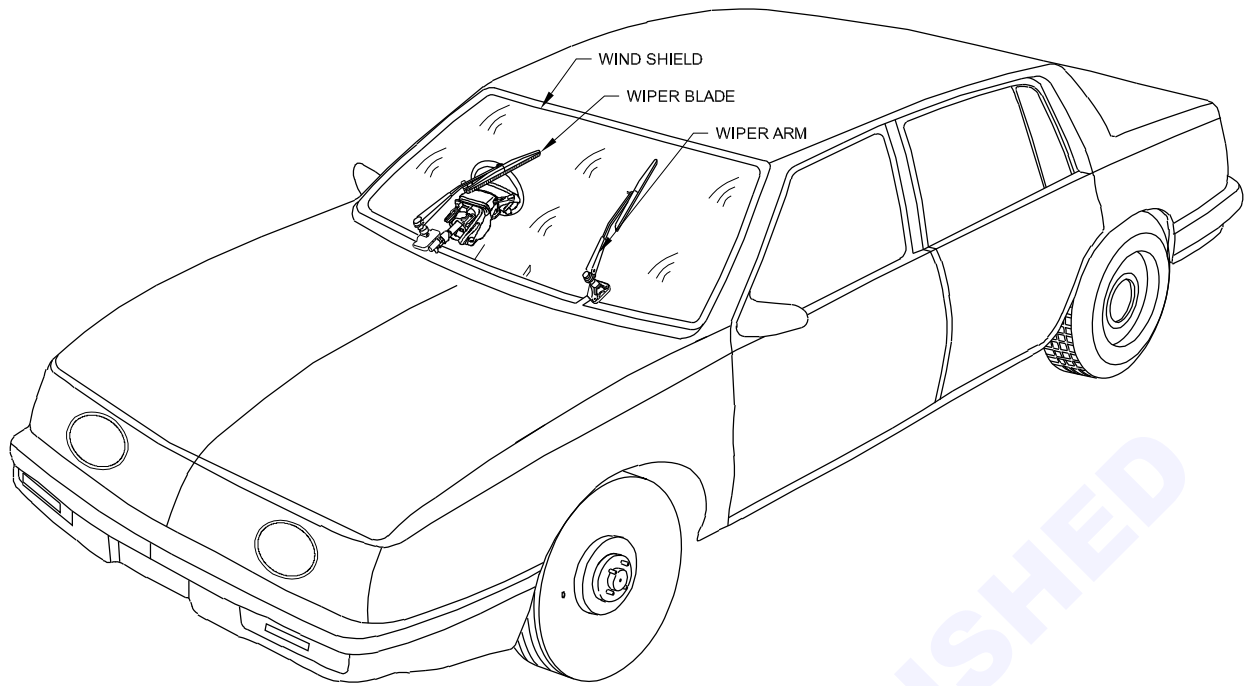
PROCEDURE

TASK 1: Removing the wiper blade and wiper motor assembly

- 1 Park the vehicle on the shop floor.
- 2 Study the vehicle manual.
- 3 Identify the wiper motor and wiper switch location in a vehicle.
- 4 Identify the wiper motor switch type, whether wiper switch with motor or lever turn switch (Combination switch).
- 5 Trace the wiring circuit of wiper motor (wiper switch to wiper motor).
- 6 Remove the wire connection of wiper motor.
- 7 Remove the wiper blade and place it in tray.
- 8 Dismount the wiper motor and remove the wiper motor from the vehicle.
- 9 Place the wiper motor on the work bench.
- 10 If wiper switch is with combination switch remove the combination switch by the disconnecting mounting screw and wire connector's.
- 11 Place the wiper motor on the table vice and connect the battery power to the motor.
- 12 Check the function of wiper motor.
- 13 If wiper motor is not working, overhaul the wiper motor by dismantling.
- 14 Dismantle the wiper motor and place the parts in a tray.
- 15 Clean the dismantled parts of wiper motor like, gear connecting rod, circlip gear box cover, motor housing armature field coil.
- 16 Visually inspect the gear wheel teeth for damages or wear.
- 17 Test the motor field winding and armature winding.
- 18 Check wiper motor carbon brushes and their spring tension.
- 19 Replace the defective parts of wiper motor.
- 20 Assemble the wiper motor as reverse on dismantle the process.
- 21 Ensure wiper motor is properly assembled.
- 22 Test the motor by connecting power supply and carry out the load test and no load test.
- 23 Test the wiping speed of the motor, it should be between 45 to 50 cycles per minute.
- 24 Check the wiper switch with help of test lamp by given power input and power output.
- 25 If found switch is defective replace it.
- 26 Assemble the wiper motor and wiper blade on the vehicle and then connect the wires as instruction given by the manufacturers.(Fig 1)
- 27 Connect the wire connector with combination switch.
- 28 Switch 'ON' the battery power and operate the wiper motor, ensure wiper motor is functioning properly
- 29 Check the wiper blade wiped area, if need change the position of the arms by removing and refitting them in appropriate position.

Note: Do not attempt to turn the spindle by hand force.

Fig 1



EV20N25143H1

Practice to identify different location of various ECU and antitheft system

Objectives: At the end of this exercise you shall be able to

- identify the various ECU location in a electrical vehicle
- identify the antitheft system is a electrical vehicle.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE**TASK 1: Identify the various ECU location in a electric vehicle**

Note: The instructor has to demonstrate to identify the various ECU/VCU location in a vehicle

- 1 Park the electric vehicle in the shop floor with following safety measures.
- 2 Study the vehicle manual for ECU location in a particular vehicle.
- 3 Identify the location of engine control module (ECU) of hybrid vehicle.
- 4 Identify the battery control module (BCM).
- 5 Identify the vehicle body control module (BCM).
- 6 Identify the ABS electronic control module.
- 7 Identify the HVAC control module.
- 8 Identify the airbag control module.
- 9 Identify the powertrain control module (PCM).
- 10 Identify the transmission control module (TCM).
- 11 Identify the central control module (CCM).
- 12 Identify the central timing module (CTM).

- 13 Identify the general electronic module (GEM).
- 14 Identify the power steering control module (PSM).
- 15 Refer the particular vehicles manual for identify the location of different ECU's in their vehicle.
- 16 Identify the location infotainment control module (ICM)
- 17 Identify the location of climate control module (ICMs).
- 18 Identify the vehicle chassis control module (VCCM).
- 19 Identify the location of ADAS (Advanced driver assistance system).
- 20 Identify the location of MAP ECU in a vehicle.
- 21 Identify the location of integrated control ECU in a vehicle.
- 22 Identify the location of LIDAR ECU in a vehicle.

Note: Now a days EV manufacturers are provided over 40 ECU in normal car and even more than 150 ECU's are used in modern luxury cars.

Practice to remove and install new horn

Objectives: At the end of this exercise you shall be able to

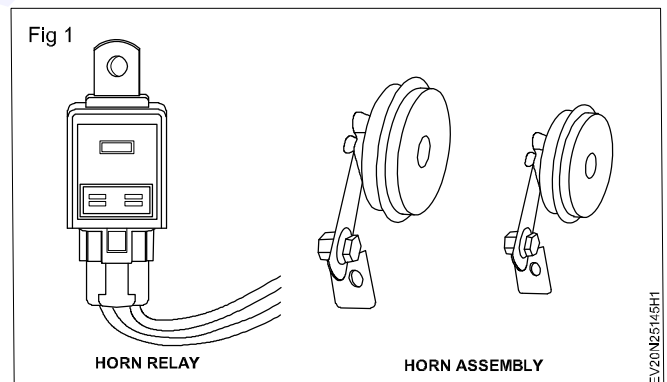
- removing and replacing with new horn assembly.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
• Test lamp	- 1 No.	• Horn assembly	- as reqd.
Equipment/Machineries		• Horn relay	- as reqd.
		• Wire	- as reqd.
• Electric vehicle	- 1 No.	• Insulation tape	- as reqd.
• Work bench	- 1 No.	• Wire clip	- as reqd.

PROCEDURE

TASK 1: Removing and replacing with new horn assembly

- 1 Park the vehicle on the repair bay.
- 2 Study the vehicle manual for know the technical data of a horn.
- 3 Identify the location of horn relay and horn in a electric vehicle.
- 4 Switch off the battery power and then disconnect the horn relay and horn wire connection by using correct size tools.
- 5 Select the suitable spanner for dismount the horn and horn relay.
- 6 Dismount mounting of the horn relay and horn.
- 7 Remove the horn relay and horn assembly from the vehicle.
- 8 Keep the horn on the work bench.
- 9 Select the new horn and horn relay as recommended by vehicle manufacturer.
- 10 Test the horn relay and horn by connecting battery power.
- 11 If need tune up the horn.
- 12 Disconnect the battery power from the horn assembly.
- 13 Mount the new horn relay and horn in correct position.
- 14 Install the fasteners and tighten them with specified torque.
- 15 Plug the electrical connector's into horn relay and horn assembly.
- 16 Reconnect the battery power and operate the horn switch for check their function. (Fig 1)
- 17 Ensure the horn assembly is properly functioning by pressing the horn switch.
- 18 Deposit the old horn and relay unit in your ITI store by using return indent.



Note: Use the protective gloves and safety glasses while you are working in a electric vehicle.

Practice to identify the various sensors fitted with vehicle

Objectives: At the end of this exercise you shall be able to

- identify the proximity sensor parking sensor and crash sensor
- identify the rain and light sensor.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• EV manual	- 1 No.	• Soap oil	- as reqd.
• Multimeter	- 1 No.	• Different sensors	- as reqd.
Equipment/Machineries		• Wire	- as reqd.
• Electric vehicle	- 1 No.	• Insulation tape	- as reqd.
• Work bench	- 1 No.		

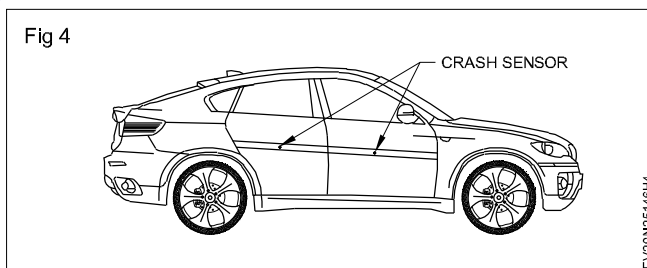
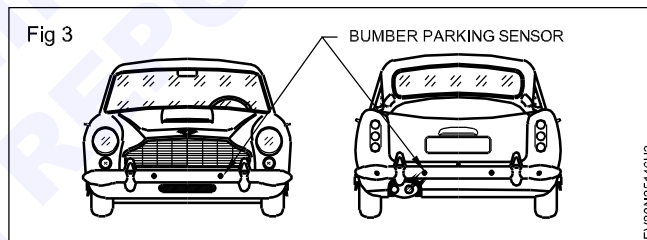
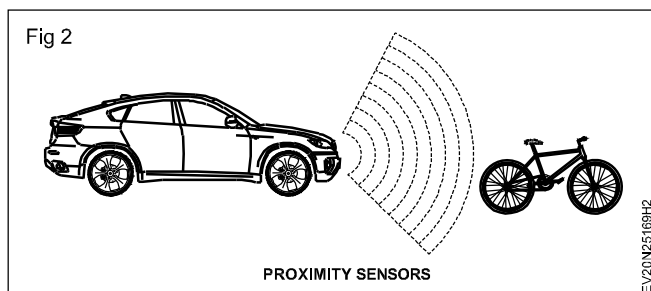
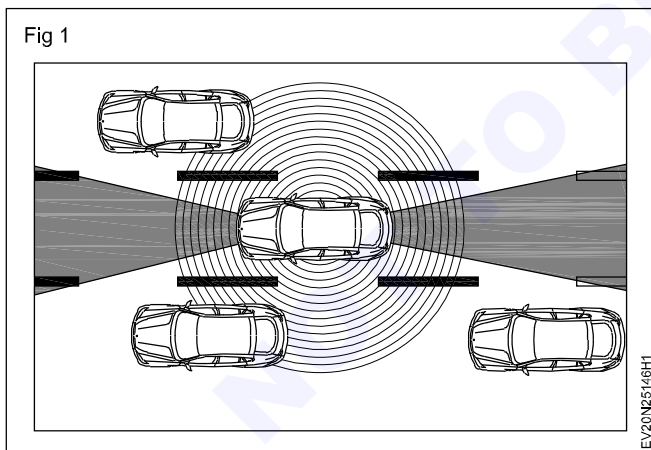
PROCEDURE

TASK 1: Identify the location of proximity sensor, parking sensor and crash sensor in a vehicle

Note: the instructor has to locate the different sensors fitted in a vehicle.

- 1 Park the vehicle on the shop floor.
- 2 Study the vehicle manual for identify the various sensors in a vehicle.
- 3 Switch 'OFF' the vehicle battery power.
- 4 Trace the location of proximate sensor fitted in a vehicle with a help of vehicle manual circuit diagram. (Fig 1,2)

- 5 Trace the location of vehicle parking sensor fitted in a vehicle. (Fig 3)
- 6 Trace the location of crash sensor fitted in a vehicle. (Fig 4)



Note:

- 1 Proximity sensor is fitted in a car front and near bumper it use an electrical signal and can detect an object without touching it. even proximity sensor's fitted driver side door and passenger side doors to detect the object without touching it.
- 2 Parking sensor also fitted in front and rear bumper.
- 3 Crash sensor also fitted in front doors. these sensors detect a side collision that pushes the outer door panel inwards for creating excess pressure.

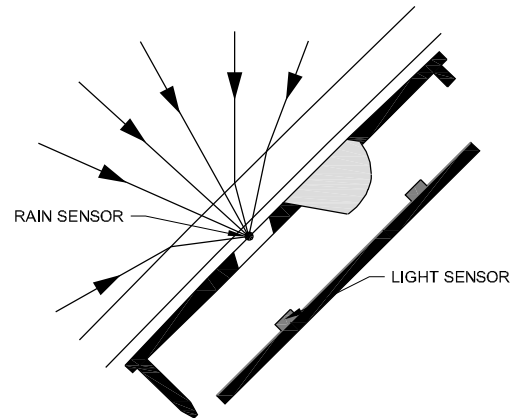
TASK 2: Identify the location of rain sensor and light sensor in a vehicle

- 1 Identify the location of rain sensor fitted in a vehicle.
- 2 Identify the location of light sensor fitted in a vehicle. (Fig 1)

Note:

- 1 Rain sensor fitted near the side rear view mirrors and it sense the rain and automatically activating the wind shield wiper system.
- 2 Rain light optical sensor is (fitted) fastened on the wind shield, which forms a level layer on the optical sensor.

Fig 1



EV20N25146J1

Practice on remove and reinstall the power window door lock

Objectives: At the end of this exercise you shall be able to

- remove the power door lock
- trace the power door lock wiring circuit
- reinstall the power door lock.

Refer Exercise No. 1.7.78 - 1st year

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Practice to identify the electric vehicle air conditioning system components

Objectives: At the end of this exercise you shall be able to

- identify the car air conditioning system components.

Requirements			
Tools and instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries			
• Electrical vehicle	- 1 No.		

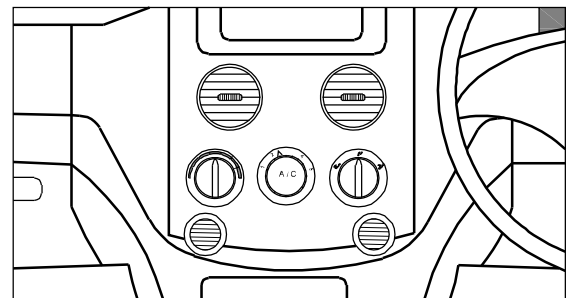
PROCEDURE**TASK 1: Identify the electric car, air conditioning system components**

Note: The instructor has to demonstrate to identify the EV air conditioning system components with car AC circuit diagram

- 1 Park the vehicle on the shop floor.
- 2 Study the vehicle manual air conditioning, circuit diagram.
- 3 Open the vehicle door and switch on the ignition switch.
- 4 Identify the car AC switches and cool air outlets.
- 5 Start the vehicle and switch on car AC system.
- 6 Check the car AC function.
- 7 Check the car AC components that absorb humidity and heat from the passengers, cabin and deliver cool air by removing moisture.
- 8 Identify the car AC cool air split components within your car cabin. (Fig 1)
- 9 Switch off the car AC system.
- 10 Identify the battery pack.

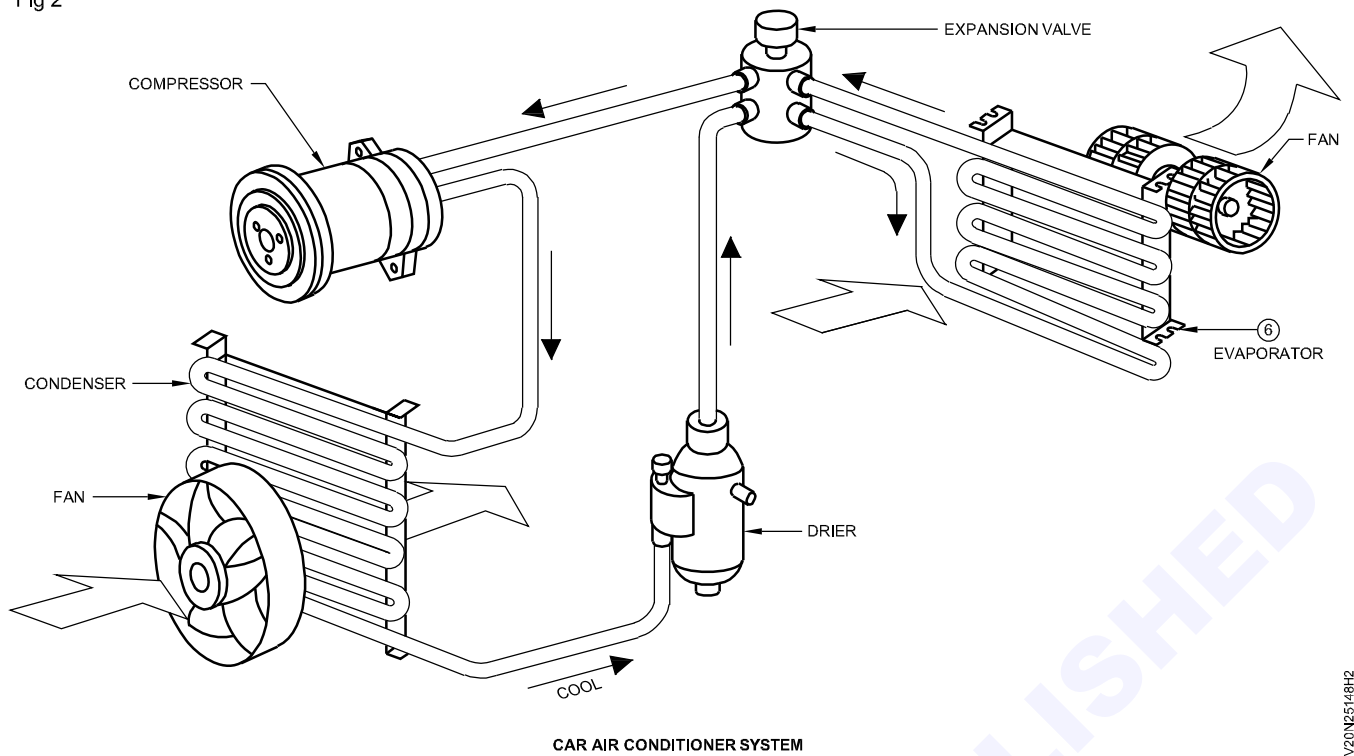
- 11 Identify the location AC compressor, drive motor. (Fig2)
- 12 Identify the car AC compressor.
- 13 Identify the condenser and cooler cooling fan.
- 14 Identify the drier and expansion valve.
- 15 Identify the evaporator.
- 16 Identify the blower unit.

Fig 1



EV20N25148H1

Fig 2



EV20N25148H2

Practice to hand adjust the cabin inside switches of a car air condition system

Objectives: At the end of this exercise you shall be able to

- hand adjust the car AC switches provided inside of car cabin.

Requirements			
Tool and instruments		Materials	
• Trainee's tool kit	-1 No.	• Cotton waste	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Electric vehicle	- 1 No.	• AC switch	- as reqd.

PROCEDURE

TASK 1: Hands on adjustment of AC inside the car cabin

Note: The instructor has to demonstrate the method of car AC switches hand adjustment within a cabin.

Note: Check your car cabin air filter to make sure it is clean a dirty filter prevents optimal air flow in your vehicle.

- 1 Park the electric vehicle on the workshop floor.
- 2 Study the vehicle manual to achieve the knowledge about car AC control switch and their functions.
- 3 Open the car door and sit on the driver seat.
- 4 Identify the dashboard switches and gauges.
- 5 Switch on the ignition switch.
- 6 Ensure EV battery power is ON.
- 7 Switch on the car AC switches and ensure compressor driver by electric motor.
- 8 Close the all doors and open one door window glass to go out for warm air inside the car cabin.
- 9 Adjust the temperature and fan speed as per your performance.
- 10 Set the temperature setting by operating temperature control switches.
- 11 When you start driving turn on the speed of air conditioner and open the windows for 10 to 20 seconds even on the hottest days the air inside the car will be much hotter than the outside air.
- 12 Getting the lowest temp and adjust the fan makes the air conditioning more efficient.(Fig 1, 2)
- 13 If you have passengers in the backseat consider turning of the recirculation mode.
- 14 If you have a new car that has an auto start stop system consider turning it off.

- 15 If you have automatic climate control in your vehicle lowering the temperature does not make cool of faster this type of system will do all the fan and temperature adjustments automatically. So you can just set automatic climate control switch and forget it for other adjustment.
- 16 Always switch off the air conditioner button before turning the EV off. So as to prevent the formation of bacteria in the cabin or air conditioner system and reduce the load on the whole system and battery.

Fig 1

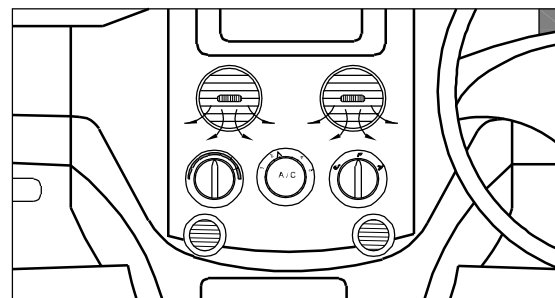
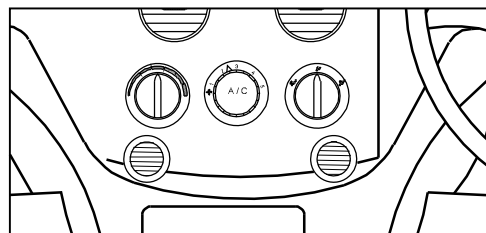


Fig 2



Practice on preventive maintenance of HVAC machine

Objectives: At the end of this exercise you shall be able to

- preventive maintenance of HVAC machine.

Requirements			
Tools/instruments		Materials	
• Trainee's toolkit	- 1 No.	• Cotton waste	- as reqd.
Equipment/Machineries		• Soap oil	- as reqd.
		• AC refrigerant	- as reqd.
• Electric vehicle	- 1 No.	• Compressor belt	- as reqd.
		• Expansion valve	- as reqd.
		• AC control switches	- as reqd.

PROCEDURE

TASK 1: Preventive maintenance of car AC system

- 1 Park the vehicle on the repair bay.
- 2 Study the vehicle manual.
- 3 Open the car door and trace the car Ac circuit component operating switches.
- 4 Check the Car AC filters if need clean or replace it as needed.
- 5 Check the condenser and make sure the evaporator coil free of dirt.
- 6 Inspect for possible blockage in the drain lines to allow free flow.
- 7 Replace worn parts such as compressor drive belts.
- 8 Check the AC components mountings, if need tighten the components base mountings.
- 9 Check the thermostat control, humidity levels and timer.
- 10 Check the car AC control ECU and their wire connections.
- 11 Inspect moving parts such as condenser cooling fan compressor pulley, compressor bearing compressor drive motor etc.
- 12 Lubricate the moving parts where ever necessary.
- 13 Replace the dead batteries and check all electrical connections.
- 14 Check the car cabin for possible leaks and see if its door is closing securely.
- 15 Check the drier unit, if need replace the drier unit.
- 16 Check the compressor operation and it output.
- 17 Check the blower unit function if need replace it.
- 18 Clean the outer unit.
- 19 Check heating equipment filters, if need clean or replace it.
- 20 Check the gas pressure and possible leakage from any of car AC components.
- 21 Inspect the heat pump periodically.
- 22 Check the car AC wire of all electrical connections.
- 23 Lubricate the moving parts as on need.
- 24 Examine the flue system for possible issues.
- 25 Check blower fan, blower unit mounting ducts and vents switches etc (Fig 1)
- 26 Check the refrigerant pressure, if need full the gas as required.
- 27 Check the condenser cooling fan blade angle, if need replace the fan blades. (Fig 2)
- 28 Routinely carried out Periodical maintenance as per manufacturers recommendations.

Fig 1

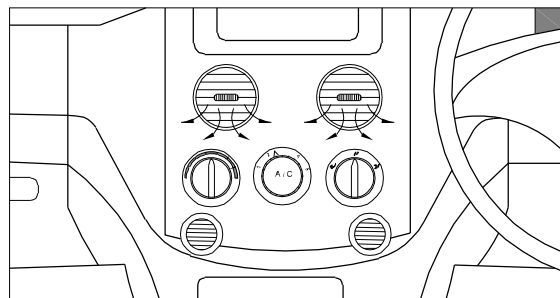
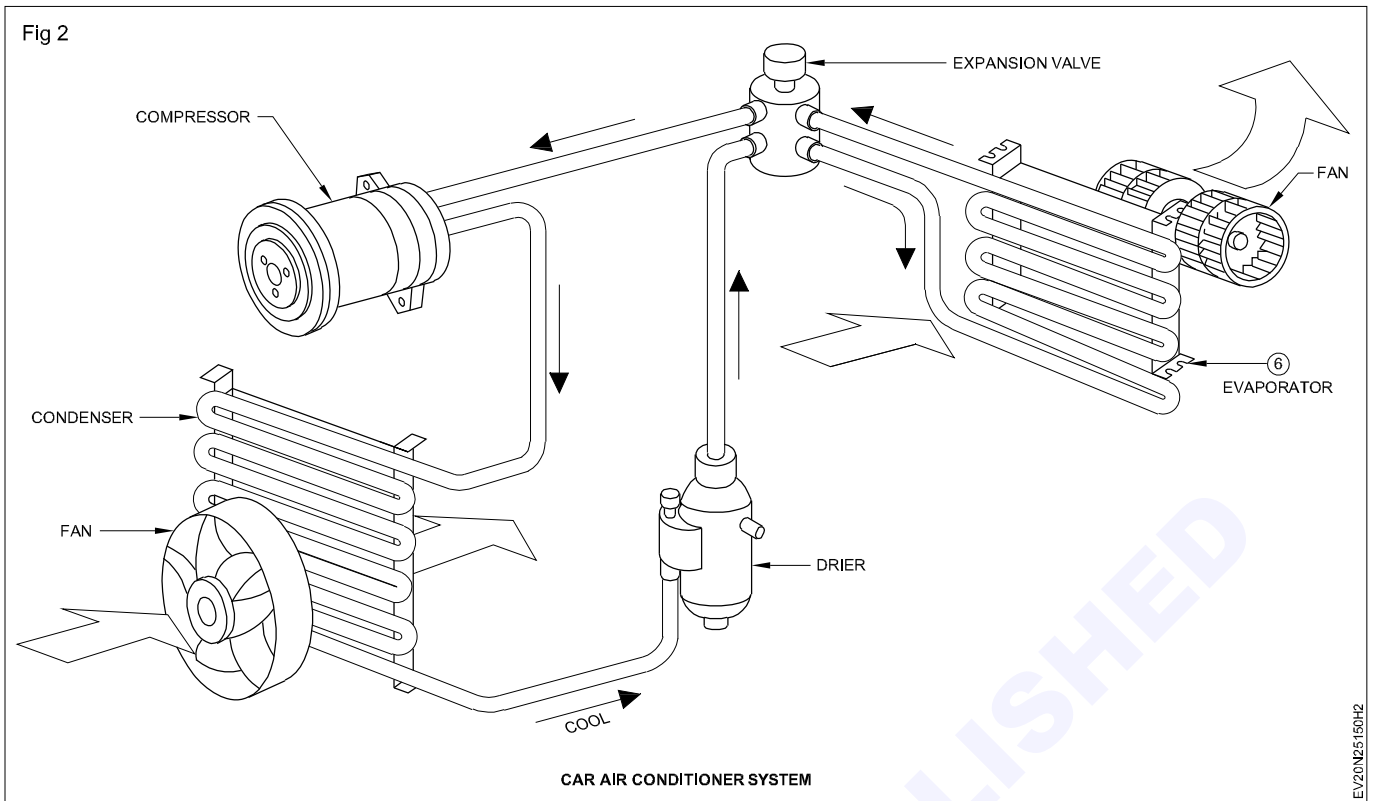


Fig 2



EV20N25150H2

Practice on demonstrate working of grinding machine

Objectives: At the end of this exercise you shall be able to

- demonstrate working of grinding machine
- operate a bench grinder with safety.

Requirements			
Tools/instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
Equipment/Machineries		• Soap oil	- as reqd.
• Grinding machine	- 1 No.	• Water	- as reqd.

PROCEDURE

TASK 1: Working of Grinding Machine

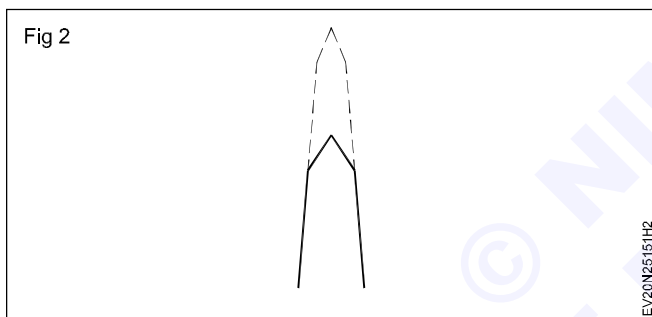
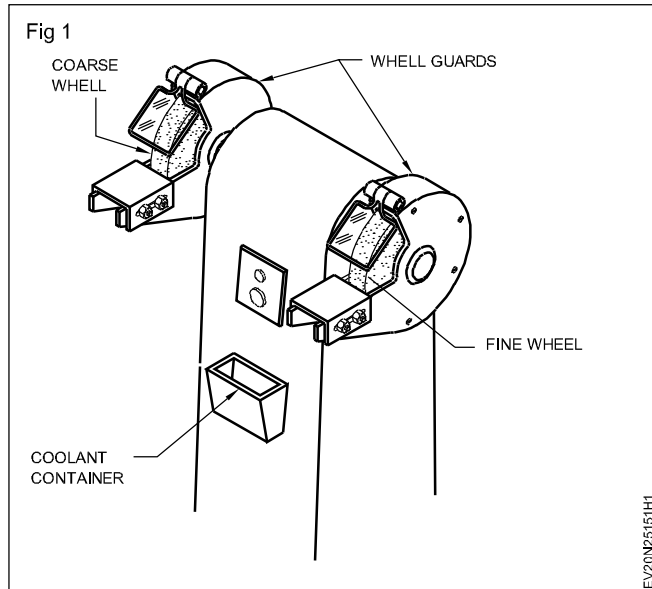
Note:

- 1 Grinding machine is a machine tool which is used for removing of rough surface of a work piece with help of rotating abrasive wheel that act as a tool.
- 2 The instructor has to demonstrate the working of grinding machine and explain the function of each part of machine.

- 1 Study the grinding machine manual for identify the parts and their function of each parts.
- 2 Identify the type of grinding machine like bench grinding, flexible, shaft grinding, swing frame grinding, abrasive belt grinding, precision grinding.
- 3 Identify the grinding machine wheels, wheel head, base, saddle table, headstock, tailstock and cross tool rest, wheel guard, ON/OFF switch motor etc.
- 4 Choosing and applying the right attachment for the job.
- 5 Pick a wire brush attachment for cleaning and paint removal job.
- 6 Make sure to pick the right type of blade for the project.
- 7 Suppose if you are operating angle grinding, follow the steps.
- 8 Put on safety gear like goggles, long sleeves and full face protection.
- 9 Put in ear plugs.
- 10 Wear a dust mask for particularly dust jobs like sanding and grinding motor.
- 11 Support the tool with both hands. Grab the handle with whatever hand feels most comfortable.
- 12 Let the grinding come to full speed before applying it to the surface.
- 13 Hit the power button to turn it on whether you are cutting grinding or sanding
- 14 Allow it to come up to speed to help you keep your action smooth and consistent.
- 15 Move angle grinder around constantly when sanding or cleaning don't keep the tool in one place when sanding as you could end up with gauges.
- 16 For smooth finish move in a rotating motor over the surface.
- 17 Apply the tool with light pressure when cutting or grinding.
- 18 Just hold the grinding on the object and the rotation will cut or grind the tool if you press down too hard you could cause the tool to yank and on the place you are working on which in turn could make the tool pack when a tool kicks it could lead to injury.
- 19 Use the correct angle for the wheel attachment for sanding apply the tool at yeah 5° to 10° angle to the work surface.
- 20 Keep the guard on, the guard may get in the way the guard provide some protection from flying derbies.
- 21 Check the grinder has stopped spinning completely before putting it down.
- 22 Unplug the tool when you are not using grinding machine.

TASK 2: Operate a bench grinder with safety

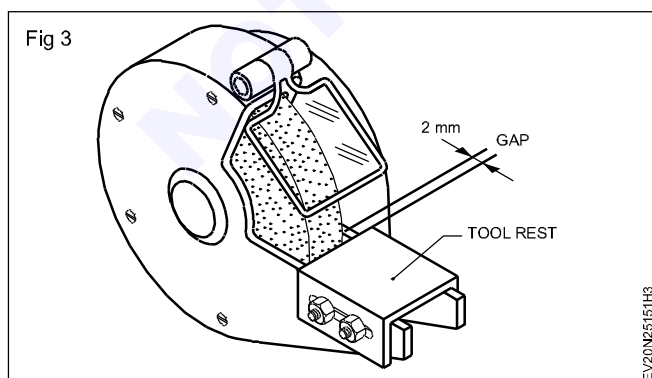
- 1 Chisel will become blunted you to use for efficiency in chipping, the chisels are to be re-sharpened regularly.
- 2 Chisels are sharpened on grinding machines. (Fig 1 & Fig 2)



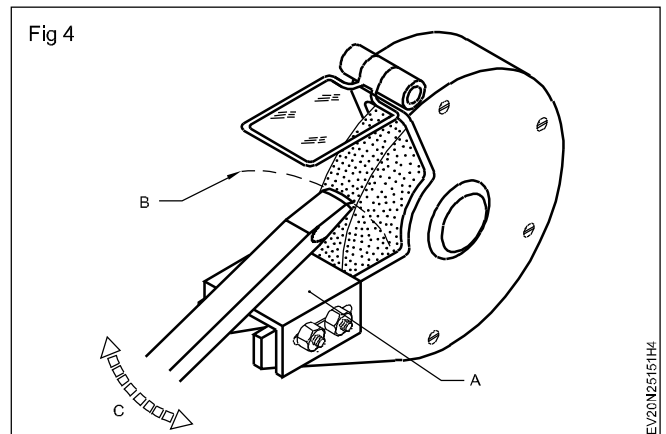
- 3 Inspect the tool-rest. If there is too much of a gap between the tool-rest and the wheel, adjust it, and position it as close to the wheel as possible. (Fig 4)

Ensure that there is sufficient coolant in the container.

While grinding, rest the body of the chisel on the tool-rest (A), and allow the point to touch the wheel. (Fig 3)



- 4 Rock the point slightly on both sides in an arc (B) to provide a slight convexity at the cutting edge. This will help to avoid digging in of the sides while chipping.



- 5 Keep moving the chisel across the face to prevent formation of curves and grooves at the cutting edge.

After re-grinding many times, the cutting edges become too thick. Such chisels are unsuitable for resharping. They should be forged and brought to shape before grinding.

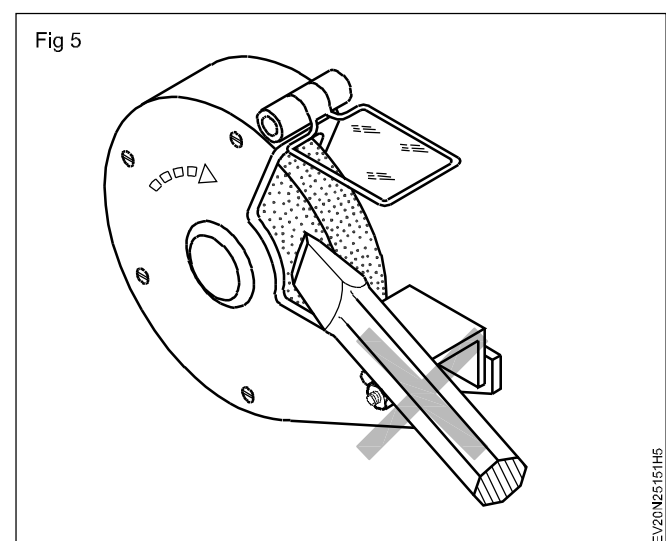
Check the wheel guards are in place, and are securely fastened.

Inspect the condition of the grinding wheel for breakage and cracks.

Wear safety goggles.

When switching on the grinding machine, stand aside until the wheel reaches the operating speed.

- 6 DIP the chisel frequently in the coolant to avoid overheating. Overheating will draw the temper of the chisel.
- 7 Clean by grinding, if the chisel-head is mushroomed.
- 8 Use only the front of the grinding wheel. Do not grind on the sides. (Fig 5)



- 9 Report to instructor, if any damage to the grinding wheel is noticed.

Do not use cotton waste or other material for holding the chisel while grinding a job.

Practice on identify the automatic transmission components

Objectives: At the end of this exercise you shall be able to

- identify the EV automatic transmission components and related sensors.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle service manual	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1: Identify the E.V automatic transmission components and their related sensors

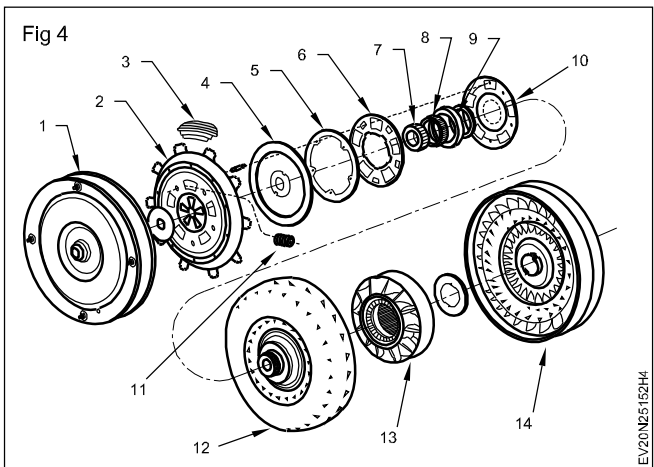
Note: The instructor has to locate the EV automatic transmission components and their related sensors.

- 1 Park the vehicle on the shop floor.
- 2 Study the vehicle service manual for achieve the knowledge about EV automatic transmission components.
- 3 Trace the EV automatic transmission system layout in a vehicle.
- 4 Identify the EV traction motor.
- 5 Identify the torque converter.
- 6 Identify the plantary gear sets. (Fig 3)
- 7 Identify the hydraulic system.
- 8 Identify the throttle position sensor.
- 9 Identify the speed sensor monitors the speed of the transmission's input shaft.
- 10 Identify the speed sensor monitors the speed of the transmissions output shaft.
- 11 Identify gear box. (Fig 2)
- 12 Identify the differential. (Fig 1)
- 13 Identify the half shaft. (Fig 1)
- 14 Identify the wheels.



Fig 1

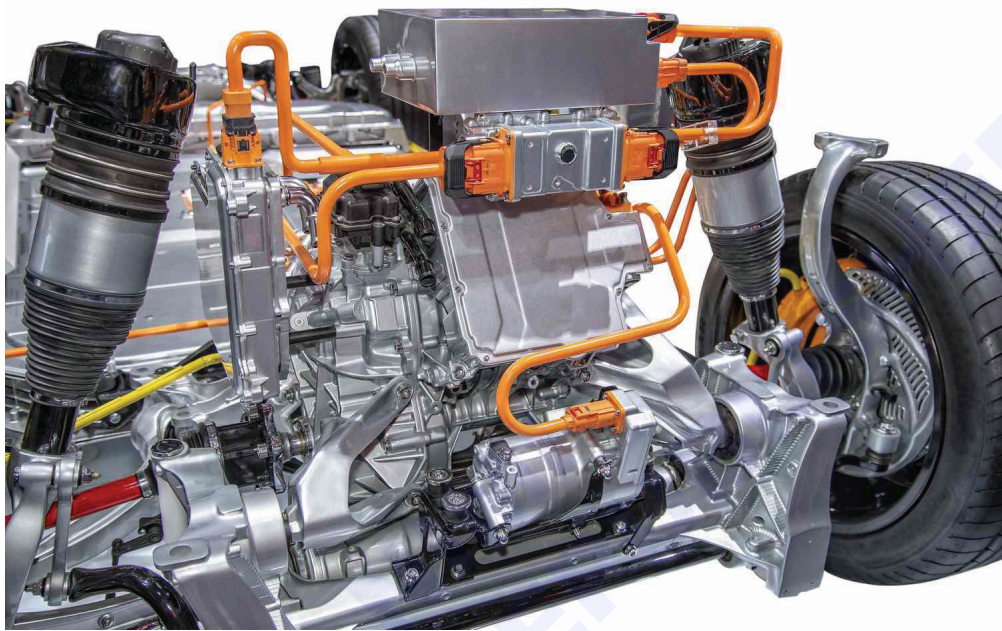
Identify the various parts of an automatic transmission system as shown in Fig 4



EV20N25152H4

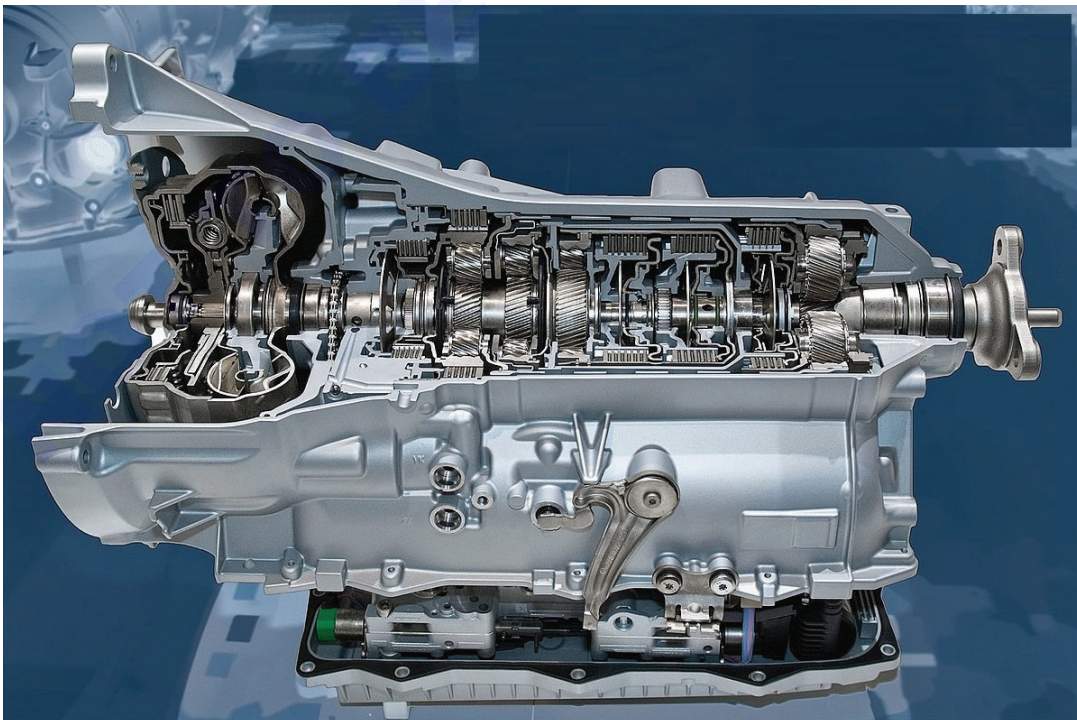
- | | |
|------------------------|----------------------------|
| 1 Cover assembly. | 8 Roller assembly one way |
| 2 Clutch transfer ring | 9 Drive hub |
| 3 Shoe assembly | 10 End cover |
| 4 Washer | 11 Spring |
| 5 Pressure plate | 12 Turbine assembly |
| 6 Plate | 13 Reactor clutch assembly |
| 7 Innerrace | 14 Impeller assembly |

Fig 2



The drive unit of an Electrical vehicle

Fig 3



Practice on trace wiring circuit of RCA and automatic transmission

Objectives: At the end of this exercise you shall be able to

- trace a wiring circuit of RCA and automatic transmission.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1: Tracing a wiring circuit of RCA and automatic transmission

- 1 Park the vehicle on the shop floor.

Note: The instructor has to demonstrate the method of tracing a wiring circuit of RCA and automatic transmission.

- 2 Study the service manual for trace the RCA and automatic transmission wiring circuits.
- 3 Trace the traction motor wire connections.
- 4 Trace the speed sensor wire connection of transmission output shaft. (Fig 1)
- 5 Trace the speed sensor wire connection of transmission input shaft.
- 6 Trace the fluid pressure sensor wire connections.
- 7 Trace the tyre pressure sensors wire connection.
- 8 Trace the ECU wire connections with automatic transmission control sensor. (Fig 2)
- 9 Trace the traction motor position sensor wire connections (Fig 2)

Fig 1

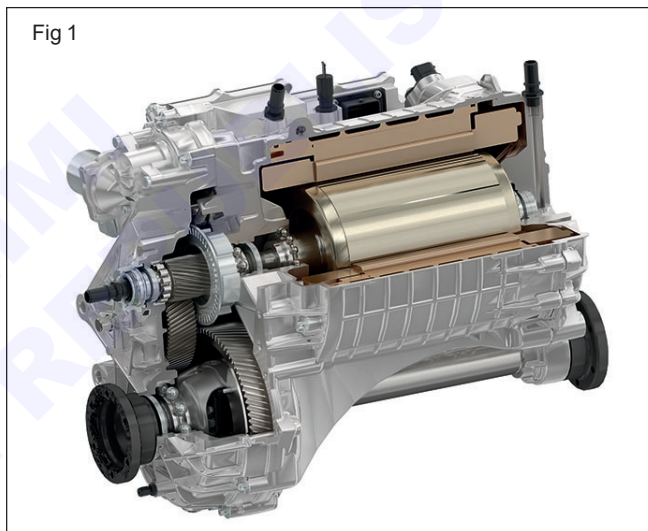
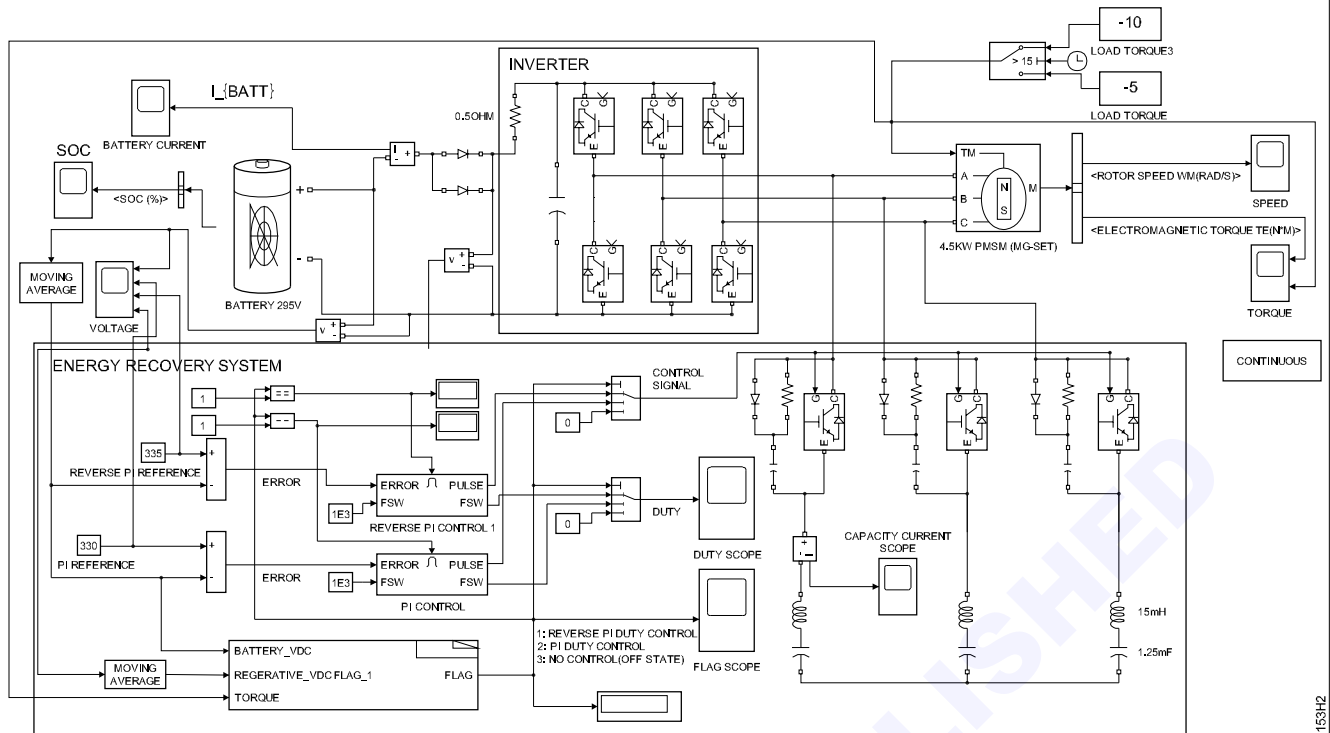


Fig 2



SIMULATOR FOR THE GENERATED VOLTAGE CONTROL ALGORITHM VERIFICATION

EV20N25153H2

Practice on identify the electronic power steering components

Objectives: At the end of this exercise you shall be able to

- identify the electronic power steering components
- identify the electronic power steering sensor.

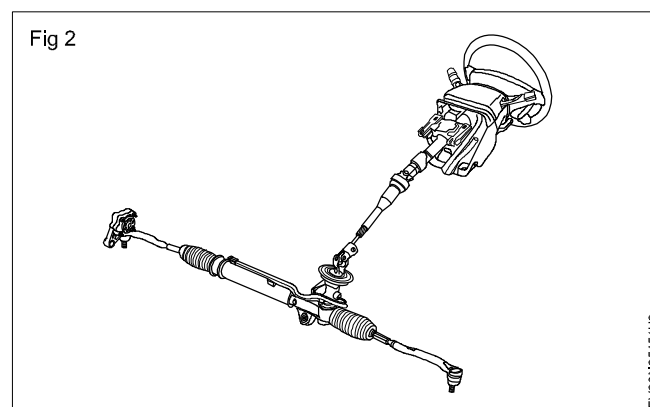
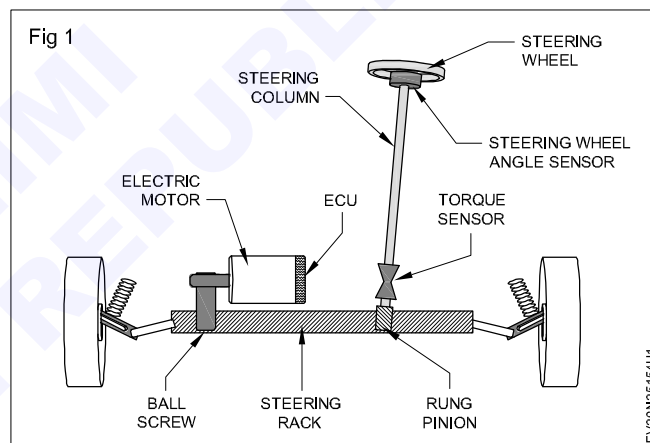
Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle service manual	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1: Identify the electronic power steering components and related sensors

Note: The instructor has to indicate the power steering components and sensor's location on the EV.

- 1 Select the electric vehicle with electronic power steering
- 2 Park the vehicle on the shop floor.
- 3 Study the vehicle manual title of electronic power steering and observe the components and sensor's location.
- 4 Study the wiring circuit of electronic power steering
- 5 Trace the EV electronic power steering layout in a vehicle.
- 6 Identify the steering mounting with vehicle body.
- 7 Identify the steering wheel.
- 8 Identify the steering column.
- 9 Identify the wheel angle sensor.
- 10 Identify the Torque sensor. (Fig 1)
- 11 Identify the Electric motor. (Fig 1)
- 12 Identify the ECU. (Fig 1)
- 13 Identify the Ball screw. (Fig 1)
- 14 Identify the Steering rack. (Fig 1)
- 15 Identify the Ring pinion. (Fig 1)
- 16 Identify the Tic rod. (Fig 2)



Practice on hand's on for RCA and tracing wiring circuit in EPS

Objectives: At the end of this exercise you shall be able to

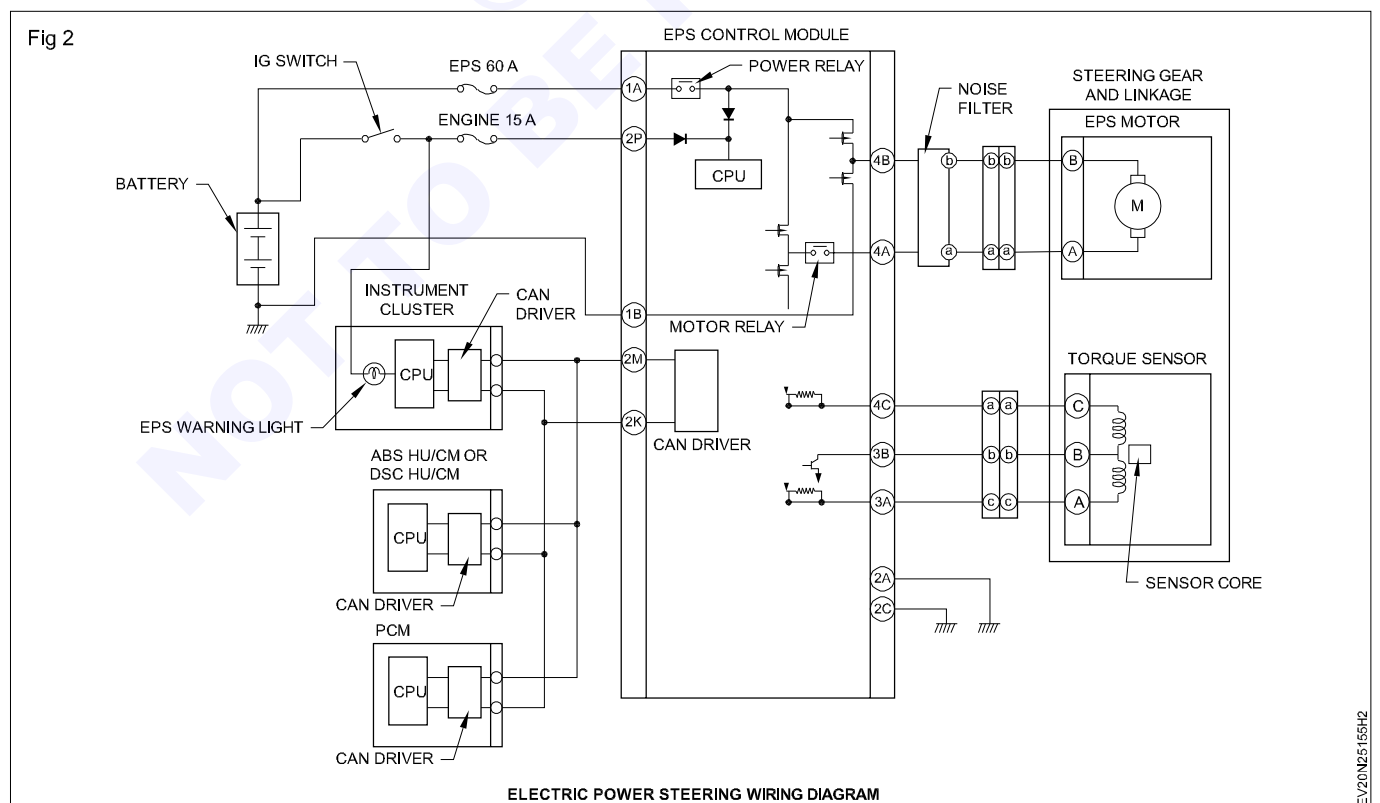
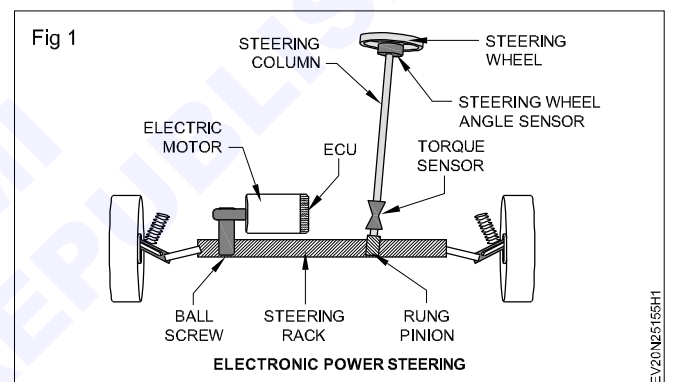
- tracing RCA and EPS wiring circuit.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Wire	- as reqd.
Equipments/Machineries	• Electric vehicle	• Insulation tape	- as reqd.
		• Cotton waste	- as reqd.
		• Soap oil	- as reqd.

PROCEDURE

TASK 1: Tracing the electronic power steering RCA and EPS wiring circuit (Fig 1)

- Park the vehicle on the shop floor.
- Open the vehicle door and trace the steering layout.
- Trace the steering electronic control unit.
- Trace the electronic control unit wiring connections.
- Trace the steering wheel angle sensor wiring connections.
- Trace the steering torque sensor wiring connection.
- Trace the central ECU wire connections with steering electrical and electronic components.(Fig 2)



Practice on recognition of EV symbols

Objectives: At the end of this exercise you shall be able to

- identify the symbols of electric vehicle.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• EV symbols chart	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1: Recognition of EV symbols, signs and road marking

Note: The instructor has to explain the EV signs and image given informations.

- 3 Identify the electric vehicle parking sign
- 4 Note down the symbols given information in table 1

- 1 Hang the Electric vehicle symbols chart on the wall
- 2 Identify the electric vehicle charging and service signs (Fig 1)

Fig 1

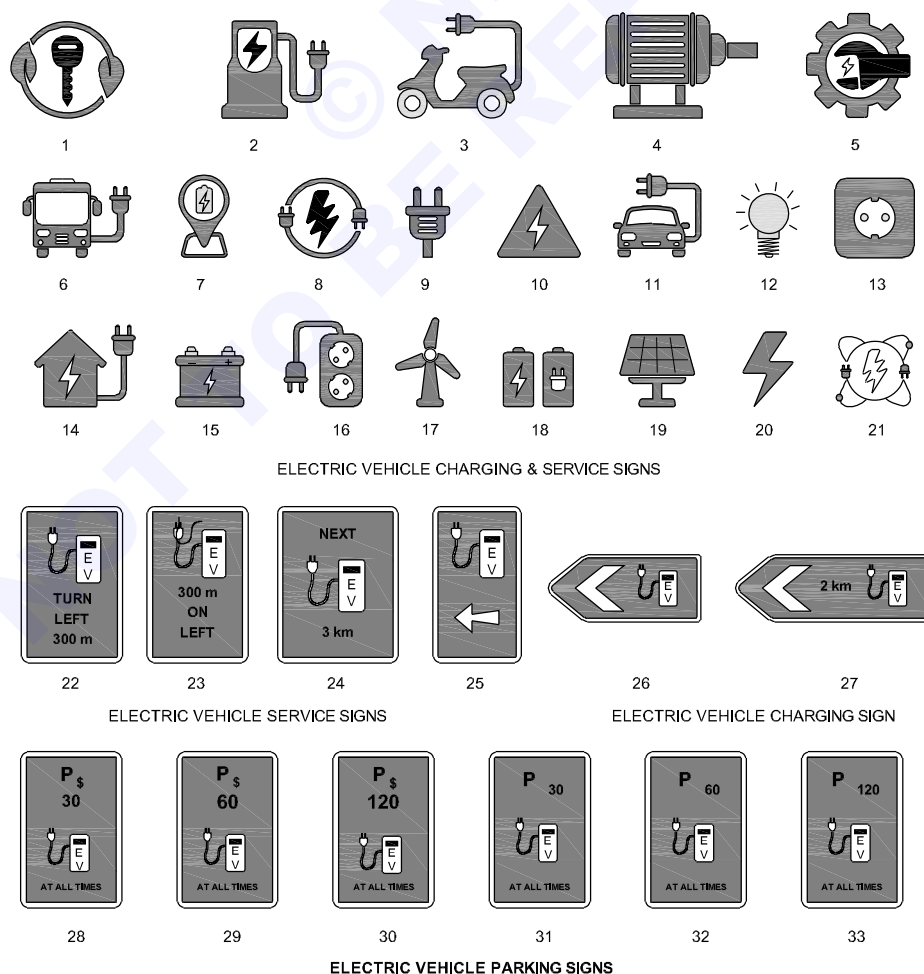


Table-01

S.No	Image S.No	Image given information	Remarks
1	2		
2	3		
3	4		
4	5		
5	6		
6	9		
7	10		
8	13		
9	15		
10	16		
11	18		
12	19		
13	20		
14	21		
15	23		
16	25		
17	26		
18	27		
19	28		
20	32		

Practice on tracing wiring circuit of parking co-passenger seat belt sensor

Objectives: At the end of this exercise you shall be able to

- tracing parking sensor wiring circuit
- tracing the passenger seat belt sensor wiring circuit.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Vehicle service manual - 1 No.

Equipments/Machineries

- Electric vehicle - 1 No.

Materials

- Cotton waste - as reqd.
- Soap oil - as reqd.

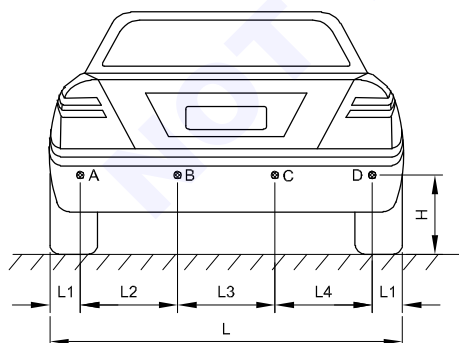
PROCEDURE

TASK 1: Tracing the wiring circuit of parking sensor, co-passenger seat belt sensor and passenger and driver seat belt sensor

Note: The instructor has to indicate the location of parking sensor passenger seat belt sensor and their wire connections of both end

- 1 Park the vehicle on the shop floor.
- 2 Use the personal safety kit while you are working with electric vehicle.
- 3 Switch off the EV battery power before tracing the sensor wiring.
- 4 Study the service manual wiring diagram figure and note the wire color code and number code on the wire.
- 5 Identify the vehicle ECU and their wiring.
- 6 Identify the front and rear parking sensor's locations.
- 7 Identify the how many sensors provided in front and rear bumper of the vehicle as shown in Fig 1, 2 & 3.

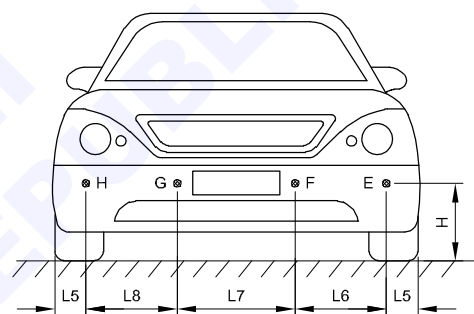
Fig 1



MOUNTING HEIGHT AND POSITION (REAR SENSORS)
 $H = 50 \sim 80 \text{ cm (20" ~ 32")}$
 $L1 = 6 \sim 15 \text{ cm (2" ~ 6")}$
 $L2 = L3 = L4 \text{ (OR) } L2 = L4 = 0.3L, L3 = 0.4L$

EV20N25157H1

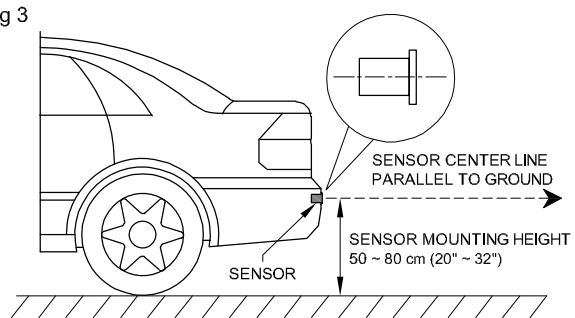
Fig 2



MOUNTING HEIGHT AND POSITION (FRONT SENSORS)
 $H = 50 \sim 80 \text{ cm (20" ~ 32")}$
 $L5 = 6 \sim 15 \text{ cm (2" ~ 6")}$
 $L6 = L7 = L8 \text{ (OR) } L6 = L8 = 0.3L, L7 = 0.4L$

EV20N26157H2

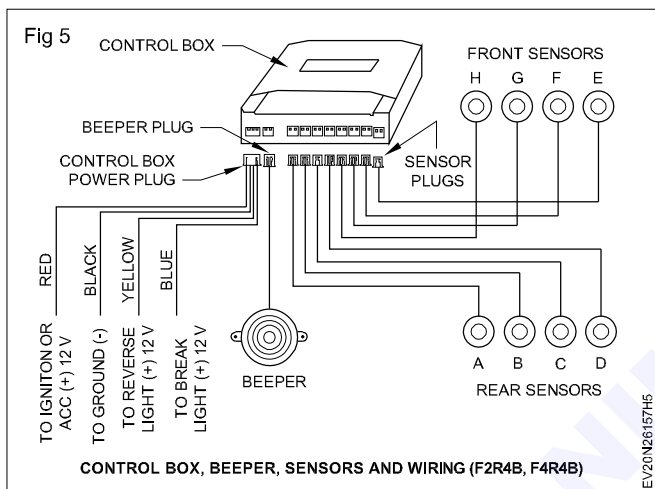
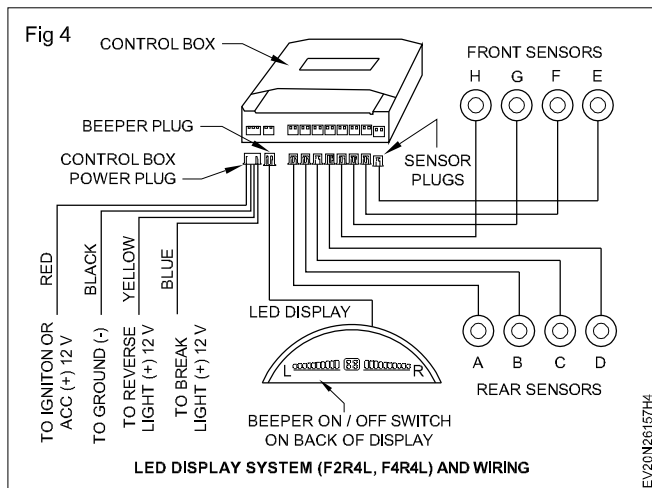
Fig 3



MOUNTING HEIGHT AND ANGLE OF SENSORS

EV20N26157H3

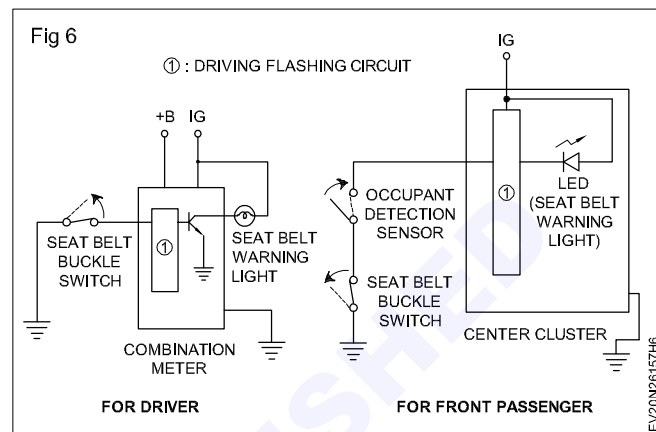
- 8 Identify the LED display system, control box and their wiring circuit as shown in Fig 4.
- 9 Identify control box beeper, sensor and their wiring as shown in Fig 5.
- 10 Identify the co-passenger seat belt sensors and driver's seat belt sensor and their wiring circuit.
- 11 Identify the seat belt warning buzzer and their wiring circuit.



12 Trace the driving flashing circuit as shown in Fig 6.

13 Identify the seat belt buckle switch and their wire connections.

Note: Refer the particular EV's service manual for correct location and wiring circuit of co-passenger and driver's seat belt sensor and warning systems wiring circuit.



Practice on check the accuracy of grinding machine

Objectives: At the end of this exercise you shall be able to

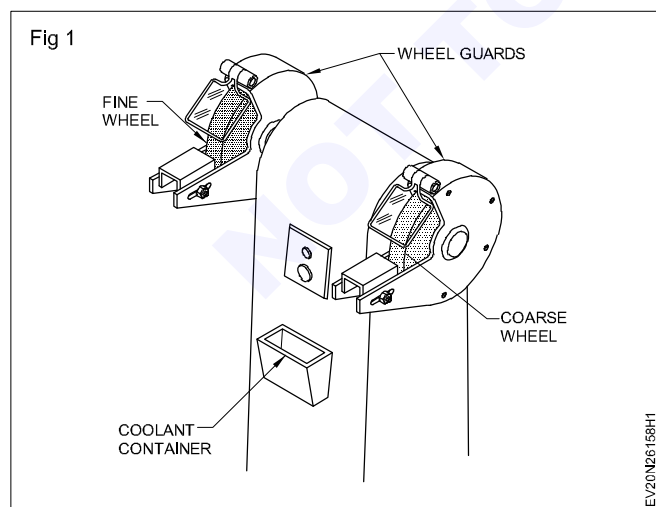
- **check the accuracy of grinding machine after assembly.**

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Chisel	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries			
• Grinding machine	- 1 No.		
• Work bench	- 1 No.		

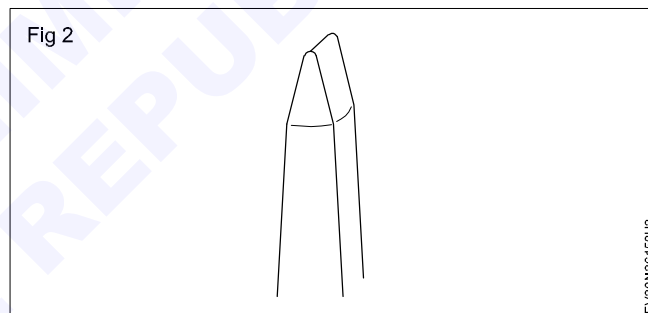
PROCEDURE

TASK 1: Check the accuracy of bench grinding machine after assembling

- Clean the dismantled parts of grinding machine parts.
- Assemble the dismantled bench grinding machine.
- Ensure the grinding machine is properly assembled and flited all part of grinding machine as per grinding machine manufacturers recommendation.
- Mount the grinding machine on the machine bed.
- Connect the electrical wire connection with motor switch.
- Connect the coolant container on the machine.
- Ensure the grinding machine mounting power connection is properly connected and tighten it as per specified limit.
- Rotate the grinding wheel and ensure both side grinding Wheel is freely rotating as shown in Fig 1.
- Select the tool for head sharpening with grinding wheel.
- Suppose you are selecting the chisel for sharpening chisel head. (Fig 2)



- Operate the machine by switch on the power.
- Ensure the machine is rotating without noise.

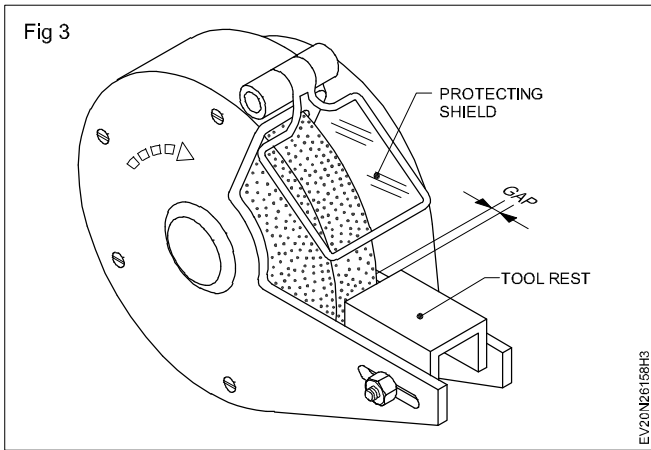


- Inspect the tool rest of the grinding machine.
- If there is too much gap between the tool rest and the wheel, adjust it, and position it as close to the wheel as possible.

Ensure that there is sufficient coolant in the container.

While grinding rest the body of the chisel on the tool-rest (A), and allow the point to touch the wheel. (Fig 3)

- Rock the point slightly on both sides in arc (B) to provide a slight convexity at the cutting edge. This will help to avoid digging in of the sides while chipping.
- Keep moving the chisel across the face (C) to prevent formation of curves and grooves at the cutting edge.
- Dip the grinding tool in the coolant frequently to avoid overheating.

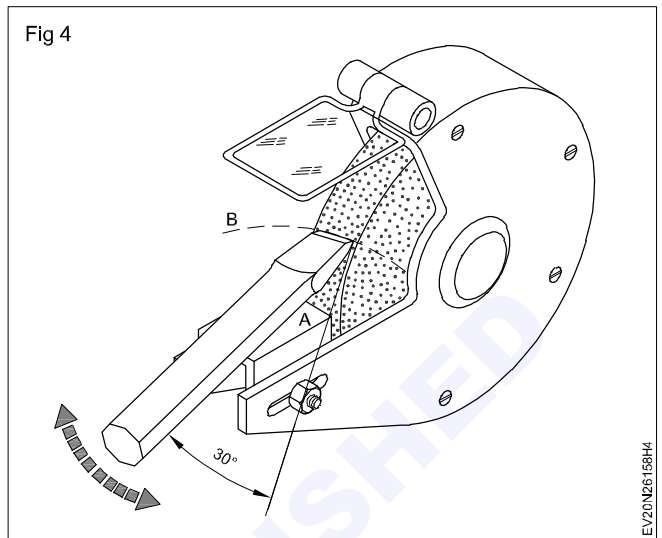


18 Check the sharpness of chisel head if need again grind the chisel head with fire wheel for smooth sharpness of chisel head.

Note: If the tool head sharpness is not as specified limit, recheck the grinding wheels quality and tool holding position while you are grinding tool. If need replace the grinding wheel.

19 Again, regrind the tool head for achieve the tool head sharpness.(Fig 4)

20 After grinding the tool, clean the chisel head angle and inspect the chisel head angle accuracy with special measuring tool.



Practice on tracing a wiring circuit of parking, co passenger and seat belt sensor

Objectives: At the end of this exercise you shall be able to

- trace the wiring circuit of parking, co-passenger and driver seat belt sensor.
-

Refer the Exercise No. 2.6.157

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Practice on safety precautions and procedures observed while working with EV kit and tools

Objectives: At the end of this exercise you shall be able to

- follow the safety precautions while working with EV kit and tools.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• PPE kit	- 1 No.	• Soap oil	- as reqd.
• Special tool kit for EV	- 1 No.		
Equipments/Machineries			
• Electric Vehicle	- 1 No.		

PROCEDURE

TASK 1: Follow the safety precautions while working with Electric Vehicle

Note: The instructor has to demonstrate to observe the safety precautions while working with electric vehicle.

- 1 Park the vehicle on the shop floor and keep the warning board in front of vehicle.
- 2 Secure the vehicle in a cordoned-off area with appropriate warning signage..
- 3 Wear the safety personal protective kit according to nature of work with electric vehicle whether it is mechanical work or electrical work or welding work or tinkering and painting work (cotton gloves inside insulated rubber gloves, face shield goggles, non-slippery insulated boots/over shoes insulated tools, overall combination) etc.
- 4 Switch OFF the battery power while you are work with electric vehicle.
- 5 Ensure there is no power in the system component after battery power cut OFF.
- 6 Check that vehicle is in a safe condition before start work.
- 7 Use the insulated tools while work with electrical and electronic power circuit components.
- 8 Don't allow the children and other friends near the vehicle repair work area.
- 9 Use the recommended tool kit for Electric vehicle repair work.
- 10 Keep the tools neat and clean.
- 11 Keep the work place neat and clean.
- 12 Don't smoke in work place.
- 13 Don't use the easily fire catch materials near the electric vehicle.
- 14 Wait for 5-10 minutes before working on the vehicle after the super capacitors have been discharged.
- 15 Ensure with a multimeter that voltage is between 10 to 0 before starting repair and vehicle maintenance.

— — — — —

Practice on study the gear box function and gear ratio

Objectives: At the end of this exercise you shall be able to

- study the gear box function
- study the gear box gear ratio.

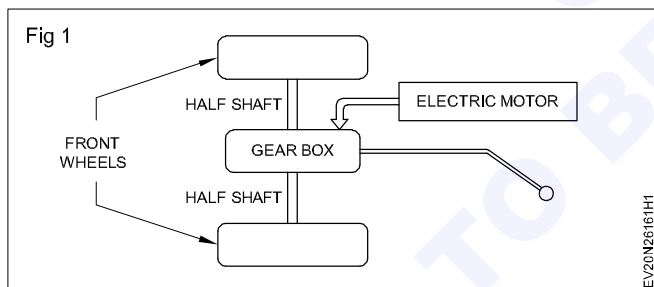
Requirements			
Tools/Instruments		Materials	
• Trainees's tool kit	- 1 No.	• Cotton waste	- as reqd.
• EV Service manual	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries			
• Electric Vehicle	- 1 No.		
• Electric Vehicle gear box	- 1 No.		

PROCEDURE

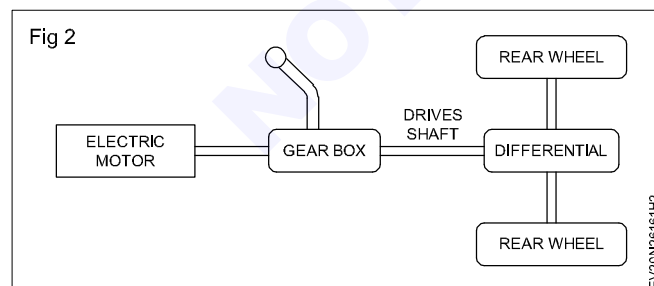
Task 1 : Study the EV gear box function

Note : The instructor has to demonstrate the function of EV gear box and explain the working procedure of gear box.

- 1 Place the cut view model gear box on the works bench.
- 2 Study the gear box construction method and design.
- 3 Study the type of gear box gear arrangements.
- 4 Study the traction motor drive system.(Fig 1)

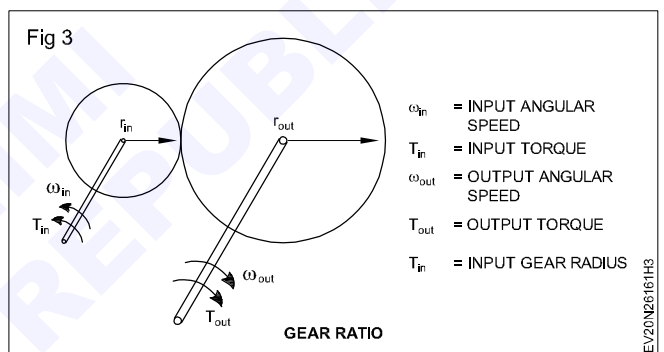


- 5 Study the gear box input and output drive shaft.(Fig 2)

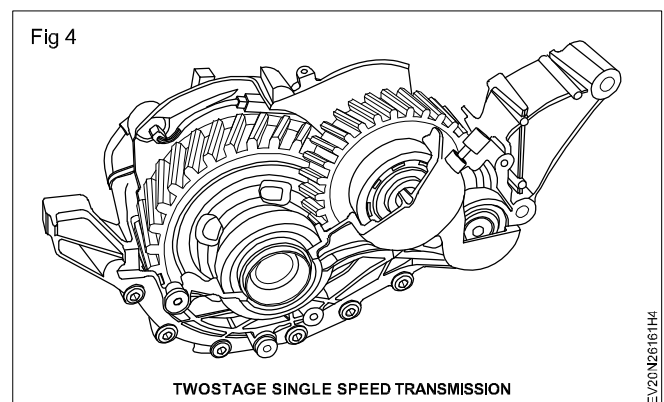


- 6 Study the gear ratio of drive gear and driven gear. (Fig 3)

Note: Gears are used to increase or decrease the vehicle speed or gear can be used as a torque multiplayer or speed reducer.



- 7 Check power to the gear box input shaft and check the power its gear box output shaft.
- 8 Check the speed of traction motor.
- 9 Identify the gear box types (Spur, helical, bevel, worm gear).(Fig 4)



Note : Gear box gears are placed in combination for transmit the power from one gear to another gear. The teeth at both gears locks the driving and driven shafts together to transfer the energy through contact with little.

Note : The gear ratio is defined in terms of the ratio of speed transformation between the input shaft and the output shaft.

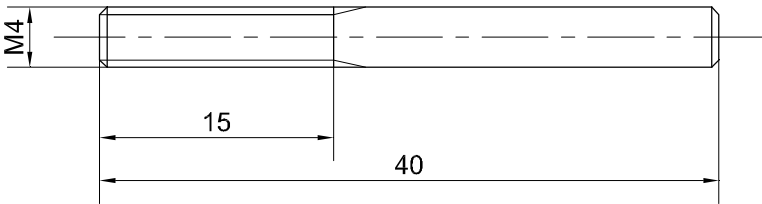
- 10 Study the each speed gear's number of teeth and note the driven gear's number of teeth drive gears number of teeth.
- 11 Compare the drive gear and driven gear teeth.
- 12 Find the each speed gear ratio for example driven gear teeth is 20 and drive gear teeth is 10 so it ratio $10/20 = 2:1$.

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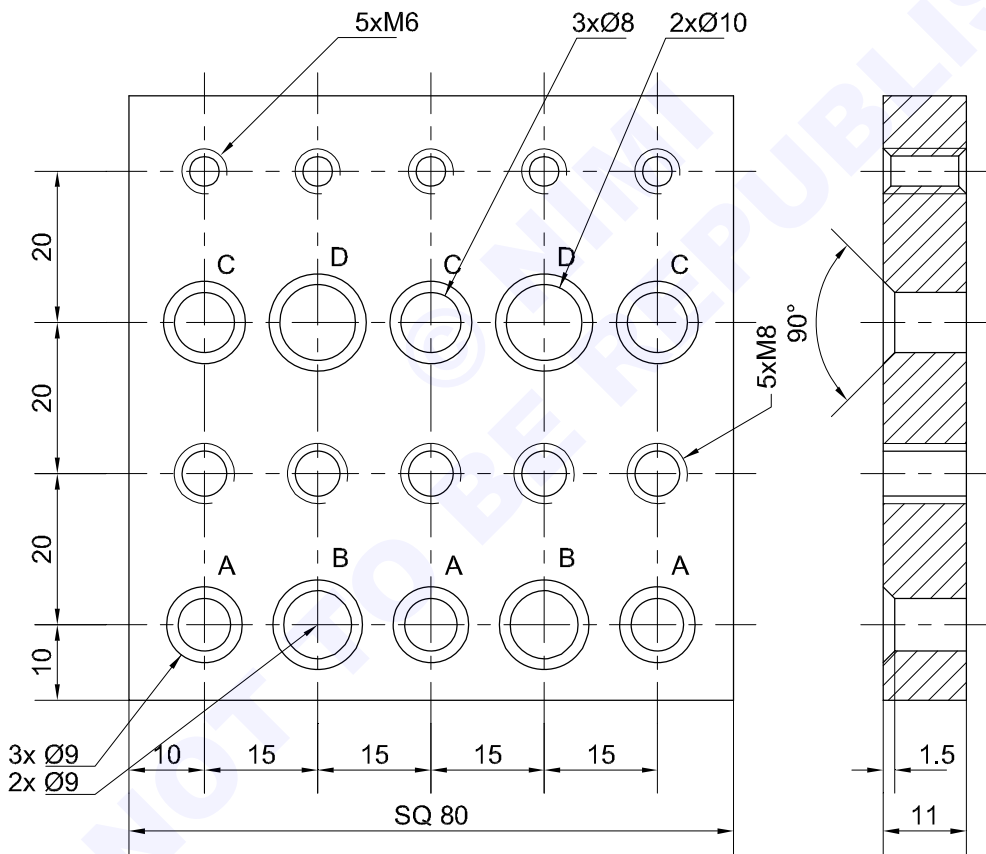
Practice on form internal threads with taps to standard size

- Objectives: At the end of this exercise you shall be able to
- file surfaces flat and parallel within ± 2 mm
 - drill through holes
 - countersink holes to fit standard screw heads
 - cut internal threads using hand taps.

1



2



1	5x45		Fe310		1	1.3.14
1	90ISF12x85	-	Fe310		2	1.3.14
NO.OFF	STOCK SIZE	SEMI-PRODUCT	MATERIAL	PROJECT NO.	PART NO.	Ex.No.
SCALE 1:1					DEVIATIONS ± 0.1	
CUTTING INTERNAL THREADINGS					CODE NO. EV20N26162E1	

PROCEDURE

- 1 Check the raw material for its size.
- 2 File and finish the plate 80 x 11 x 80 within + 0.2mm.
- 3 Locate centres for holes to be drilled, tapped and countersunk.
- 4 Centre punch the centres.
- 5 Drill five, Ø5mm tapping drill size holes for M6 tapping.
- 6 Drill five, Ø6.8 mm tapping drill size holes for M8 tapping.
- 7 Drill four Ø8 mm through holes as per drawing. Enlarge by drilling Ø10mm the 2nd and 4th hole of the second row.
- 8 Drill five Ø 7 mm through holes as per drawing.
- 9 Enlarge the 2nd and 4th holes by drilling Ø9 mm on the 4th row.
- 10 Countersink Ø 8 and Ø10 holes with 90° countersink as per standard. (Refer to the Table)
- 11 Countersink Ø7 and Ø9 mm holes with 120° countersink as per 5 standard. (Refer to the Table)
- 12 Cut M6 internal thread in the four Ø5 mm drilled holes.
- 13 Countersink 120° all the four Ø6.8 mm holes on both sides as per drawing.
- 14 Cut M8 internal threads in all the five Ø6.8 mm drilled holes with M8 taps.
- 15 Check M6 and M8 tapped holes with the supplied M6 and M8 screws, respectively.
- 16 Hold cylindrical blank on vice.
- 17 Cut M4 external thread using M4 dies on part 2.

Skill sequence

Internal threading of through holes using hand taps

Objectives: This shall help you to

- determine the tap drill size for internal threading
- cut internal threads using hand taps.

Determining the tap drill size

For cutting internal threads, it is necessary to determine the size of the hole (tap drill size). This can be calculated using a formula or can be chosen from the table of tap drill sizes.

Drill the hole to the required tap drill size.

Do not forget to give the chamfer required for aligning and starting the tap. (Fig 1)

Hold the work firmly and horizontally in the vice. The top surfaces should be slightly above the level of the vice jaws.

This will help in using a try square without any obstruction while aligning the tap. (Fig 2)

Use soft jaws while holding the finished surface on a vice.

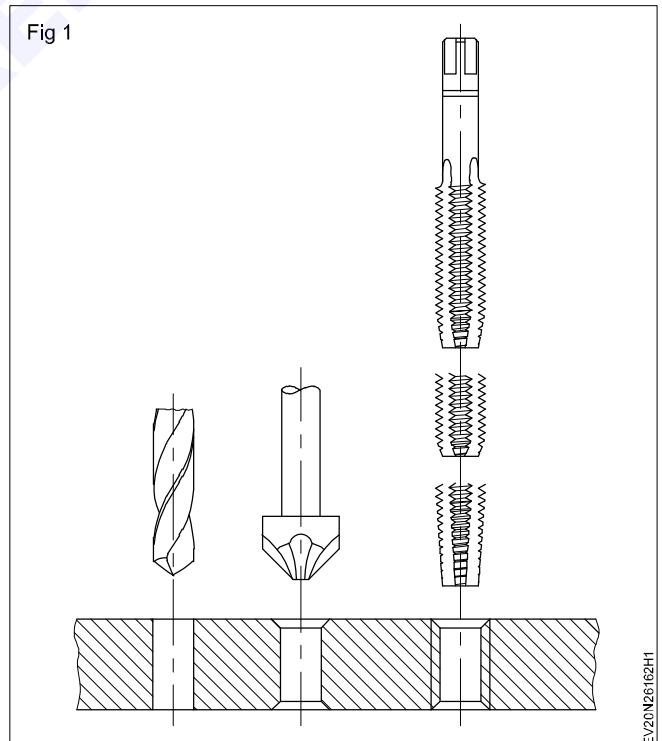
Fix the first tap (Taper tap) in the wrench.

Too small a wrench will need a greater force to turn the tap. Very large and heavy tap wrenches will not give the feel required to turn the tap slowly as it cuts.

Position the tap in the chamfered hole vertically by ensuring the wrench is in the horizontal plane.

Exert steady downward pressure and turn the tap wrench slowly in a clockwise direction to start the thread. Hold the tap wrench close to the centre. (Fig 3)

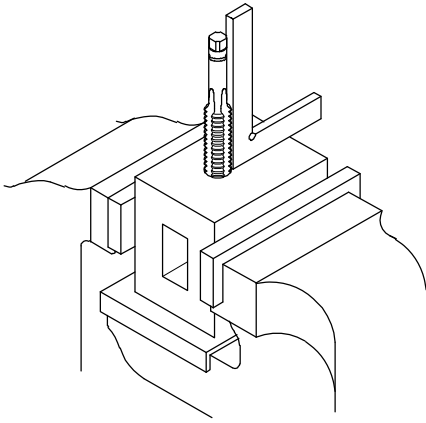
Fig 1



When you are sure of starting of the thread, remove the tap wrench without disturbing the tap alignment.

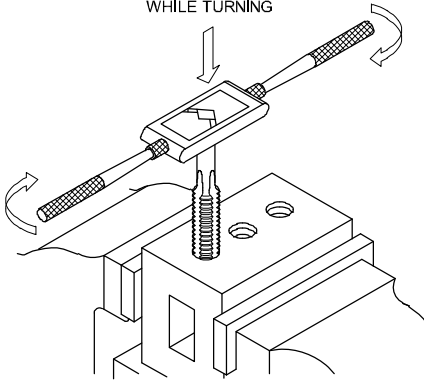
Check and make sure the tap is vertical, use a small try square for help. Place the try square in two positions, 90 to each other. (Fig 4 & Fig 5)

Fig 2



EV20N26162H2

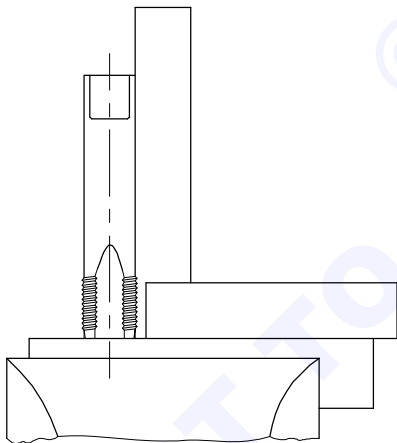
Fig 3

APPLY DOWNWARD PRESSURE
WHILE TURNING

STARTING THE TAP

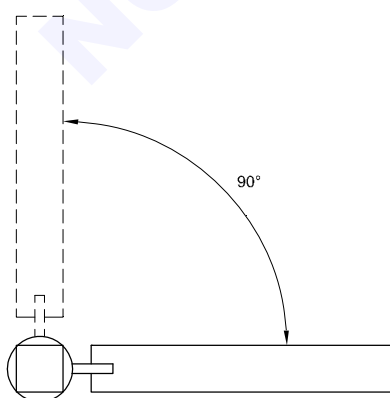
EV20N26162H3

Fig 4



EV20N26162H4

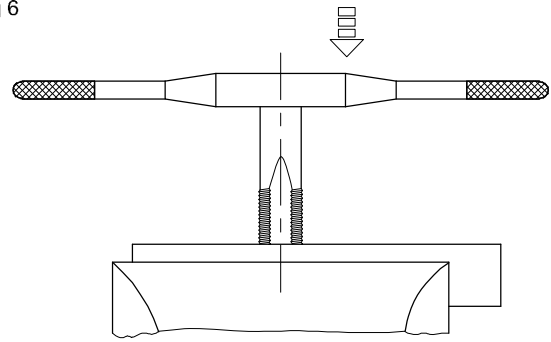
Fig 5



EV20N26162H5

Make corrections, if necessary. This is done by exerting slightly more pressure on the opposite side of the tap inclination. (Fig 6)

Fig 6



SQUARING UP THE TAP

EV20N26162H6

Never apply side pressure without giving a turning motion to the tap.

Check the tap alignment again with a try square.

Fit the tap wrench, and tighten without disturbing the tap alignment.

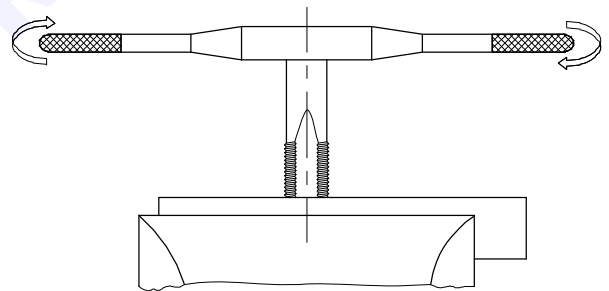
Make one or two turns and check the alignment.

The tap alignment should be corrected within the first few turns.

After the tap is positioned vertically, turn the wrench lightly by holding the ends of the wrench handles without exerting any downward pressure. (Fig 7)

Fig 7

APPLY CONSTANT TURNING PRESSURE



EV20N26162H7

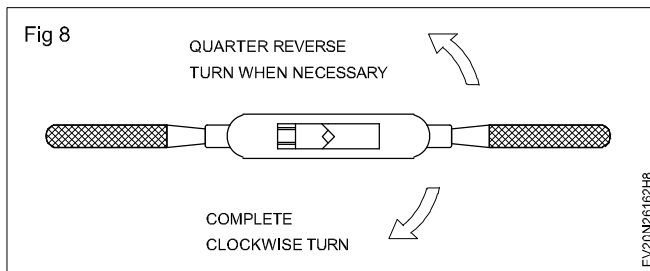
While turning the wrench, the movement should be well balanced. Any extra pressure on one side will spoil the tap alignment and can also cause breakage of the tap.

Continue cutting the thread. Turn backward frequently about quarter turn to break the chip. Stop and turn backward also when some obstruction to movement is felt. (Fig 8)

Use a cutting fluid while cutting the thread.

Cut the thread until the tap is fully inside the hole being threaded.

Finish and clean up using intermediate and plug tap. The intermediate and plug tap will not cut any thread if the tap has entered the hole fully.



Remove the chips from the work with a brush.

Check the threaded hole with a matching screw.

Clean the tap with a brush, and place it back on the stand.

Internal threading blind holes using hand taps

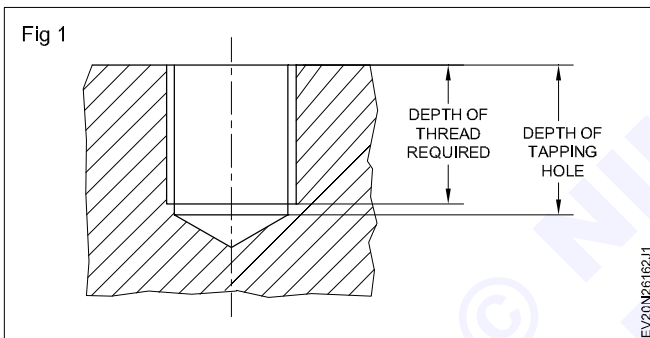
Objectives: This shall help you to

- cut internal threads in blind holes.

Drilling a blind hole

Determine the tapping drill size using the table for tapping drill sizes.

Drill a blind hole (Fig 1) using the depth stop arrangement. The depth of the tapping hole should be slightly more than the depth of the required thread.



Procedure for threading

Remove metal chips, if any from the blind hole by turning it upside down and slightly tapping it on a wooden surface.

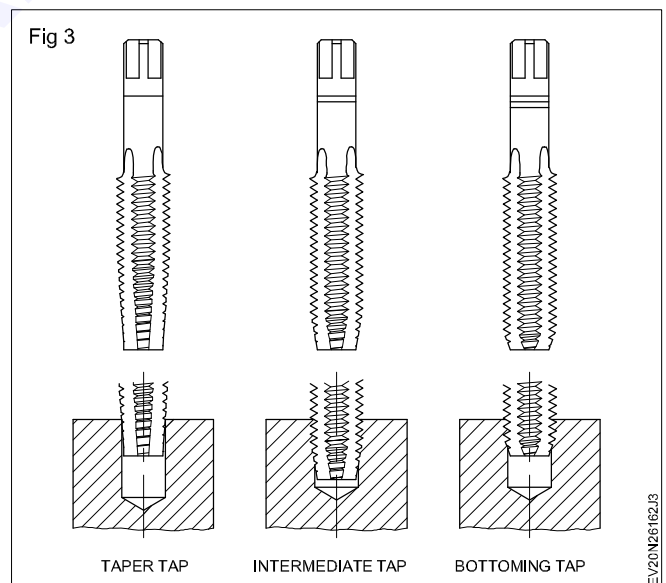
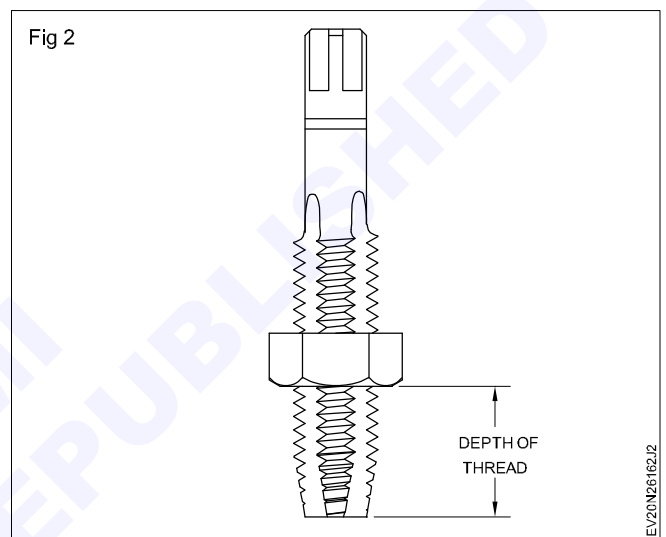
Do not clear chips by blowing as it can cause injury to your eyes.

Screw a matching nut on the first tap to act as a depth stop. (Fig 2)

Thread the blind hole until the nut touches the plate surface.

Remove the chips from the hole frequently, using a flattened and bent wire.

Finish tapping the hole with intermediate and bottoming tap. Set nut to control the depth of thread. (Fig 3)



Practice to list out various requirements for electric vehicle

Objectives: At the end of this exercise you shall be able to

- list out various requirements of electric vehicle.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit		• Cotton waste	- as reqd.
Equipment/Machineries		• Soap oil	- as reqd.
• Electric vehicle		• Electric vehicle kit	- as reqd.

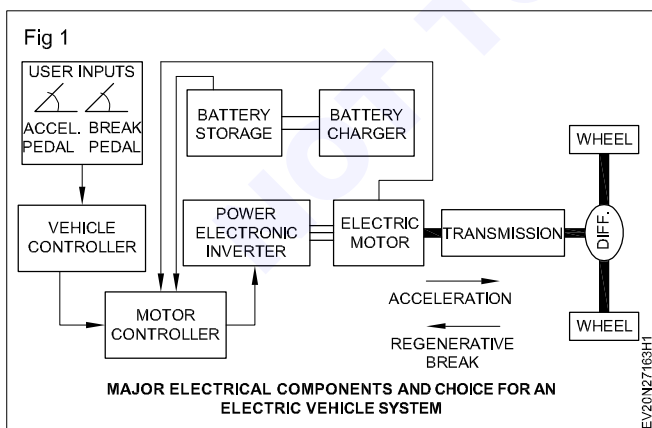
PROCEDURE

TASK 1 : List out the various requirements of electric vehicle

Note : The instructor has to explain the various requirement components of electric vehicle and explain the function of each component and their important role on vehicle function.

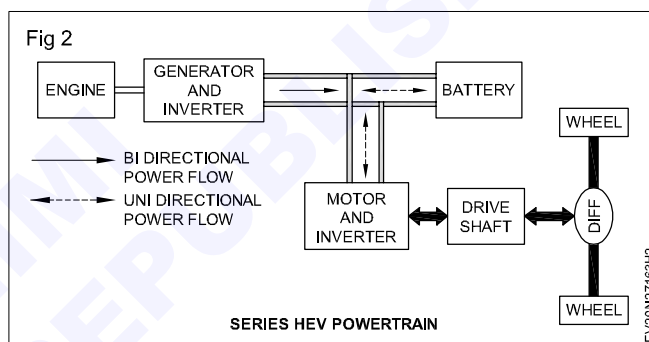
- 1 Park the vehicle on the shop floor.
- 2 Study the manual for achieve the knowledge about vehicle components filled with in a vehicle.
- 3 Take your note book and start to write the various component name by tracing the vehicle functional system of electrical vehicle.
- 4 Note the BEV's power transmission system components.
- 5 Trace the battery charger point, charging port, energy storage (battery), power converter, electric motor, transmission drive shaft wheels and drive control unit, sensor's as shown in Fig 1.

Major electrical components and choices for an EV system. (Fig 1)



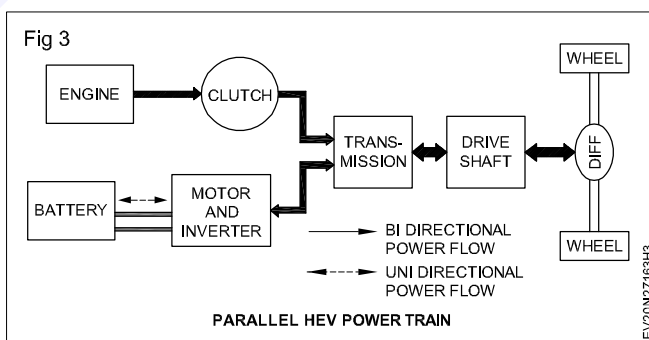
- 6 Note the various components of HEV power train system.

Series HEV powertrain. (Fig 2)



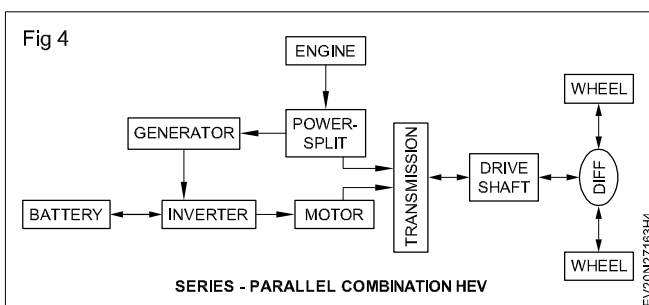
- 7 Note the various components of parallel HEV power train components.

Parallel HEV powertrain (Fig 3)



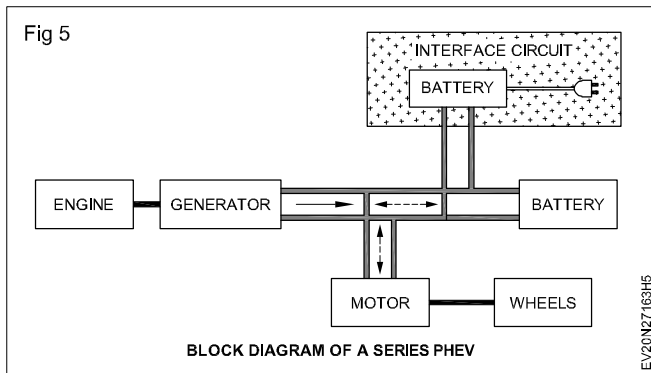
- 8 Note the various components of series parallel combination of HEV.

Series-parallel combination HEV. (Fig 4)



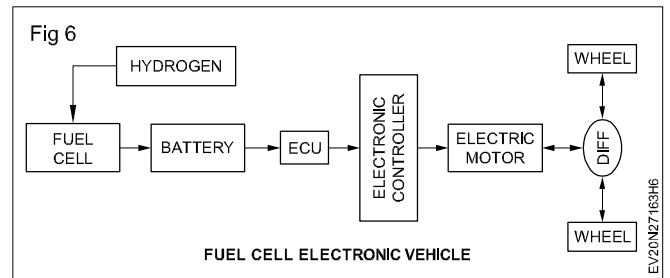
9 Note the various components of series PHEV.

Block diagram of a series PHEV. (Fig 5)



10 Note the various components of fuel cell electric vehicle as shown in Fig 6.

11 Note the power steering components.



12 Note the ABS components.

13 Note the suspension system components.

14 Note the E vehicle interior and exterior components.

15 Note the E Vehicle dash board gauges and warning lights.

16 Note the E Vehicle cooling system components.

17 Note the EV AC components.

18 Verify the noted components with your instructor.

Understanding recycling and reuse vehicles

Objectives: At the end of this exercise you shall be able to

- understanding the recycling and reuse the electric vehicle.

Requirements			
Tools/Instruments		Materials	
• Trainees's tool kit	- 1 No.	• Cotton waste	- as reqd.
Equipment/Machineries		• Soap oil	- as reqd.
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1 : Understanding the recycling and reuse procedure of electric vehicle

Note : The instructor has to explain the recycling and reuse procedure of electric vehicle.

- 1 Park the electric vehicle on the shop floor.
- 2 Study the vehicle manual for recycling components of electric vehicle.
- 3 Check the EV battery type and their life cycle.
- 4 Lead acid batteries life is normally two to three years there after need to replace or recycling it for reuse.
- 5 Lithium ion cell based batteries life cycle is 10 to 15 years depend upon capacities of battery and their usage.
- 6 Check the EV battery when it comes to reduce the capacity upto 70 % at that time of reusing them in other applications before end of the full battery life.
- 7 After end of battery operational life and then send it to recycling process.
- 8 After recycling the battery for second life application these batteries are vast and varied.
- 9 Recycling batteries second life will lost upto 12 years.

- 10 EV Batteries in the market not being made with second life applications in mind.
- 11 Some battery manufacturers are seeing potential business opportunities in second life applications and are incorporating them into their battery designs.
- 12 Some battery manufacturers are recycled their brand batteries and resold to EV users with limited warranty.

Note :

- Recycling batteries could improve the economic outlook of reuse is accurate molding of a battery pack's health during its time in an EV
- During recycling the battery packs, determine their cells health and reasonable them with specific control and safety equipment and with the most degraded cells replaced.

- 13 Electric Vehicle's electronic defect components may not be recycled and reuse.
- 14 Electric vehicle's Electrical and mechanical component may be repaired and reuse in electric vehicle.

Understand the latest development of electric vehicle

Objectives: At the end of this exercise you shall be able to
 • **understand the latest development of electric vehicle.**

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• New technological marines	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

Task 1 : Understanding the latest development of electric vehicle

Note: The instructor has to explain the latest development of electric vehicle new technology used by electric vehicle manufacturers

- 1 EV manufacturers are mastered the different type of designing the electric vehicle.
- 2 EV shift from manual operation to automatic operation.
- 3 EV manufacturers improved the battery quality and capacity for cover the more mileage.
- 4 EV manufacturers manufactured different type of vehicle's with safety measures for vehicle users.
- 5 EV manufacturers consider to fulfill the vehicle consumers need of vehicle design, safety, comfortability, fast charging high vehicle speed, price they can afford, OEM's, quick electrification solutions.

- 6 EV manufacturers accelerate EV innovation and flawlessly lunch vehicle into the market.

Note: Electric vehicle are not yet perfect. vehicle electrification is still it is need new technology and its constantly evolving.

- 7 Electric Vehicle thermal management has developed in new electric vehicle.
- 8 Electric vehicle manufacturers improved their product in cameras quality, ADAS collision prevention system and increased sensors for vehicle control system etc.
- 9 Compare the old electric vehicle and latest electric vehicle operating and vehicle control systems.
- 10 Write down the comparision between old and new electric vehicle in following table-01

Table 01

S.No	Vehicle operating system	Old vehicle technology	New vehicle technology	Remarks
1				
2				
3				
4				
5				
6				

Understanding the autonomous vehicle system

Objectives: At the end of this exercise you shall be able to
 • understand the autonomous vehicle system.

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1 : Understanding autonomous vehicle systems

Note : The instructor has to be locate the autonomous vehicles operational system

- 1 Park the electric vehicle on the shop floor.
- 2 Open the door and identify the vehicle operation systems.

Note : Autonomous vehicle architecture includes hardware and software segments with data exchange between them. The hardware components include sensors, actuators and processors.

- 3 Study the electric vehicle ADS model system of the human driver in every driving scenario including extreme environments such as dirt roads and understand the important of ADS use in EV.
- 4 Understand the radar, lidar, camera, ultrasonic sensor's function and its important. (Fig 1)
- 5 Understand the EV external communication system.
- 6 Study and understand the comparison of different sensor provided in a autonomous vehicle. (Table 1)
- 7 Understand the perception while drive the vehicle.
- 8 Understand the convert state of localization map.
- 9 Understand the path planning.
- 10 Understand the vehicle controls like, starting, drive by wire, brake by wire and auxiliary controls.
- 11 Study and understand the safety.
- 12 Study and understand the autonomous vehicle driving safety enhancements like cruise control, lane control, traction control, automatic speed control etc.

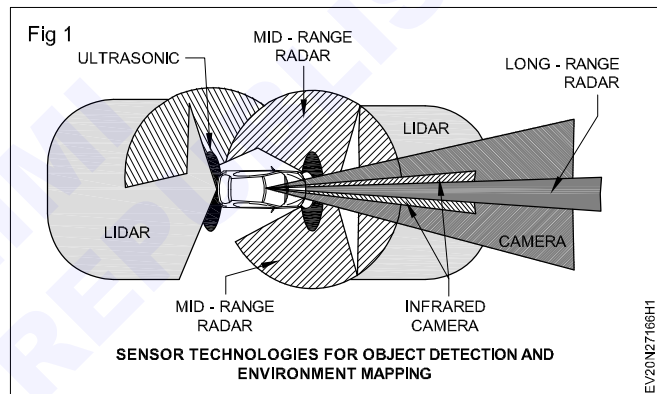
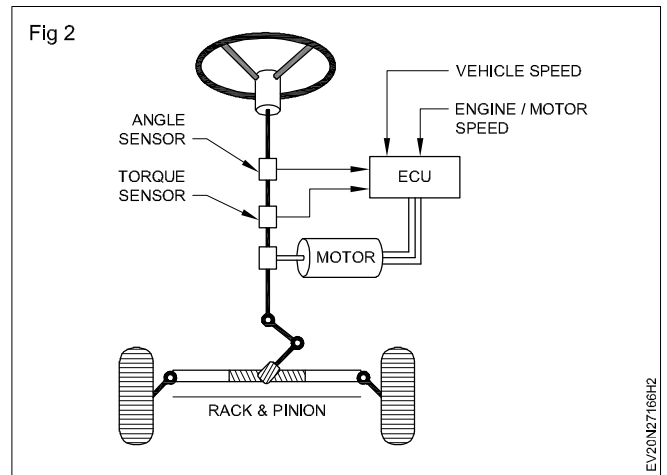


Table 1

Comparison of Different Sensor Technologies for Autonomous Vehicles

	Range	Range Resolution	Angle Resolution	Bright Light Performance	Low Light Performance	Radial Velocity	Weather Robustness	Material Cost
Radar	Very good	Good	Average	Very good	Very good	Very good	Very good	Medium
Lidar	Good	Very good	Very good	Good	Very good	Average	Average	High
Camera	Very good	Average	Good	Good	Poor	Poor	Poor	Low
Ultrasonic	Poor	Poor	Poor	Good	Good	Poor	Good	Low

- 13 Study the auto pilot and actuators of autonomous vehicles like throttle - by wire, steer by wire, brake by wire etc. (Fig 2)



Understanding of autonomous vehicle system components

Objectives: At the end of this exercise you shall be able to

- **understand the autonomous vehicle system components.**

Requirements			
Tools/Instruments		Materials	
• Trainee's tool kit	- 1 No.	• Cotton work	- as reqd.
• Vehicle manual	- 1 No.	• Soap oil	- as reqd.
Equipment/Machineries			
• Electric vehicle	- 1 No.		

PROCEDURE

TASK 1 : Understanding the autonomous vehicle system components

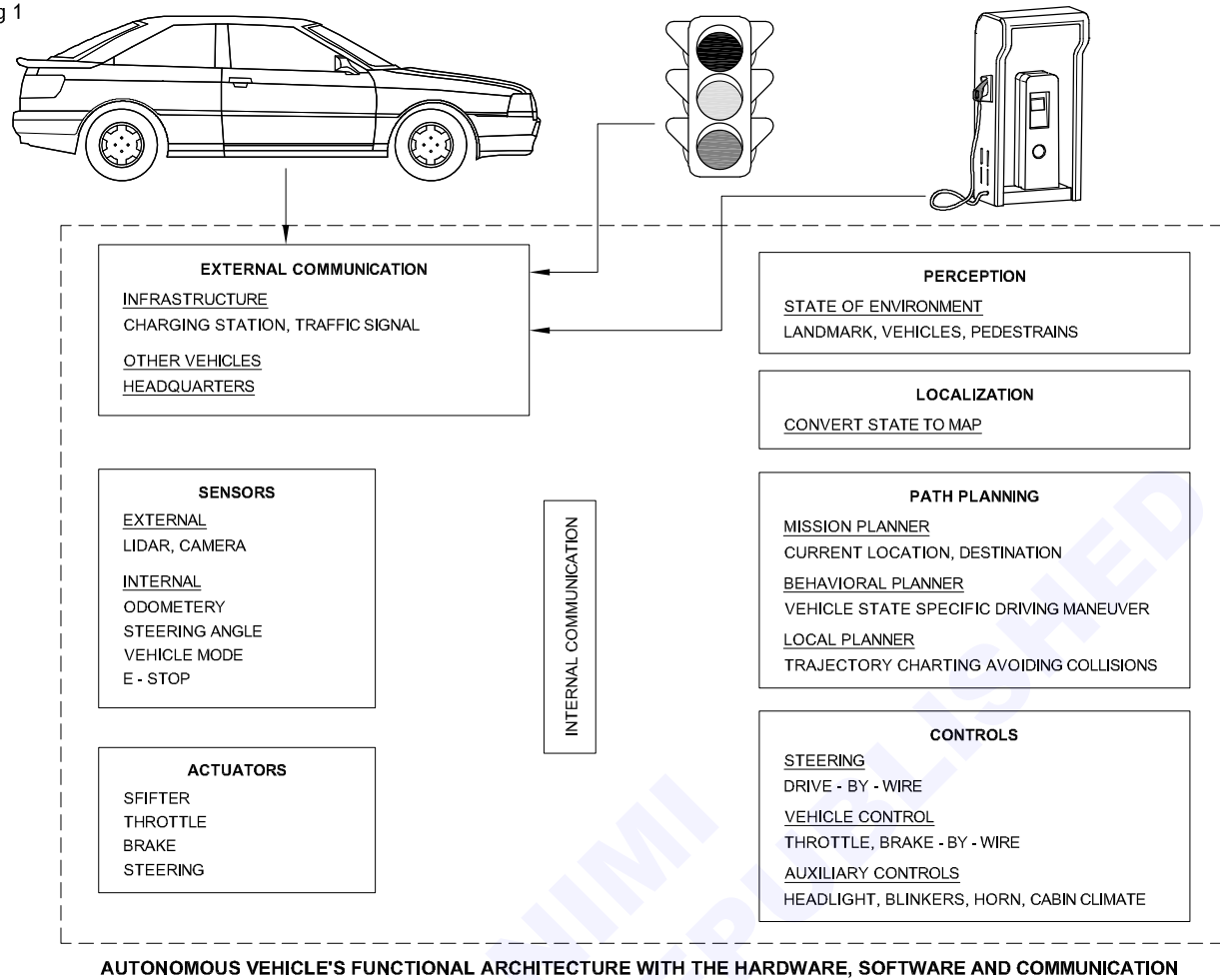
Note: The instructor has to locate the vehicle system components explain the function of each components.

- 1 Park the electric vehicle in shop floor with following safety.
- 2 Study vehicle manual for achieve the knowledge about precautions vehicle operating system components.
- 3 Study vehicle external communication system components like charging station, traffic signal and other vehicle system components and understand the function and location and its importance for vehicle operation.
- 4 Study and understand the external communication systems components like lidar, camera sensors and their functions.
- 5 Study and understand the internal communication system components like odometer sensors, steering angle sensor, vehicle drive made sensor, vehicle E-stop sensor location and its functions.
- 6 Study and understand the EV actuator like shifter, throttle brake and steering and its function.
- 7 Study and understand vehicle perception like land mark, vehicle environment, pedestrians walking and crossing the signal etc.(Fig 1)

- 8 Study and understand localization shown in dashboard monitor display (moving road map).
- 9 Study and understand the current location of the vehicle and destination.
- 10 Study and understand the behavioral planner (vehicle state) specific driving maneuver.
- 11 Study and understand the cautions of trajectory, charting avoiding collisions.
- 12 Study and understand the function of steering controls drive by wire, throttle, brake by wire.
- 13 Study and understand the function of auxiliary controls of head lights, blinkers, horn, cabin climate controls .

Note: In the autonomous vehicle, the sensing and communication components provide the necessary information to enable the perception and mapping tasks such as object detection and vehicle trajectory tracking. The software processes start with the hardware sensors some of which may depend on external communications. Advanced signal processing techniques play a key role in the software processes of perception, localization and path planning.

Fig 1



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