SKILL ACTIVITY NO: 1

Date : 15/01/25

(To be filled by the Instructor)

Title : To acquire necessary technical skills with respect to safety Repair and maintainance of HEV's.

Skills / competencies to be acquired :

1. High voltage identification.
2. Isolation of HV system
3. Understanding international standards and regulations,
4.
5. Use of appropriate tools and measures.
6.
7. Checking critical subsystems.
8.

Duration of activity (hours) : 1 Hr.

(To be filled by the Student)

1. What is the purpose of this activity ? (Explain in 3 - 4 lines)

1) To develop technical skills for safe handling of HEV's.
2) To learn high-voltage identification and isolation procedures.
3) To understand international safety standards & regulations.
4) To use appropriate tools & protective equipment for HV systems.

2. Steps performed in this activity (Explain in 5 - 6 lines)

1) To open LN labsoft → Under Car train.
2) Open the safety and Hazard tab.
3) To explore various aspects under safety & Hazard.
4) To write a note indetailed of aspects which are required.

1). High Voltage Identification :-

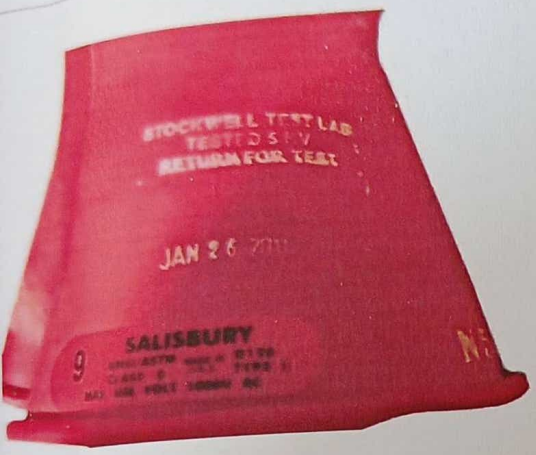
Hybrid and electric vehicles operates on high voltage HV-systems, typically ranging from 200V to 800V or more. Exposure to such high voltage can be Hazardous making it crucial to identify HV components accurately.

- Recognizing High-voltage components - Identifying cables, Connectors, batteries, inverters and motor controllers that are part of the HV system.
- Understanding Color codes and markings - HV components are usually marked with orange-colored cables and safety symbols.
- Awarness of potential Hazards :- Electric shocks, are flash and thermal bems are common risk associated with HV systems.
- Labelling and signage :- Using proper warning labels and ensuring all HV components are clearly marked.

2). Isolation of High voltage (HV) systems :-

Before servicing on HEV, it is essential to disconnect and isolate the HV system to prevent electrical hazards.

- Shutting down HV system properly - following manufactures specific procedures to powes down the HV system.
- Using personal protective Equipment (PPE) :- measuring insulated gloves, face shield and safety boots while working on High voltage HV components.
- Verifying zero voltage condition :- Using a multimeter or voltage tester to confirm the absence of voltage; before handling electrical components.
- Lockout / Tagout (LOTO) Procedures :- Implementing LOTO protocols to prevent accidental re-energizeltion of HV systems.
- Properly reconnecting the system :- Ensuring all safety checks are performed before re-energizing the vehicle.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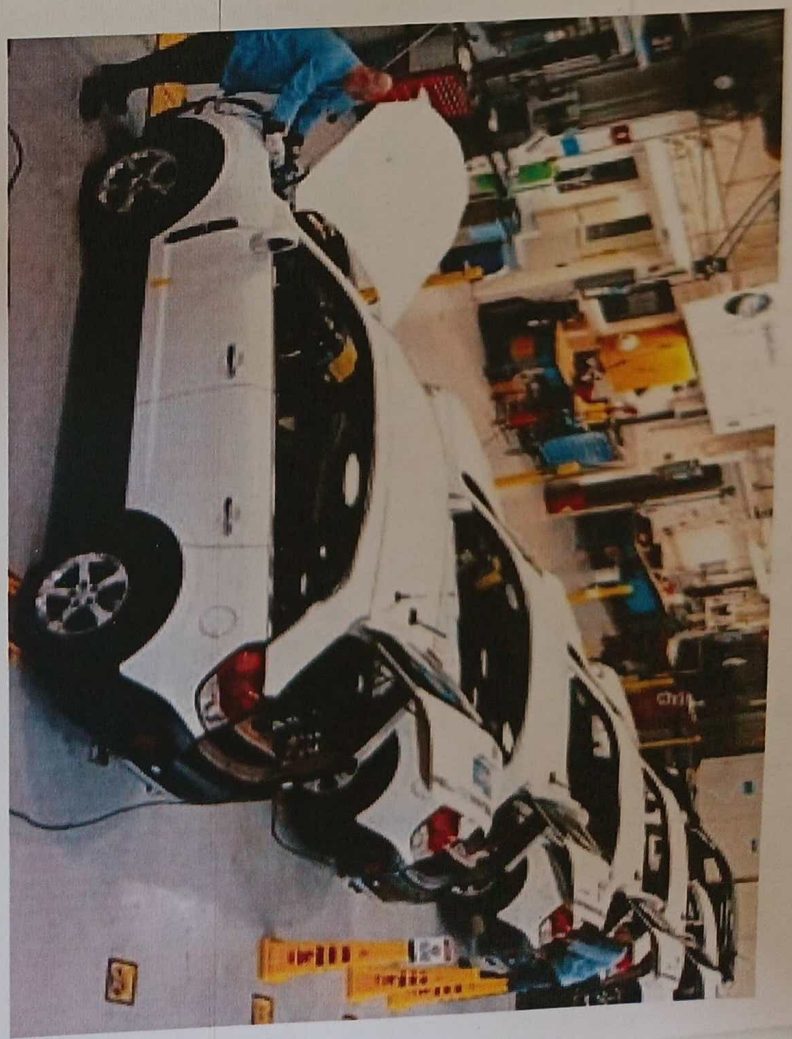


3. What resources / materials / equipments / tools did you use for this activity ?

1. LN - labsoft
2. PC / Laptop
3. Reference book
4. Google search
5.
6.
7.
8.

4. What skills did you acquire ?

1. High voltage Identification.
2. Isolation of HV systems.
3. Understanding international standard's
4. and regulation.
5. Use of appropriate tools and measures.
6.
7. Checking critical sub systems.
8.

5. Time taken to complete the activity ? 1 (hours)

(Signature)
Instructor

(Signature)
Student

3). International Standards & Regulations :-

Working with HEVs require compliance with various safety standards and regulations to ensure proper handling and operations.

Key standards are! -

- ISO 6469 :- safety specifications for electric road vehicles.
- SAE J1772 :- Standard for charging connectors & systems.
- IEC 61851 :- Electric vehicle conductive charging and systems.
- OSHA & NFPA 70E – Occupational safety guidelines for electrical work.
- Automaker :- Specific Guidelines - following HEV manufacturing safety and repair manuals

4). Use of Appropriate Tools and Measures :-

Technician must be use specialized insulated tools and diagnostic equipments when working on HEVs to minimize electrical risks.

- Essential Tools :-
  - Insulated Hand Tool :- wrenches, screwdrivers, pliers and sockets rated for high-voltage work.
  - Voltage Tester and Multimeter :- Used to check voltages presence and continuity.
  - Personal Protective Equipment (PPE) :- Includes class 0 or class 1 insulated gloves, arc-rated clothing and face shields.
  - Thermal Imaging Camera :- Used for diagnosing battery overheating issues.
  - High Voltage Rescue Hooks :- Essential for safety removing a person from a electrical surface in case of an accident.

5). checking of Critical Subsystems :-

HEVs have multiple critical systems that must be checked for proper functionality & safety.

- Battery Management System (BMS) :- Ensures battery pack, safety, monitors temperatures & prevents overcharging.
- Cooling System :- keeps the battery inverter and motor at optional operating temperatures.
- Regenerative Braking Systems :- Ensures the efficient recovery of energy and proper braking performance.
- Electrical Insulation & Grounding :- Prevents Leakage currents & short circuit

SKILL ACTIVITY NO: 2

Date : 31/01/25

(To be filled by the Instructor)

Title : Selection of Battery for 2/3/4 wheeler electric vehicle [HEV].

Skills / competencies to be acquired :

1. Knowledge of different batteries & chemical used.
2. Evaluating efficiency cost and efficiency.
3. Applying selection criteria for vehicle integration.
4. Optimizing energy efficiency charging & thermal stability.
5.
6.
7.
8. Understanding environmental impacts of battery technologies.

Duration of activity (hours) : 1 Hour.

(To be filled by the Student)

1. What is the purpose of this activity ? (Explain in 3 - 4 lines)

1) Optimize performance :- Ensure the battery meets the vehicle's power efficiency and range requirements.
2) Enhance safety :- Select batteries with reliable thermal management and safety features.
3) Cost Effective :- Balance performance with affordability & long energy
4) Sustainability :- Promote environmentally friendly & energy-efficient solutions.

2. Steps performed in this activity (Explain in 5 - 6 lines)

1) Analyze vehicle requirements.
2) Research and compare battery options.
3) Evalute performance and safety.
4) Conduct cost-benifit analysis.
5) Ensure compatibility with vehicle systems.
6) Optimize for performance & safety.
7) Test & validate battery performance.

3. What resources / materials / equipments / tools did you use for this activity ?

1. Reference Notes.
2. Data sheet
3. Laptop
4. UN-set up.
5. _____
6. _____
7. _____
8. _____

4. What skills did you acquire ?

1. Understanding different batteries.
2. Evaluting efficiency cost & specs.
3. Ensuring vehicle integration & safety
4. Optimizing energy, charging and
5. _____
6. _____
7. _____
8. thermal stability

5. Time taken to complete the activity ? 1 (hours)

(Signature)
Instructor

(Signature)
Student

i] Battery Selection for 2/3/4-Wheeler Electric & Hybrid Electric Vehicles.

ii] Types of Vehicles, Batteries used & Technical specifications.

Vehicle Type	Battery Type	Voltage Range	Capacity (KWh)	Energy Density (Wh/Kg)	Cycle life (cycles)	charging Time (hours).
2 Wheeler	Lithium-ion [Li-ion]	48V-72V	1-3KWh	150-200	1000-2000	2-4
2 Wheeler	Nickel-Metal [NiMH) Hydride	36V-48V	0.5-1.5 KWH	60-120	500-1000	4-6
3 Wheeler	Lithium Ferro-phosphate [LFP]	72V-96V	4.8 KWh	60-120	2000-3000	3-5
3 Wheelers	Nickel Metal Hydride	72V-96V	3-5 KWh	150-250	500-1000	4-6
4 Wheeler	Nickel Manganese Cobalt (NMC)	300V-400V	30-60 KWh	150-250	1000-2000	6-8 [Fast charging 1-2]
4 Wheeler	Lithium-ion [Li-ion]	300V-400V	40-70 KWh	150-250	1000-2000	6-8 [Fast Charging 1-2]
4 Wheeler	Nickel-Metal Hydride [NiMH].	200V-300V	20-40KWh	60-120	500-1000	8-10

2) Battery Selection Criteria for 2/3/4-Wheeler Electric Vehicles:-

- Energy Capacity:- Ensure the battery provides sufficient energy to meet the required range for the vehicle. Higher Capacity is required for 4-Wheeler.
- Voltage & Current:- The voltage must match the vehicle's power requirements. Higher voltage system (100V-400V) are typically used for 4-Wheeler, while lower voltage (48-72V) systems are used for 2/3 wheelers.
- Life Cycle:- The battery should be with high life cycle to ensure long-term durability and cost-effectiveness. Lithium-ion batteries typically offer 1000-2500 cycles.
- Charging time:- The vehicle should have a reasonable charging time, balancing fast charging with battery life. Fast charging is crucial for consumer convinience.

- Temperature Range :- The battery should function optimally in various environmental conditions. A range from -20°C to -50°C is common for EV batteries.

- Weight :- The battery weight should be optimized to ensure vehicle performance and efficiency. Lighter batteries are crucial for 2/3 wheelers.

- Safety :- Battery Management System [BMS] to ensure safety against overheating, short circuits and overcharging.

- Cost :- The cost should be within the budget for the intended market, balancing performance & price.

3] To Design 4-Wheeler Hybrid Electric Vehicle [HEV].

Battery Type : Lithium-ion [Li-ion].

i] Technical Specifications :-

- Nominal Voltage : 200-400 V.
- Energy Capacity : 20,000 - 80,000 Wh
- Charging Time :- 4-10 Hr.
- Life Cycle :- 1000-2500 Cycles.
- Energy Density :- 150-250 Wh/kg.
- Thermal Management :- Liquid-cooled or air-cooled.
- Weight : 150-300 kg.
- Temperature range :- 20°C - 60°C

ii] Features :-

- High Energy Density :- Ideal for long-range 4 wheelers.
- Long Life Cycle :- Reduces battery replacement costs.
- Low Maintenance :- Minimal upkeep compared to lead-acid batteries.
- Fast charging :- Support quick charging with properties infrastructures.

iii] Pros :-

- Long Range
- Light weight.
- High efficiency.
- Eco friendly.

iv] Cons :-

- High cost
- Thermal sensitivity.
- Performance Degradation.

Vehicle Type	Battery Type	Voltage Range	Capacity (Kwh)	Energy Density (Wh/kg)	Cycle life (Cycles)	Charging Time (Hrs)
2 wheeler	lead acid battery	24V-48V	0.5-1.5 Kwh	30-50	300-500	6-8
2 wheeler	solid state Battery	48V-72V	2-4 Kwh	250-300	2000-3000	Fc.
2 wheeler	Grophene Battery	48V-72V	2-5 Kwh	200-300	2000-4000	Fc
3 wheeler	Lead acid battery	48V-72V	2-4 Kwh	300-500	300-500	6-8
3 wheeler	Solid state battery	96V-120V	4-6 Kwh	250-300	2000-5000	Fc
3 wheeler	Sodium ion battery	72V-96V	3-5 Kwh	100-150	1000-3000	4-6
4 wheeler	Solid State	350V-450V	50-100 Kwh	250-300	2000-5000	Fc
eeler	Hydrogen fuel cell	200V-600V	80-120 Kwh	200-350	3000-6000	Fc.

SKILL ACTIVITY NO: 3

(To be filled by the Instructor)

Date : 4/02/2025

Title : Selection of Motor for 2/3/4 wheeler Hybrid Electric Vehicle [HEV].

Skills / competencies to be acquired :

1. Choosing suitable motor for different
2. Understanding motor specs like power,
3. Basics of motor control systems.
4. Applying motor selection principle in
5. HEV's.
6. torque, efficiency & coding.
7.
8. real world EV's.

Duration of activity (hours) : 1 Hr.

(To be filled by the Student)

1. What is the purpose of this activity ? (Explain in 3 - 4 lines)

1) To understand motor selection for 2/3/4 wheelers.
2) To compare different motor types based on technical specs.
3) To identify key selection criteria for performance.
4) Analyze pros & cons of various motors.
5) To gain knowledge of motor efficiency control & integration in EV's.

2. Steps performed in this activity (Explain in 5 - 6 lines)

1) Identified different motor types for 2/3/4 wheelers.
2) Collected technical specifications for each motors.
3) Compared various motors.
4) Defined selection criteria.
5) Analyzed features, pros, cons, working principle.

3. What resources / materials / equipments / tools did you use for this activity ?

1. Reference Notes.
2. Data sheets
3. PC/ laptop
4. LN setup.
5. _____
6. _____
7. _____
8. _____

4. What skills did you acquire ?

1. Able to choose suitable motor for
2. Able to understand technical specifications.
3. Able to understand basics of motor
4. Able to apply motor slection principle
5. different HEV's.
6. _____
7. control systems.
8. in real world EV's.

5. Time taken to complete the activity ? _____ (hours)

(Signature)

1] Motor Selection for 2/3/4 Wheeler Hybrid Electric Vehicle [HEVs]

Vehicle Type	Motor Type	Power Rating	Efficiency	Torque [Nm]	Speed [RPM]	Cooling Type	Application.
2 wheeler	BLDC [Brushless DC motor]	1-3 Kwh	85-90%.	30-50	3000-5000	Air Cooled	Scooters, E-bike
2 wheeler	HUB motor	0.5-2 Kwh	80-85%.	20-40	2000-4000	Air Cooled	Light weight E-bikes.
3 wheeler	PMSM [Permanent magnet Synchronous]	3-6 KW	90-95%.	80-120	2000-4000	Air cooled	Rickless Cargo EVs.
3 wheeler	switched Reluctance Motor [SRM]	4-8 KW	85-90%.	100-150	1500-3500	Air cooled	Commercial EVs.
4 wheeler	AC Induction Motor	30-60 KW	85-90%.	200-400	6000-25000	Liquid cooled	Commercial EVs.
4 wheeler	PMSM	50-100 KW	92-98%.	300-500	5000-10000	Liquid cooled	Cars, SUVs Commercial EVs.
4 wheeler	SRM	40-70 KW	88-92%.	250-450	4000-8000	Liquid cooled	Heavy duty trucks, SUVs.
4 wheeler	Axial Flux Motor	60-120 KW	94-97%.	350-550	5000-11000	Liquid cooled	Sports, cars, trucks, SUVs.
4 wheeler	Dual Motor System	80-150 Kw	93-97%.	400-600	5000-12000	Liquid cooled	High performance AWD EVs.

2] Motor Selection Criteria for 2/3/4 Wheelers :.

- Power Requirements : Based on vehicle load, acceleration needs & terrain.
- Efficiency :- Higher efficiency ensures better mileage and energy savings.
- Torque and Speed :- Depends on the vehicle type, higher torque for heavy loads higher RPM for speed.
- Weight & Size :- Compact motors preferred for 2 wheelers, robust designs for 4 wheelers.
- Cooling System :- Air-cooled for light weight applications, liquid-cooled for high performance vehicles.

- Cost and Maintenance:- Balance between performance and cost effectiveness.

3] Technical Specifications :-

-Type :- Permanent Magnet Synchronous Motor (PMSM).

-Power output : 50-100 KW

-Efficiency :- 92-96%.

-Torque :- 300-500 Nm

-Speed- 5000-1000 RPM.

-Cooling System :- Liquid-Cooled.

-Voltage :- 300-400V, Weight : 50-70 kg.

Working Principle :-

PMSM operates on the principle of Electromagnetic induction. It uses permanent magnets embedded in the rotor and a Stator with 3-phase windings. This field causes the rotor to spin in sync with the stator's field with speed proportional to AC supply frequency. This ensures efficient torque production & precise speed control.

Features :-

- High power Density.
- Superior Efficiency.
- High Torque at low speed.
- Regenerative Braking support.

Pros :-

- Maximize battery life & range
- Compact & light weight.
- Low Noise.
- Reliable Performance.

Cons :-

- Higher Cost.
- Complex control system.
- Temperature Sensitivity.
- Maintanence.

Vehicle Type	Motor Type	Power Rating	Efficiency	Torque (Nm)	Speed (Rpm)	Cooling Type	Application.
2 wheeler	PMSM (Permanent magnet Sync)	3-5 Kw	90-95%.	50-80	2000-5000	Air cooled	High performance bikes.
2 wheeler	Axial flux Motor	1-3 Kwsh	92-96%.	40-60	3000-6000	Aircooled	Sports E-bike.
2 wheeler	SRM (Switch Reluctance Motor)	2-4 Kw	85-90%.	30-60	2000-4500	Air Cooled	High efficiency Scooter
3 wheeler	Induction Motor	5-10 Kw	85-92%.	50-100	2500-5000	Aircooled	Passenger Rickshaw.
3 wheeler	Hub Motor	3-6 Kw	80-85%.	60-120	2000-4000	Air cooled	light weight cargo
3 wheeler.	SRM (Switch Reluctance motor)	4-8 Kw	85-90%.	90-130	1500-3500	Air cooled	High efficiency 3 wheeler

SKILL ACTIVITY NO: 4

Date : 21/01/25

(To be filled by the Instructor)

Title : Fault Analysis and Diagnosis for HEV's.

Skills / competencies to be acquired :

1. Able to diagnase & analyse HEV using LN lab experiment.
2. Understanding High voltage system
3. Able to interpreting faults codes and
4. Hands on experience of fault systems
5.
6. safety protocols.
7. troubleshooting HEV systems.
8.

Duration of activity (hours) : 1 Hr.

(To be filled by the Student)

1. What is the purpose of this activity ? (Explain in 3 - 4 lines)

The purpose of this activity is to equip learness with technical expertise in fault analysis and diagnosis of HEVs by using the LN Training system, enabling them to identify & resolve high-voltage system faults effectively while adhering to safety protocols & industry standards.

2. Steps performed in this activity (Explain in 5 - 6 lines)

1) Familiarizing with LN HEV Trainer. Understand layout and components of the HEV simulate trainer including high voltage battery, inverter, electric motor & control modules.
2) Initial safety checks & setup.
3) Use fault simulation feature to introduce specific faults into the system, such as battery over voltage, motor failure or inverter malfunction.
4) Troubleshooting and resolution.

3. What resources / materials / equipments / tools did you use for this activity ?

1. LN / labsoft
2. PC / Laptop
3. Reference Books
4. _____
5. _____
6. _____
7. _____
8. _____

4. What skills did you acquire ?

1. Able to diagnose & analyse HEV using LN.
2. Able to interprete fault codes & troubleshooting HEV systems.
3. Understanding HV system safety protocols
4. Hands on experience of fault system
5. _____
6. _____
7. _____
8. _____

5. Time taken to complete the activity ? _____ (hours)

(Signature)
Instructor

(Signature)
Student

* Fault in Hybrid-Serial *

1) Diagnostic steps :- Customer details were insufficient to detect fault. Diagnostic unit ruled it to be motor short-circuited.

2) Affected Components :- HV system, Motor Generator 1 & 2.

3) Diagnosis :- LM2333 used for resistance check, 0.5Ω induced the short circuit.

4) Resolution :- Repair / Replacement of the defective phase.

* Fault in Parallel Hybrid *

1) Diagnostic steps :- Using Jumper the battery was tested. Thus, fault determination was high voltage battery defect.

2) Affected Components :- Battery.

3) Diagnosis :- LM2333 used for voltage measurement, defective component show 8.5 V.

4) Resolution :- Repair / Replacement to restore functionality.

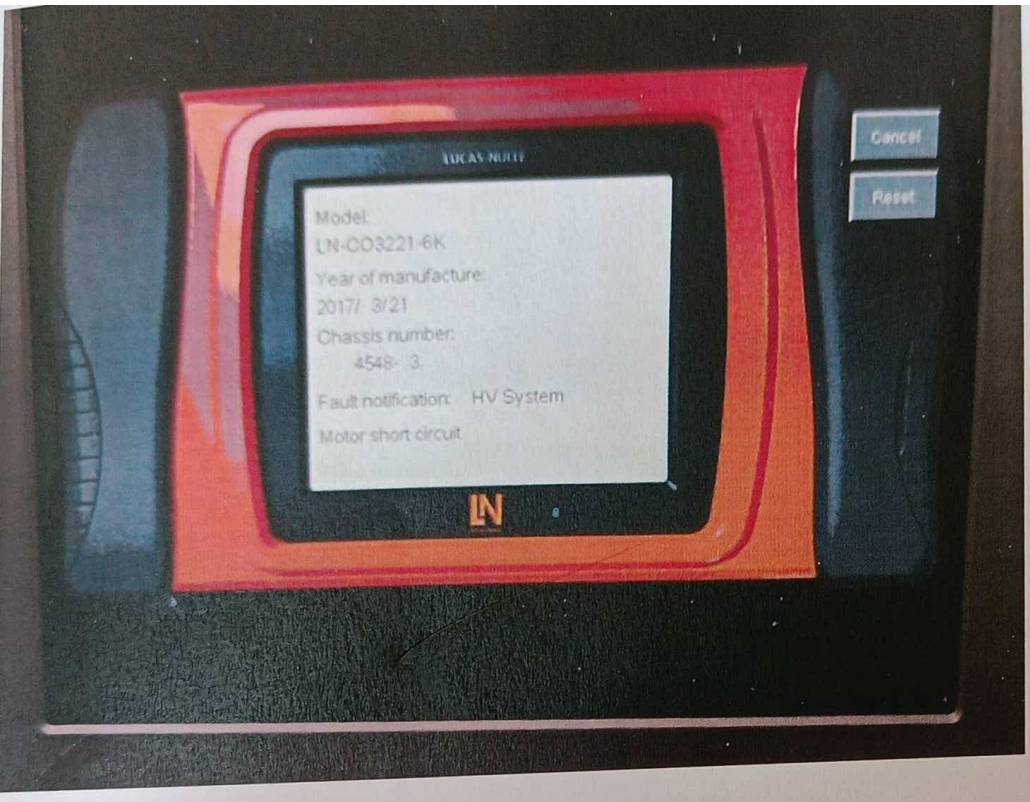
* Fault in fuel Cell Vehicle *

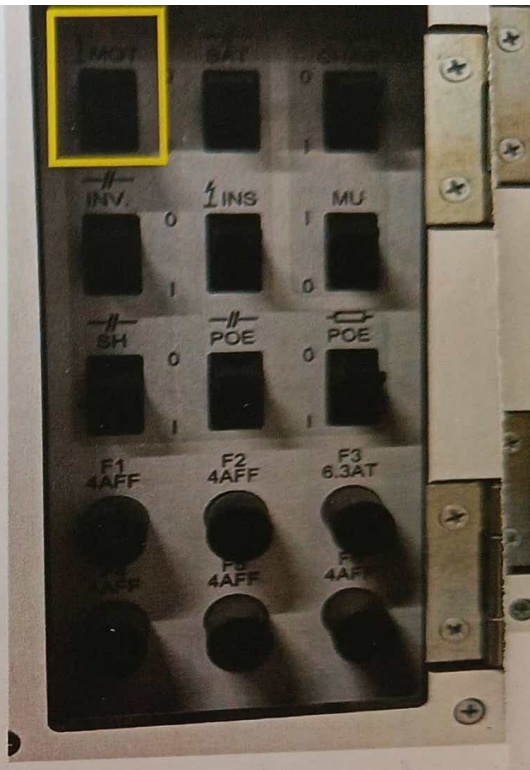
1) Diagnostic Steps :- Using Jumpers connect to the system on overlay C03221-fKE6 and the diagnostic unit detects it to be defective inverter.

2) Affected Components :- Inverter.

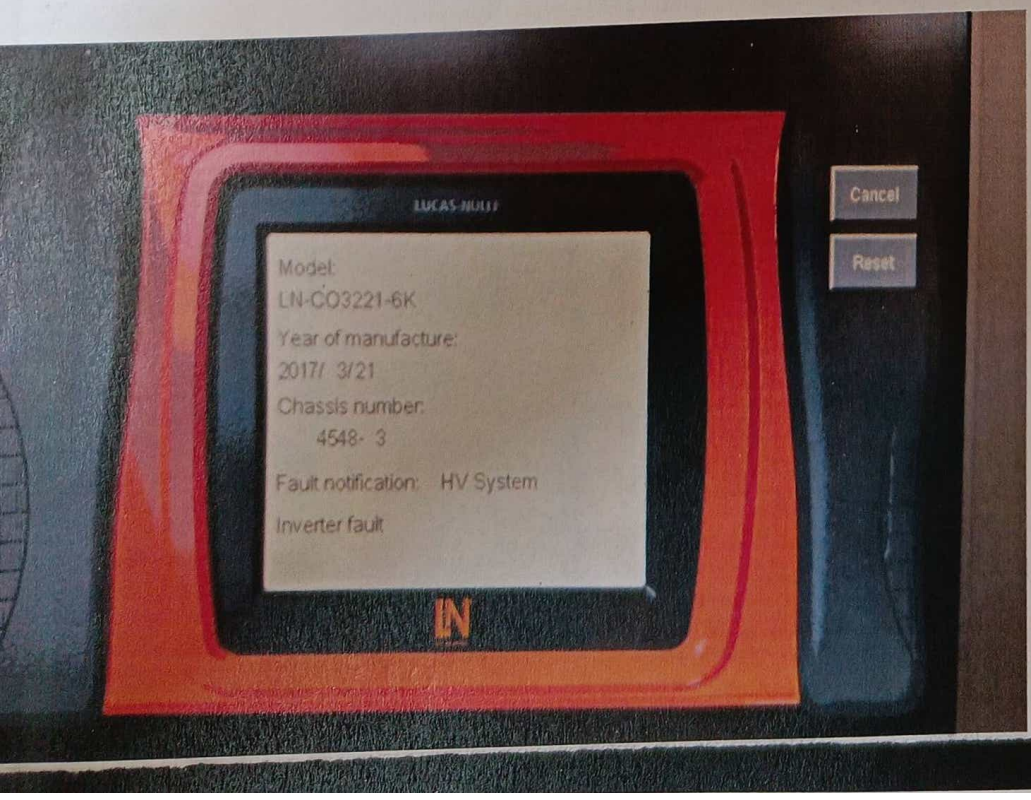
3) Diagnosis - LM2333 confirms 0.5V on the inverter.

4) Resolution - Repair / Replacement required.

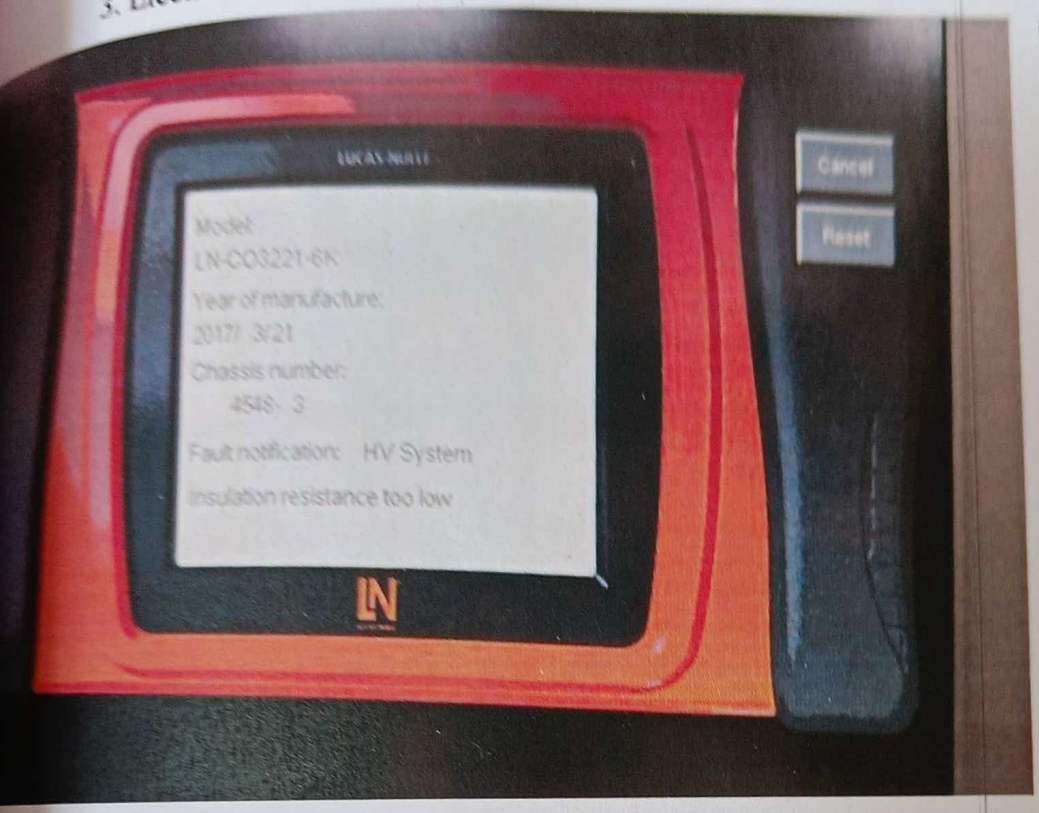


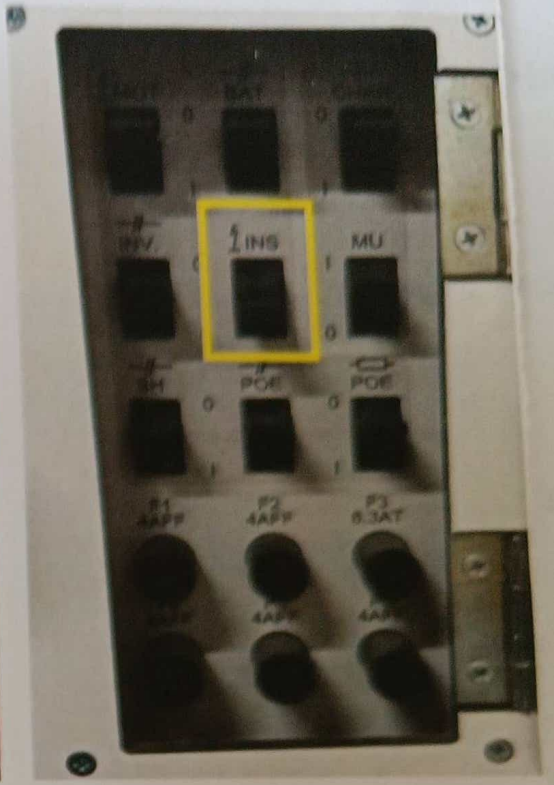


2. Fuel cell drive - Inverter Fault

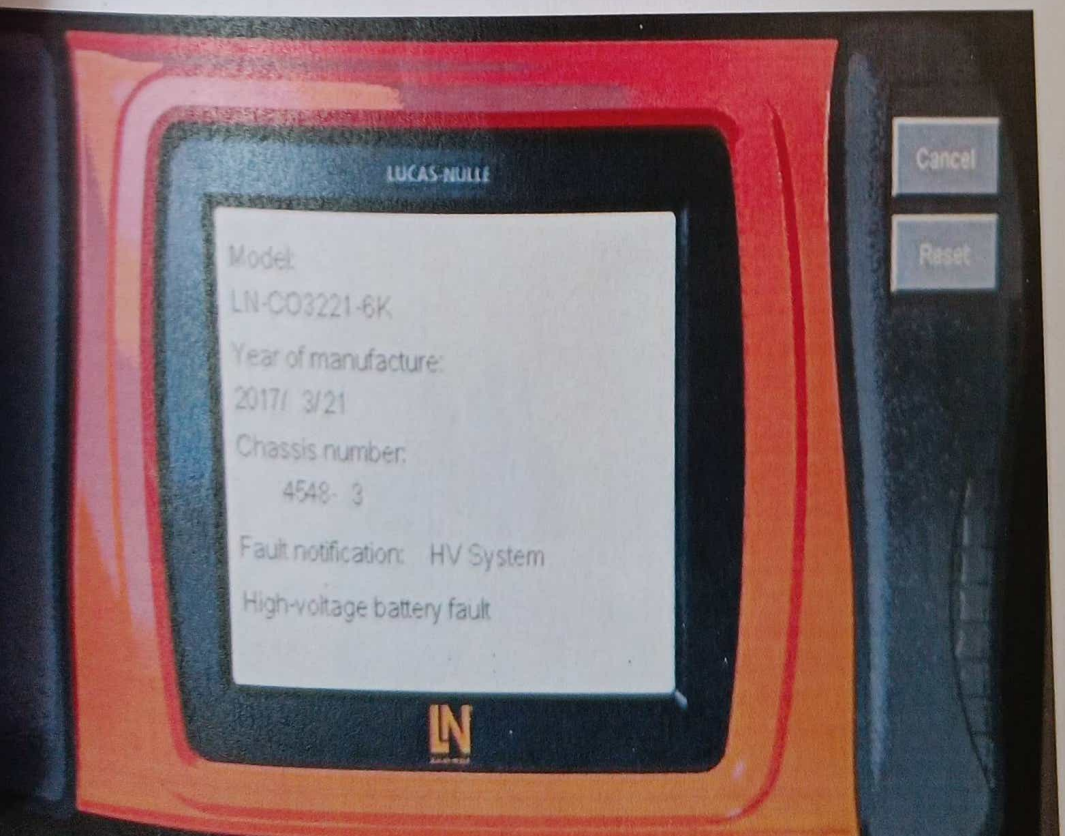


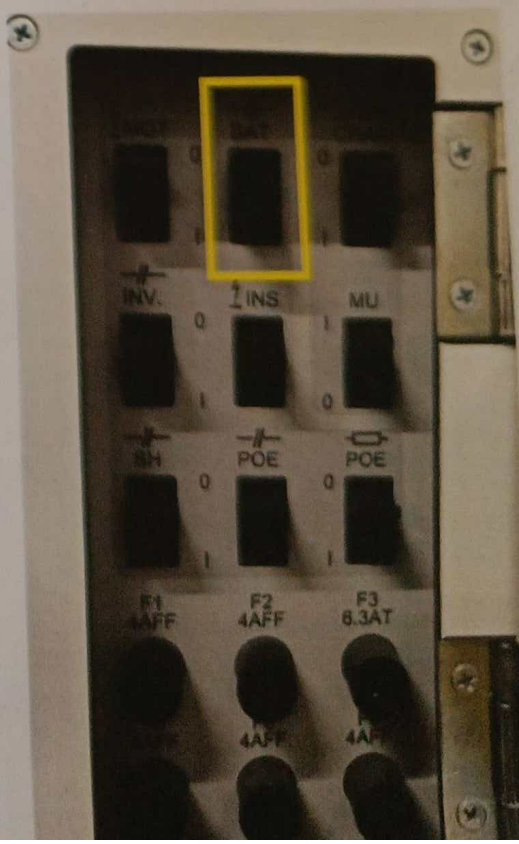
3. Electric Vehicle fault - Insulation resistance too low





4. Parallel hybrid drive - high voltage battery fault





* Fault in Electric Vehicle *

1) Diagnostic Steps :- Use overlay co3221-6KE6 · Fit Jumpers on high voltage battery and the eight handside. Turn on Ignition.

2) Fault Analysis :- Use diagnostic unit which detects the faults as Insulation resistance too low.

3) Fault Determination :- Use LM2333 to measure insulation resistance by applying 1000 V pulse to test.

4) Fault localization : - Measurements confirmed the motor generator as the defective component.

5) Resolution :- Replace the motor generator to restore the vehicle's functionality.

SKILL ACTIVITY NO: 5

Date : 9/4/25

(To be filled by the Instructor)

Title : SOC (State of charge) by using Matlab and Simulink.

Skills / competencies to be acquired :

1. Understand the various SOC estimation
2. Understand working & efficiency of each
3. Implementation of any one method
4. Understand the use of Matlab &
5. methods.
6. method.
7. on Matlab.
8. Simulink.

Duration of activity (hours) : 4 Hrs.

(To be filled by the Student)

1. What is the purpose of this activity ? (Explain in 3 - 4 lines)

The main purpose of this activity is to understand the various SOC estimation methods, understand their working, efficiency & pros & cons. Understand the implementation of any 1 method & implement on simulink.

2. Steps performed in this activity (Explain in 5 - 6 lines)

1) Explore the various SOC estimation methods.
2) Understand implementation of SOC in matlab (simulink).
3) Implement the SOC estimation method in Matlab (Simulink).
4) Check & verify the output.

3. What resources / materials / equipments / tools did you use for this activity

1. Matlab/ Simulink
2. E- Resources.
3.
4.
5.
6.
7.
8.

4. What skills did you acquire ?

1. Understand various SOC estimation methods
2. Understand working & efficiency of each method.
3. Implementation of any 2 method on
4. Understand the use of Matlab & Simulink
5.
6.
7. Matlab.
8.

5. Time taken to complete the activity ? 4

Method	Description	Advantages	Disadvantages	Accuracy	Complexity
Coloumb Counting	Tracks charges by integrating current over time.	· Simple to implement · Low computational cost.	· Requires inital SOC · Drifts over time.	Moderate	Low
Opn current voltage	Estimates SOC based on voltage of cell.	· High accuracy when battery is stable.	· Requires battery to be at most. · Temp sensitive	High	Low
Kalman Filter.	Uses a mathematical model & algorithms to estimate SOC.	· Corrects errors in real time.	· Complex to implement. · Intensive Computation required	High	High
Impedance Measurement	Estimates SOC by analyzing battery impedence of specific frequencies.	· Good for ongoing assessment. · Works during operation.	· Temp sensitive. · Requires specalized Hardware.	Moderate to High	Moderate to High

* Reasons to choose Coulomb Counting :-

1) Simple :- · It is very easy method to understand and implement.
· Ideal for basic simulations.

2) Low Computational Demand :- · Requires minimal processing power.

3) Real time tracking :- · Provides continuous SOC updates during charge & discharge cycle.

4) Cost - Effective.

* Columb Counting Method :-

The Method calculates SOC by measuring current flowing into or out of the battery and integrating it over time.

Steps :-

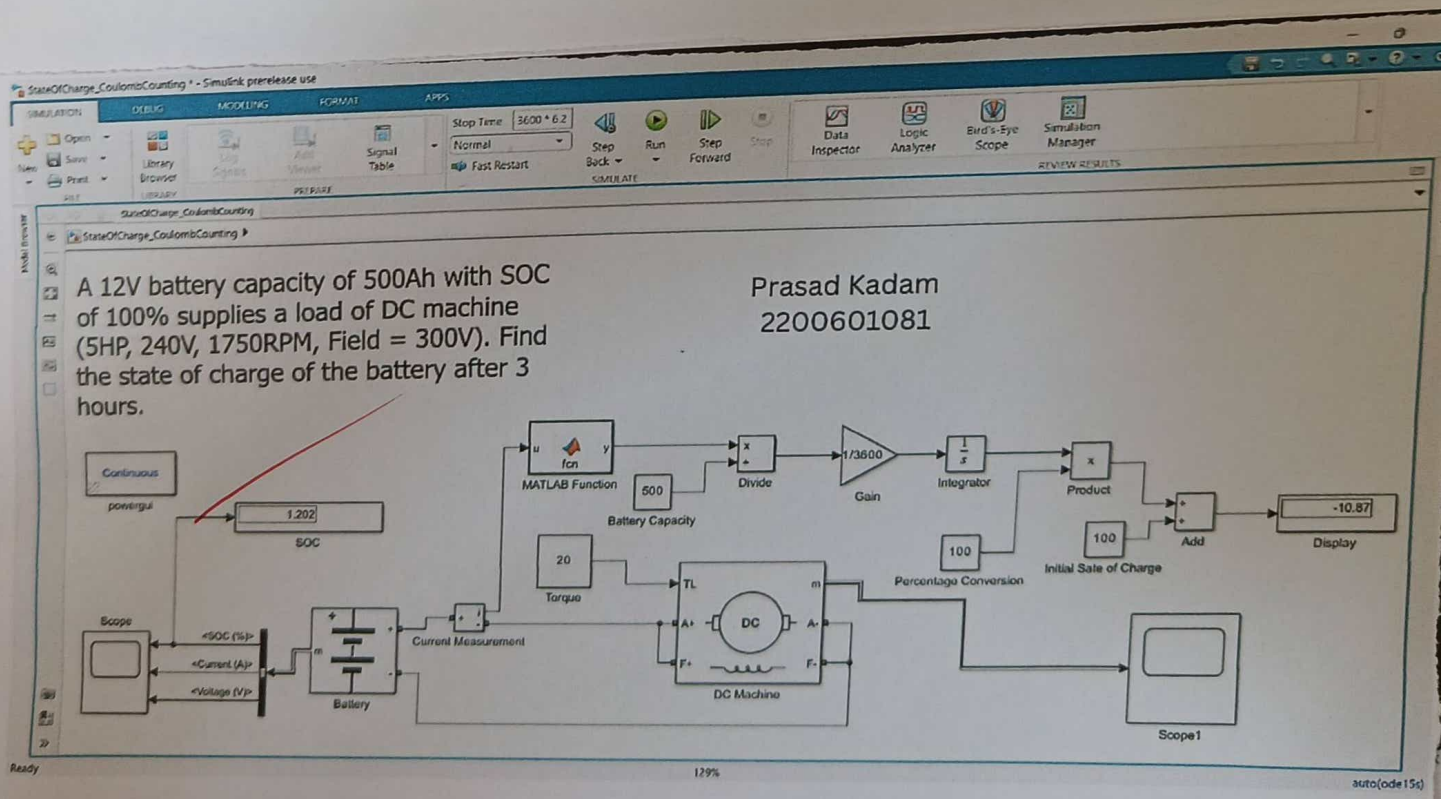
1) Initial SOC :- Could be 100% of battery is fully charged, or some known value based on voltage.

2) Current Measurement :- A sensor continuously measures the current positive current increases the SOC, while negative current decreases it.

3) Integration over time :- $Q = \int I(t)\,dt$.

4) Update SOC :- $SOC = SO_{Cinitial} + \frac{Q}{C_{nominal}} \times 100$.

5) Continuous Tracking :- Process repeats, updating SOC in real time as the battery charges or discharges.



SKILL ACTIVITY NO: 6

Date : 9/04/25

(To be filled by the Instructor)

Title : Resolver.

Skills / competencies to be acquired :

1. Understanding the working principle of
2. Learning about resolver applications in
3. Identifying the components of a
4. Analyzing resolver signals (sine and
5. resolver.
6. Industries.
7. resolver.
8. cosine output).

Duration of activity (hours) : 1 Hr

(To be filled by the Student)

1. What is the purpose of this activity ? (Explain in 3 - 4 lines)

To understand the working principle of a resolver & its role in measuring angular position & speed. Resolvers are widely used in industrial automation aerospace & robotics for precise motion control. This activity will help in analyzing resolver signals & their conversion into digital data for practical applications.

2. Steps performed in this activity (Explain in 5 - 6 lines)

1) Studied the construction and working principle of a resolver.
2) Analyzed how an AC voltage applied to the rotor induces ~~new~~ signals in the stator windings.
3) Observed how sine & cosine outputs are used to determine angular positions.
4) Examined resolver-to-digital conversion for real-time applications.

3. What resources / materials / equipments / tools did you use for this activity ?

1. LN labsoft
2. laptop
3. Reference books
4. Web
5.
6.
7.
8.

4. What skills did you acquire ?

1. Understanding working principle of
2. Learning how sine & cosine signals
3. Gain knowledge of resolver to digital
4. Learning about resolver appl^{n}
5. resolver.
6. determine angular position.
7. conversion.
8. in industries.

5. Time taken to complete the activity ? 1 (hours)

(Signature)
Instructor

(Signature)
Student

* What is Resolver *

A resolver is an electro mechanical device used for measuring angular position and speed. It functions similarly to a rotary transformer and it is often used in motion control systems. Resolver are known for their high reliability, durability and ability to operate in harsh environments making them ideal for applications requiring precision position feedback.

Resolver work based on electro magnetic induction and provide analog output signals that represent angular displacement unlike digital encoders resolver do not have discrete positions but intead generate continuous signals corresponding to the rotor's position.

* Principle of Resolver :-

A Resolver operates based on the principle of electromagnetic induction. It consists of the following Components :-

- Rotor :- The rotating part, which is excited by an alternating current (AC) voltage.
- Stator :- Contains two orthogonal windings (sine & cosine windings) that receive induced voltage from the rotor.
- Excitation Source :- Provides an AC input signal to the rotor windings.

* Working Mechanism :-

1) An Ac voltage is applied to the rotor winding, which induces voltages in the stator windings due to electromagnetic induction.

2) The stator consists of two windings placed at 90° to each other. These windings generate sine & cosine signals proportional to the rotors angular positions.

3) The output signals from the stator windings are processed by a Resolver-to-digital converter (RDC) to determine the precise angular position & speed.

4) The sine & cosine signals helps determine the rotor's absolute position with 360°.

Since resolver provide continuous and noise-resistance analog signals, they are highly reliable in applications where precise motion control is required.

* Where is Resolver Used :-

1) Aerospace and Defense.
2) Industrial Automation (servo motor control).
3) Automotive Industry - used in electric power steering (EPS).
4) Marine and Submarine Applications.
5) Power plants. (Used for valve position monitoring in nuclear and thermal power plants).

* Advantages of Resolver :-

1) High Durability :- can withstand extreme environmental conditions.
2) Analog Output :- Provide smooth, continuous position feedbacks.
3) No discrete steps :- Unlike encoders, resolver do not have limited resolution.
4) Resistant to electromagnetic interference :- Suitable for aerospace and defence applications.
5) Operates in harsh conditions :- works well in extreme temperatures and vibrations.

SKILL ACTIVITY NO: 7

Date : 15/04/25

(To be filled by the Instructor)

Title : Battery Management System (BMS).

Skills / competencies to be acquired :

1. Understanding function of Battery
2. Learning about battery monitoring and
3. Analyzing cell balancing techniques.
4. Understanding (state of charge, State
5. Management System.
6. protection mechanism (BMS).
7.
8. of Health).

Duration of activity (hours) : 1Hr.

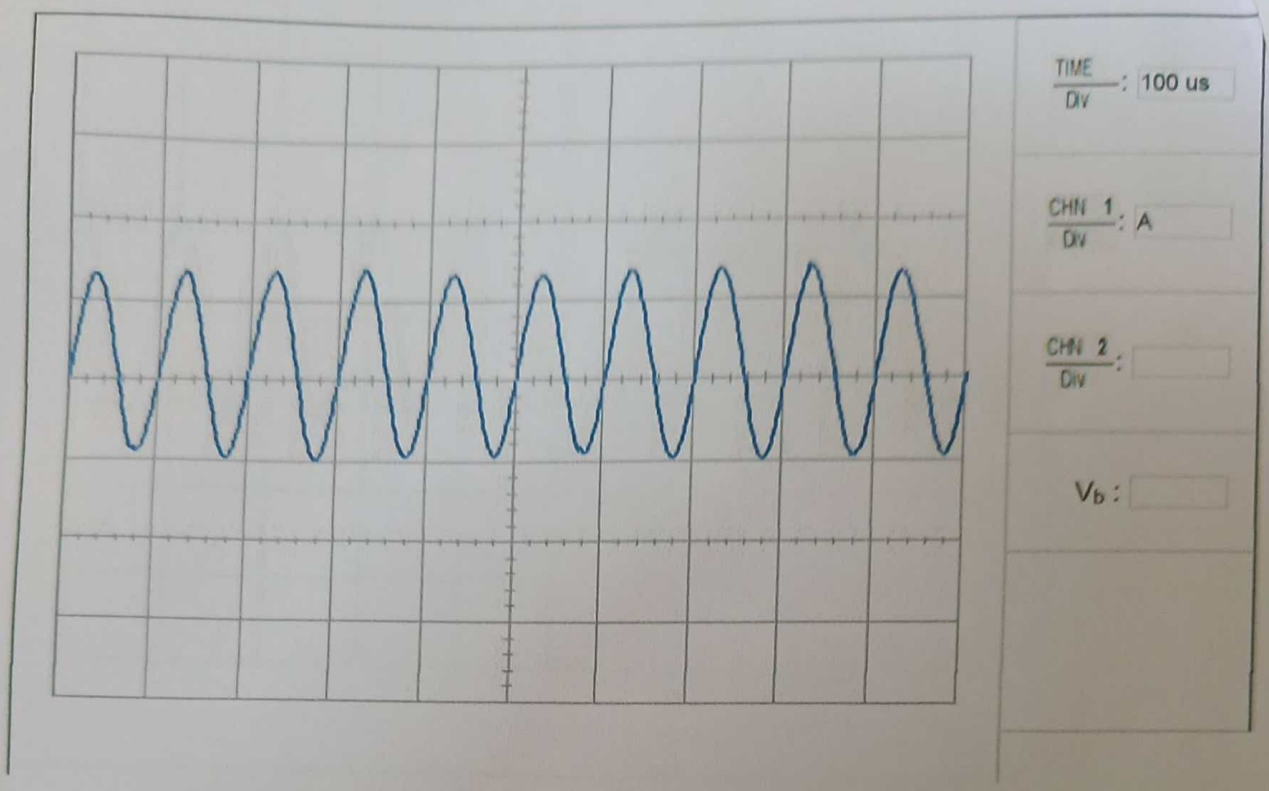
(To be filled by the Student)

1. What is the purpose of this activity ? (Explain in 3 - 4 lines)

To understand working of BMS and it's role in monitoring and protecting battery packs. The BMS ensures battery safety efficiency, and longerity by managing charge-discharge cycles, cell balancing and thermal regulations & learning the importance of BMS in electric vehicles, renewable energy systems and industrial applications.

2. Steps performed in this activity (Explain in 5 - 6 lines)

1) Studied the components and architecture of BMS.
2) Analyzed how BMS monitors, voltage, current and temperature of battery cells.
3) Learned about cell balancing techniques used to maintain uniform charge distribution.
4) Explored different battery state estimation methods (SOC, SOH, SOP).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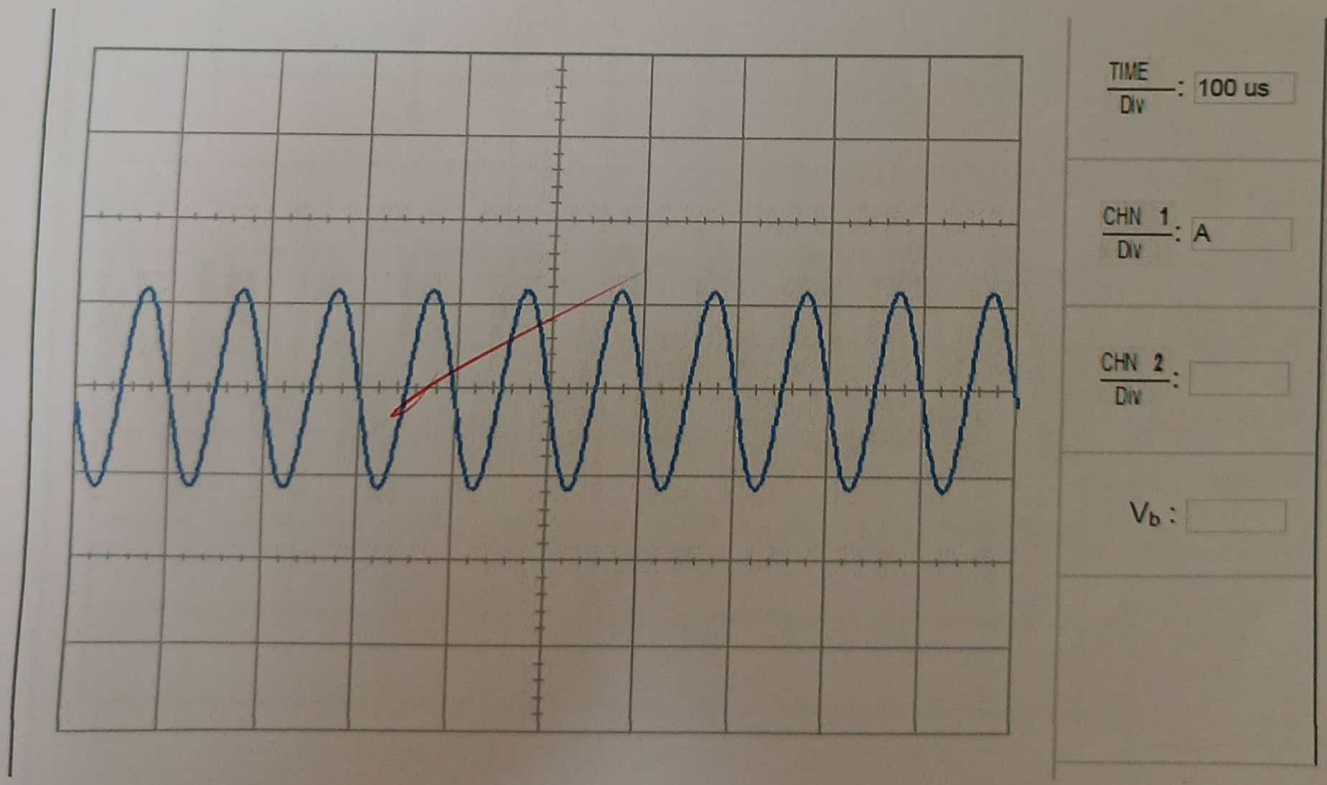
CHN 2/Div:
Vb :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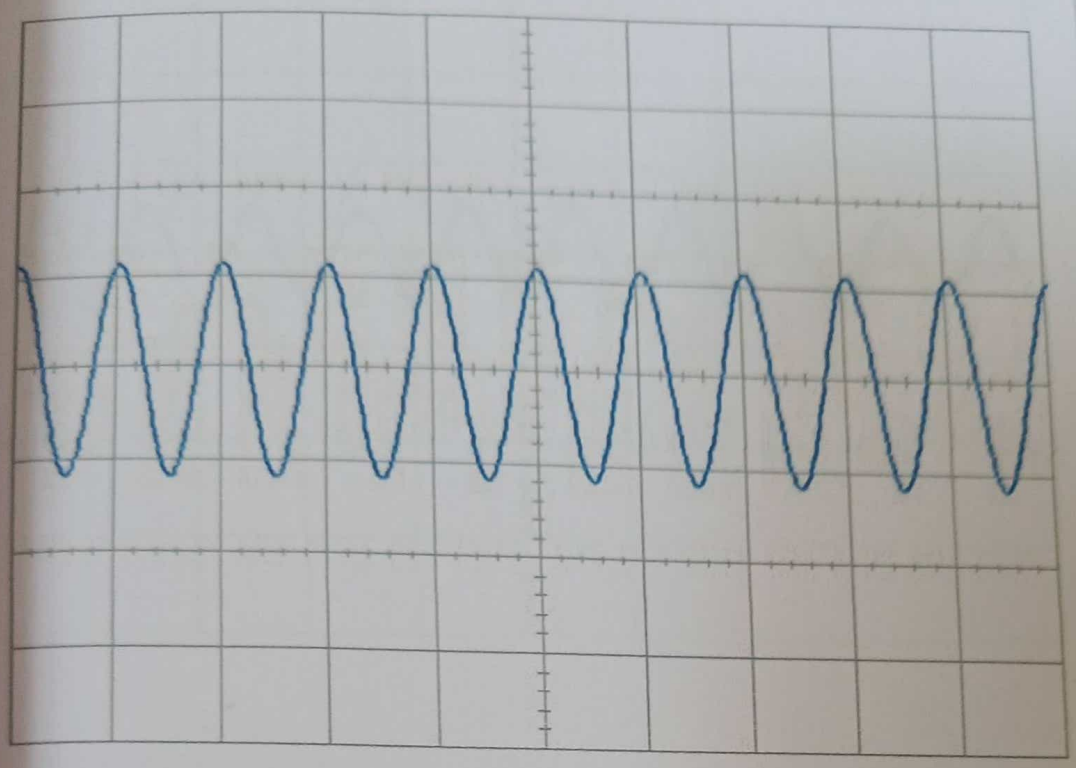

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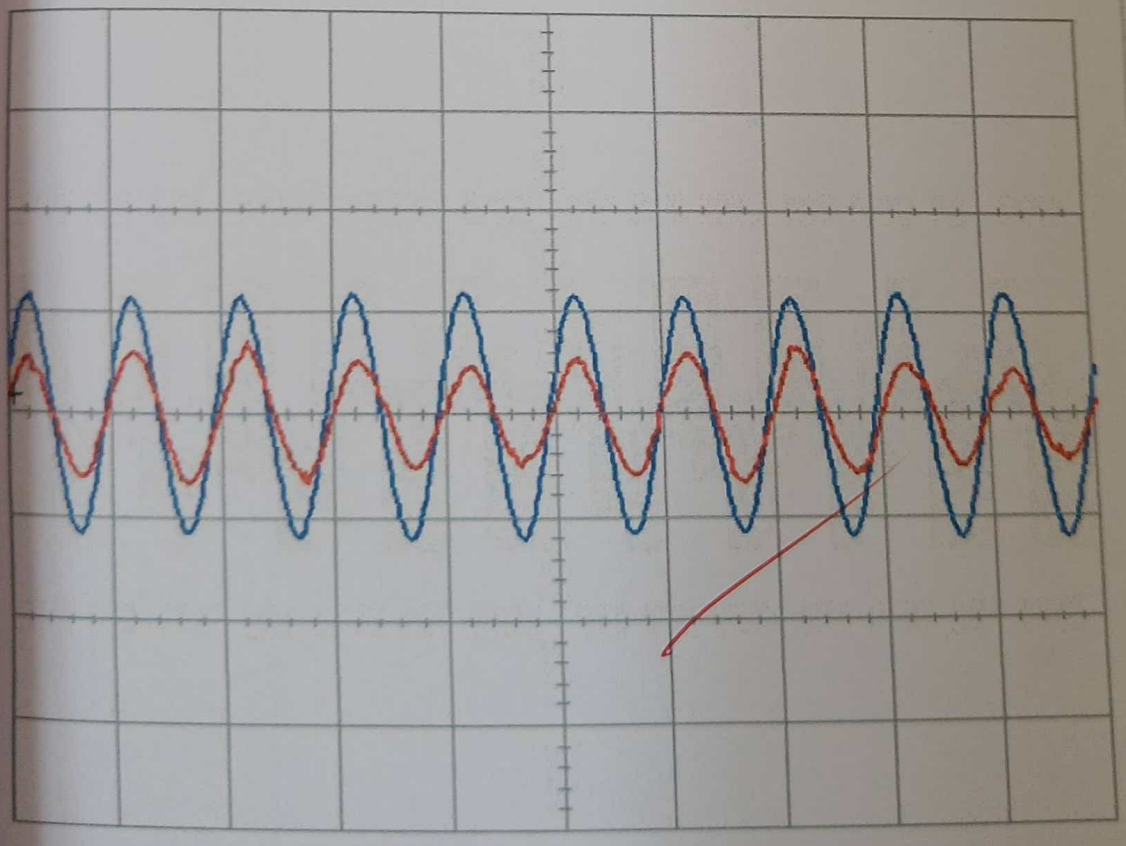

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V_b :

3. What resources / materials / equipments / tools did you use for this activity ?

1. LN labsoft
2. laptop
3. Reference books
4. Web.
5.
6.
7.
8.

4. What skills did you acquire ?

1. Understanding working of BMS.
2. Learning battery monitoring and
3. Analyzing cell balancing methods; Gaining
4. Using diagnostic tools like multimeter
5.
6. protection techniques.
7. knowledge of SOC.
8. & oscilloscopes

5. Time taken to complete the activity ? 1 (hours)

(Signature)

(Signature)

* What is Battery Management System (BMS)?

It is an electronic system that monitors, controls and protects battery pack to ensure safe and efficient operations. It is primarily used in lithium-ion, lead-acid, and other rechargeable batteries to optimize their performance prevent failure and extend lifespan. BMS is widely used in electric vehicles (EVs), renewable energy system, UPS systems and Industrial battery applications.

* Important Features / functions of BMS :-

1) Cell Monitoring :- Continuously measures the voltage, current and temperature of individual battery cells.

2) Over charge and over-discharge :- Prevents battery damage by ensuring cells operate within safe voltage limits.

3) Cell Balancing :- Ensures all cells in a battery pack are charged and discharged evenly to improve efficiency and longevity.

4) State of Charge (SOC) :- Estimation calculates the remaining battery capacity, similar to a fuel gauge.

5] State of Health (SOH) :- Monitoring - Assesses battery degradation over time and predicts it's lifespan.

6] Thermal Management :- ~~Monitoring~~ Controls the battery's temperature using cooling or heating systems to prevent overheating.

7) Short Circuit and Over Current :- Protection - Detection and prevents excessive current flow that could cause damage.

8) Communication Interface :- Use protocols like CAN, SMBus or Modbus to transmit battery data to external systems.

9] Fault Diagnosis and Alerts :- Detects issue such as, overheating voltage imbalances, or cell failure and triggers safety mechanisms.

10) Energy Efficiency Optimization :- Ensures proper charging and discharging strategies to maximize battery life.

* Voltage Monitoring in BMS :- Sensor used – voltage sensor or differential voltage sensor.

. Function :- Continuously measures the voltage of individual cells and the overall battery pack.

* Temperature Monitoring in BMS :- Sensors used - Thermistor resistance temperature detectors (RTD's), or thermocouples.

. Functions :- Measures the temperature at different points of battery pack.

* Current Monitoring in BMS :- Sensors used - Hall effect, Current sensor, Shunt resistors or Rogowski coils.

. Functions :- Measures charge & discharge current flowing in and out of the battery.