SKILL ACTIVITY NO: 1

Date : 24/1/25

(To be filled by the Instructor)

Title : To be able to do the repair & maintenance of HEV following safety rules & regulations, appropriate measures & risk assessment

Skills / competencies to be acquired :

1. Identify of high Voltage components
2. Isolating the battery
3. Risk Assessment
4. Use of safety measures
6. Checking critical subsystems
7. Understanding international Standards
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 develop technical skills for safe handling of hybrid electric vehicles. To learn high-voltage identification & isolation procedures and to understand safety, repair and maintainance of HEVs.

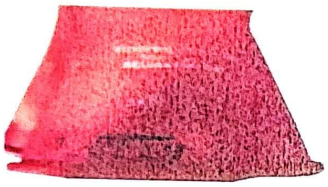
2. Steps performed in this activity (Explain in 5 - 6 lines)

① Open LN Labsoft
② Then under certain cource open Safety Manual
③ Open the Safety & Hazard Tab
④ To explore various aspects under safety and Hazard.
⑤ To write a note in detailed of the aspects which are required.

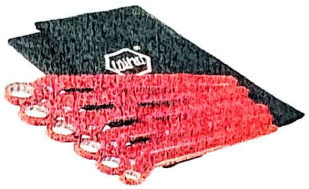
TY MTRX

Name – Tanishq Zade

PRN – 2200601058

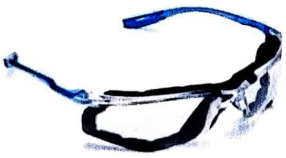


Testing Gloves
Overalls



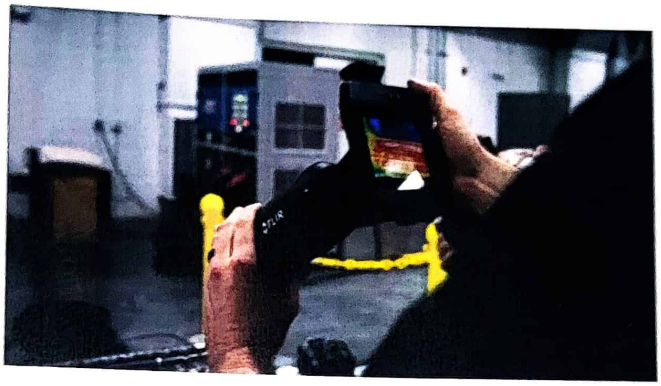
Insulated Tools

Face Shield
Safety Footwear



Safety Glasses

Insulated Rescue Hook Camera



Thermal Imaging of Battery using Thermal

① High Voltage Identification :-

→ HEVs operate on high voltage HV systems, typically ranging from 200 to 800 V 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 & motor controllers that are part of the HV system.
- Understanding Colour Codes & Markings : HV components are usually marked with orange-coloured cables & safety symbols.
- Awarness of Potential Hazards : Electric Shocks, Arc Flash, and thermal burns are common risks associated with HV systems.
- Labeling & Signage : Using proper warning label & ensuring all HV components are clearly marked.

② Isolation of HV Systems :-

→ Before servicing HEV, it is essential to disconnect & isolate the HV system to prevent electrical Hazards.

- Shutting Down the HV system Properly : Following manufacturer's specific procedures to power down the HV system
- Using Personal Protective Equipment : Wearing Insulated Gloves, Face shields & safety boots while working on HV components.
- Verifying Zero Voltage Conditions : Using a multimeter or voltage tester to confirm the absence of voltage before Handling electrical components.
- LocRout / Tagout (LOTO) Procedures : Implementing LOTO protocols to prevent accidental re-energization of the HV System.
- Properly Reconnecting the system : Ensuring all safety checks are performed before re-energizing the vehicle.

③ International Standards & Regulations :-

→ Working the HEVs required compliance with various safety standards & regulations to ensure proper handling & operations.

Key Standards :-

- ISO 6469 : Safety specification for electric road vehicles
- SAE J1772 : Standard for charging connectors & systems.
- IEC 61851 : Electric vehicle conductive charging & systems.
- OSHA & NFPA 70E : Occupational safety guidelines for electric work.
- Automake specific Guidelines : Following HEV manufacturers Safety & Repair manuals.

④ Use of Appropriate Tools & Measures :-

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

Essential Tools :-

- Insulated hand tool : Wrenches, screwdrivers, pliers & sockets rated for high voltage works.
- Voltage Testers & Multimeters : Used to check Voltage presence & continuity.
- PPE : Includes class 0 or class 1 insulated gloves, arc-rated clothing & face shields.
- Thermal Imaging Cameras : Used for diagonsing battery overhead issue.
- High Voltage Rescue Hooks : Essential for safety removing a person from a electrified surface in case of an accident.

⑤ Checking for Critical Subsystems :-

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

- Battery Management System : Ensures battery pack safety, monitor temperature & prevents overcharging.
- Cooling Systems : Keeps the battery inverter & motor at operating temperatures.
- Regenerative Braking Systems : Ensures the efficient recovery of energy & proper braking performance.
- Electrical Insulation & Grounding : Prevents leakage currents & short circuit.

SKILL ACTIVITY NO: 2

Date : 31/1/25

(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 && effectiveness
3. Applying selection criteria x for vehicle integration
4. Optimizing energy efficiency & charging & thermal stability
5. Understanding environmental impacts of battery technologies.

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 Optimize Performance : Ensure the battery meets the vehicles's power efficiency & range requirements.
② Enhance Safety : Select batteries with reliable thermal management & safety features.
③ Cost Effectiveness : Balance performance with affordability & long
④ Sustainability : Promote environmentally friendly & terminative energy-efficient solutions.
⑤ System Integration : Ensure seamless compatibility with the vehicle's powertrain & electrical systems.

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

① Analyze vehicle requirements.
② Research & compare battery options.
③ Evaluate performance and Safety.
④ Conduct cost-benefit analysis.
⑤ Ensure compatibility with vehicle systems.
⑥ Optimize for performance & safety.
⑦ Test & validate battery performance.
⑧ Select the best battery based on criteria.

Features:

1. Maintenance-free operation;
2. The long service life of 10~15 years;
3. Inbuilt BMS multiple security protection;
4. High-quality lithium iron phosphate batteries, safe and reliable;
5. More rechargeable time, longer lifetime, economic and environmental protection.

Item	Lead Acid Battery	Lithium Iron Phosphate Battery
Weight energy density	35-50Wh/kg	120-260Wh/kg
Volume energy density	80Wh/L	>230Wh/L
1C discharge current capacity	35% rated capacity	>95% rated capacity
Max charge current	0.2C	1C
Fully charge time	>10~12 hrs	2.5hr @ 0.5C rate
Cycle life @ 10% DOD	200~500 cycles	5000+ cycles
Weight	Lithium battery weight is 30% of lead-acid battery	
Volume	Lithium battery volume is 40% of lead-acid battery	

Specification:

51.2V 30Ah Lithium Battery LiFePo4 Deep Cycle Rechargeable Battery Replace the Lead Acid Battery

Electric Characteristics

Battery Type	LiFePo4	Nominal Capacity	30Ah
Nominal Voltage	48V	Actual Voltage	51.2V
Energy	1536Wh	Cycle Life	3500+

Charging and Discharging Parameters

Full charge volt	58.4V	Discharge cut-off volt	≤40V
Max charge current	15A	Max continuous discharge current	30A
Peak discharge current	60A@1~3 Seconds	Suggested charge Volt	58.4V

Operation Temperature Parameters

Charge	0~45°C	Storage less than 12 months	-20 ~25°C
Discharge	-20~60°C	Storage less than three months	-20~35°C
Recommended	18~28°C	Storage over 12 months	25 °C

Mechanical Properties

Dimension Length	328mm	Housing materials	ABS/PVC/Customized
Dimension Width	172mm	Terminal size	M6/M8 optional
Dimension Height	220mm	Waterproof level	IP65
Weight	About 15kg	Configuration	16S1P/ 16S5P

BMS function

Protect battery from Overcharge, Over-discharge, Over-current, Short circuit

Advantage

High safety (no fire, no explosion)	No memory effect	High energy density	Long lifespan
Fast Charge Capability	Waterproof	Individual cell balancing	Easy maintenance

(To be filled by Instructor)

Sr. No.	Skills / Competencies	Achieved / Not Achieved (YES / NO)

Why choose MANLY:

1. 36 months longer warranty time
2. OEM/ODM custom is acceptable without MOQ Request
3. Made of industrial Grade original MANLY factory lifepo4 battery cell with Factory price
4. With advanced smart BMS (Battery Management System)

	Safety.	
4.	Optimizing energy, charging & thermal stability	
5.	Considering environmental impact.	

Remarks

① Battery Selection for 2/3/4 Wheeler Electric & Hybrid Electric Vehicles :

⇒ Types of vehicle, Batteries used & Technical Specifications

Vehicle Type	Battery Type	Voltage Range	Capacity (KWh)	Energy Density (Wh/Kg)	Cycle life (cycles)	Charging Time (hrs)
2 Wheeler	Li-ion	48-72 V	1-3 KWh	150-200	1000-2000	2-4 hrs
2 Wheeler	Nickel metal Hydride (Ni-MH)	36-48 V	0.5-1.5 KWh	60-120	500-1000	4-6 hrs
3 Wheeler	Lithium ferro phosphate [LFP]	72-96 V	4.8 KWh	60-120	2000-3000	3-5 hrs
3 Wheeler	Ni-MH	72-96 V	3.5 KWh	150-250	500-1000	4-6 hrs
4 Wheeler	Nickel Manganese Cobalt (NMC)	300-400 V	30-60 KWh	150-250	1000-2000	6-8 hrs (Fast Charging 1-2)
4 Wheeler	Li-ion	300-400 V	40-70 KWh	150-250	1000-2000	6-8 hrs (Fast charging 1-2)
4 Wheeler	Ni-MH	200-300 V	20-40 KWh	60-120	500-1000	8-10 hrs

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

1. Energy Capacity : Ensures the battery provides sufficient energy to meet the req^d range for the vehicle. Higher capacity is req^d for 4-wheeler.

2. Voltage & Current : The voltage must be matching the vehicle's power requirement. Higher V system (100-400 V) are typically used for 4-wheeler, while lower V (48-72 V) system are used for 2/3 wheelers.

3. Life Cycle : The battery should be with high life cycle to ensure long-term durability & cost-effectiveness. Li-ion batteries typically offer 1000-2500 cycles.

4. Charging Time : The vehicle should have a reasonable charging time, balancing fast charging with battery life. Fast charging is crucial for consumer convinience.

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

6. Weight : The battery weight should be optimized to ensure vehicle performance & efficiency. Lighter batteries are crucial for 2|3 wheelers.

7. Safety : The Battery Management System (BMS) to ensure safety against overheating, short circuits and overcharging.

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

---

③ To Design 3-Wheeler HEV/Electric Vehicle :-

✱ Battery Type : Lithium Ferro Phosphate [LFP] Battery

1. Technical Specifications :

i) Voltage Range : 72-96 V
ii) Capacity : 4.8 KWh
iii) Charging Time : 3-5 Hours
iv) Life cycle : 2000-3000 cycles
v) Energy Density : 60-120 Wh/Kg
vi) Thermal Management : Air-Cooled
vii) Weight : 150-200 Kg
viii) Temperature Range : -20°C to 60°C

2. Features & Safety :-

i) Safety : LFP are considered to be more safe when the temperature rises. They are less suspectable to explosion.

ii) Cycle Life : It has a long cycle life (1800-2000+)

iii) Cost : Cheaper & cost friendly compared to Li-ion

iv) Thermal Stability : It can sustain wide range of temperature.

v) Environmental Impact : Generally considered more environmentally friendly.

3. Pros :-

i) High Safety
ii) Long Lifespan
iii) Cost-effective
iv) Thermal Stability
v) Eco-friendly.

4. Cons :-

i) Lower Energy Density
ii) Heavier
iii) Slow charging
iv) Reduced cold performance
v) Low voltage

SKILL ACTIVITY NO: 3

Date : 4/2/25

(To be filled by the Instructor)

Title : Selection of Motor for 2/3/4 Wheeler hybrid Electric Vehicle [HEV]

Skills / competencies to be acquired :

1. Choosing suitable motor for a different HEVs.
2. Understanding motor spes like power, torque, efficiency & cooling
3. Basics of motor control systems
4. Applying motor selection priciple in real-world EVs

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 motor selection for 2/3/4 wheeler HEVs.
- To compare different motor types based on technical specs.
- To identify key selection criteria for performance.
- Analyze pros & cons of various motors.
- To gain knowledge of motor efficiency, control & integration in EVs.

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.

No.	Competencies	Achieved / No (YES /
1.	Able to choose suitable	

High Efficiency Industrial Motors

Permanent Magnet Synchronous Motor

Voltpro
"Upgrade your energy"

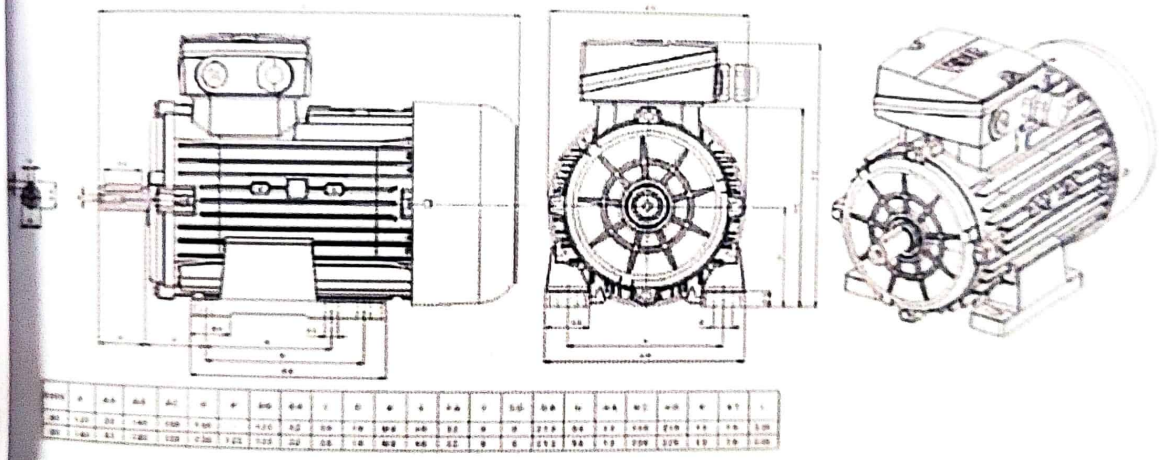
Driver setup

Driver should be adjusted for the motor. Firstly, all electrical connection must be done. And below steps should be followed one by one. Driver has 'Auto Tuning' mode to drive PMSM motor. For ramp up and ramp down settings, detail information can be found in manual

Step	Parameter	Description	Value
1	P0.0.02	Control Mode	1
2	P0.0.11	Acceleration Time	100
3	P0.0.12	Deceleration Time	20
4	P0.0.11	Type of Motor	2
5	P0.0.14	Rated Power	xx
6	P0.0.15	Rated Frequency	xx
7	P0.0.16	Rated Voltage	xx

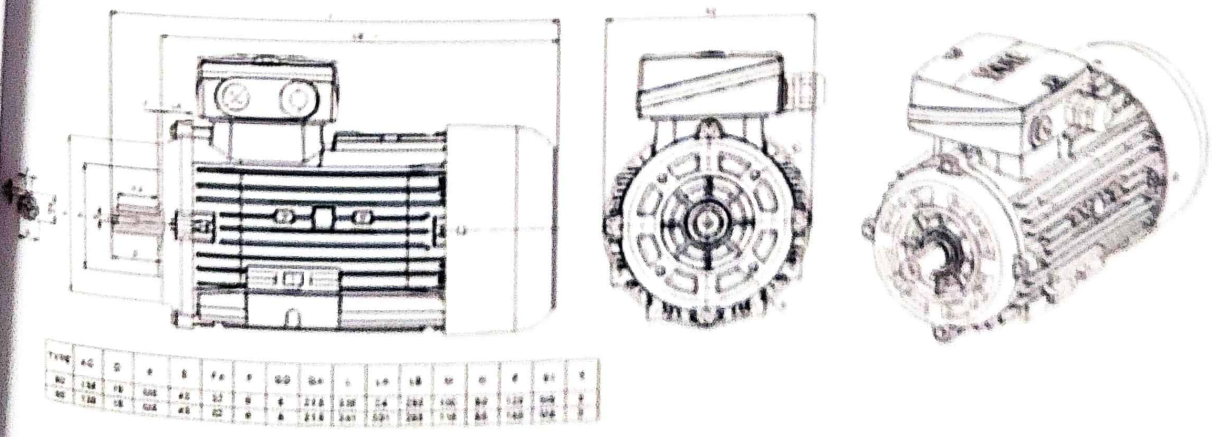
Step	Parameter	Description	Value
8	P0.0.17	Rated Current	xx
9	P0.0.18	Rated Speed	xx
10	P5.2.11	Back electromotive force current	30
11	P5.2.12	Start initial position to detect pulse current	80
12	P0.0.24	Auto Tunning	12

Construction Type of B3



Type	AC	D	E	S	FA	F	GD	GA	L	LD	LB	M	N	P	S
80	134	19	40	M6	22	6	15.5	21.5	330	234	200	165	130	200	10
90	138	24	50	M8	22	8	20	27	351	251	200	165	130	200	10

Construction Type of B14



Type	AC	D	E	S	FA	F	GD	GA	L	LD	LB	M	N	P	S
80	134	19	40	M6	22	6	15.5	21.5	330	234	200	165	130	200	10
90	138	24	50	M8	22	8	20	27	351	251	200	165	130	200	10

Sign of
Date:

09

1. Able to choose suitable motor for different HEVs.
2. Able to understand technical specifications.

Frame	kW	Nm	Rated Current [A]	Rated Eff [%]	Max.Torque [Nm]	Max. Current [A]	Max. "d" axis Current [A]	Max. Speed [rpm]
80	0.55	3.5	1.4	86.4	10.5	5.6	7	3000
80	0.75	4.8	2.1	89.3	14.4	8.4	10.5	3000
80	1.1	7.0	2.6	88.9	21.00	10.4	13	3000
80	1.5	9.6	3.2	89.5	28.8	12.8	16	3000
80	0.55	1.8	1.2	91.2	5.4	4.8	6	6000
80	0.75	2.4	1.4	92.6	7.2	5.6	7	6000
80	1.1	3.5	2.6	93.5	10.5	10.4	13	6000
80	1.5	4.8	3.4	92.3	14.4	13.6	17	6000
80	2.2	6.4	4.9	93.5	19.2	19.6	24.5	6000

tion Chart

is used to drive PMSM motor with sensor or sensorless. Drive type is FOC (Field Oriented Control)

	1500				3000				
	0.55	0.75	1.1	1.5	0.55	0.75	1.1	1.5	2.2
	1.40	2.10	2.6	3.2	1.20	1.40	2.6	3.4	4.9
	VoltPro 0.75kW Input: 3~ 400V Output: 3~ 400V 0-500Hz	VoltPro 0.75kW Input: 3~ 400V Output: 3~ 400V 0-500Hz	VoltPro 1.5kW Input: 3~ 400V Output: 3~ 400V 0-500Hz	VoltPro 1.5kW Input: 3~ 400V Output: 3~ 400V 0-500Hz	VoltPro 0.75kW Input: 3~ 400V Output: 3~ 400V 0-500Hz	VoltPro 0.75kW Input: 3~ 400V Output: 3~ 400V 0-500Hz	VoltPro 1.5kW Input: 3~ 400V Output: 3~ 400V 0-500Hz	VoltPro 1.5kW Input: 3~ 400V Output: 3~ 400V 0-500Hz	VoltPro 2.2kW Input: 3~ 400V Output: 3~ 400V 0-500Hz

① Motor Selection for 2/3/4 Wheeler Hybrid & Electric Vehicle [HEV] :-

⇒ Type of vehide, Motor used & Technical specifications.

Vehide Type	Motor Type	Power Rating	Efficiency	Torque [Nm]	Speed [RPM]	Cooling type	Appⁿ
2 Wheeler	BLDC motor	1-3 Kwh	85-90%	30-50	3000 - 5000	Air cooled	Scooters, E-bikes
2W	HUB motor	0.5 - 2 Kwh	80-85%	20-40	2000 - 4000	Air cooled	Light weight E-bikes
3W	PMSM motor	3-6 Kwh	90-95%	80-120	2000 - 4000	Air cooled	Rickshaws Cargo EVs
3W	SRM	4-8 Kwh	85-90%	100-150	1500 - 3500	Air cooled	Commercial EVs
4W	AC Indⁿ motor	30-60 Kwh	85-90%	200-400	6000 - 25000	Liqd cooled	Commercial EVs
4W	PMSM	50-100 Kwh	92-96%	300-500	5000 - 10000	Liqd cooled	Cars, SUVs, Commercial EVIs
4W	SRM	40-70 Kwh	88-92%	250-450	4000 - 8000	Liqd cooled	Heavy Duty Trucks, SUVs
4W	Axial Flux motor	60-120 Kwh	94-97%	350-550	5000 - 11000	Liqd cooled	Sports car, Truck & SUVs
4W	Dual motor system	80-150 Kwh	93-97%	400-600	5000 - 12000	Liqd cooled	High performance AWD EVs.

② Motor Selection for 2/3/4 W Criteria :-

1. Power Requirement : Based on vehicle load, Acceleration needs & terrains.
2. Efficiency : Higher efficiency ensures better mileage & energy savings.

3. Torque & Speed : Depends on the vehicle type, higher torque for heavy loads higher RPM for speed.

4. Weight & Size : Compact motors preferred for 2 wheelers, Robust designs for 4 wheelers.

5. Cooling System : Air cooled for light weigh applications, liquid-cooled for high performance vehicles.

6. Cost & Maintenance : Balance b/w performance & cost effectiveness.

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③ To Design 4-Wheeler Hybrid & Electric Vehicle :-

(*) Battery Type : Permanent Magnet Synchronous Motor (PMSM)

1. Technical Specification :

i) Power o/p : 50-100 KW
ii) Efficiency : 92-96 %.
iii) Torque : 300-500 Nm
iv) Speed : 5000-10000 RPM
v) Cooling System : Liquid-cooling
vi) Voltage Range : 300-400 V
vii) Weight : 50-70 Kg
viii) Regenerative Braking Feature Available.

2. Working Principle :

PMSM operates on the principle of Electromagnetic induction. It uses permanent magnets embedded in the rotor to spin in sync with the stator's field with speed proportional to AC supply frequency. This ensures efficiency, efficient torque production & precise speed control.

PTO

3. Features :

i) High Power Density
ii) Superior Efficiency
iii) High Torque at low speed
iv) Regenerative Braking Support.

4. Pros :

i) Maximize Battery Life & Range
ii) Compact & Light Weight
iii) Low Noise
iv) Reliable Performance.

5. Cons :

~~i) Maximize battery life & Range~~
~~ii)~~

i) Higher Cost
ii) Complex control system
iii) Temperature sensitivity
iv) Maintenence.

SKILL ACTIVITY NO: 4

Date : 31/1/25

(To be filled by the Instructor)

Title : Fault Analysis & Diagnosis for HEVs

Skills / competencies to be acquired :

1. Able to Diagnose & Analyse HEV using LN Lab Equipment.
2. Able to intepret fault codes & troubleshooting HEV systems.
3. Understanding High Voltage system safety protocols
4. Hands on experience of Fault & systems.

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 the activity is to equip learners with technical expertise in fault analysis & 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 & components of the HEV simulator trainer including high voltage battery, inverters, electric motor & control modules

② Initial Safety Checks & Setup.

③ Use fault Simulation features to introduce specific faults into the system, such as battery over voltage, motor failure or inverter malfunction.

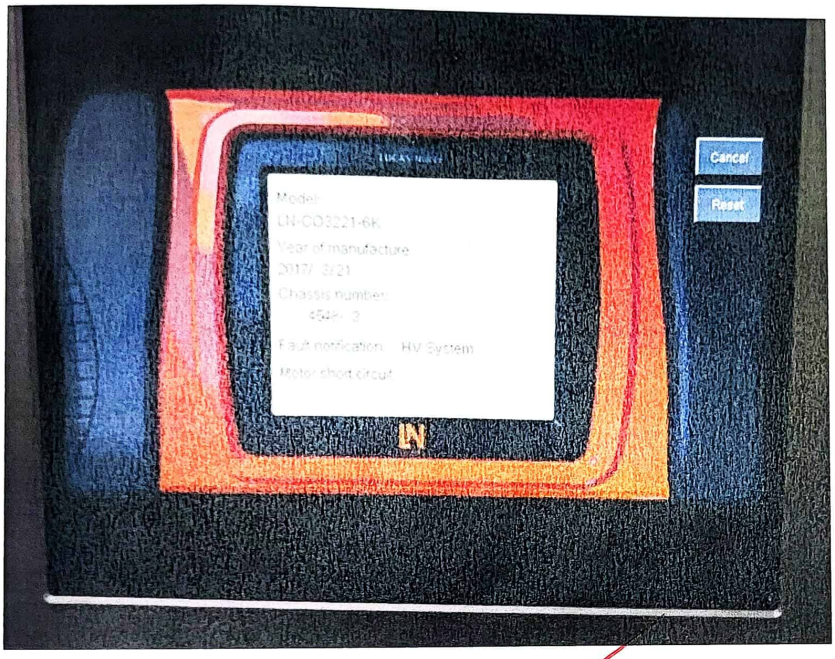
④ Troubleshooting & Resolution

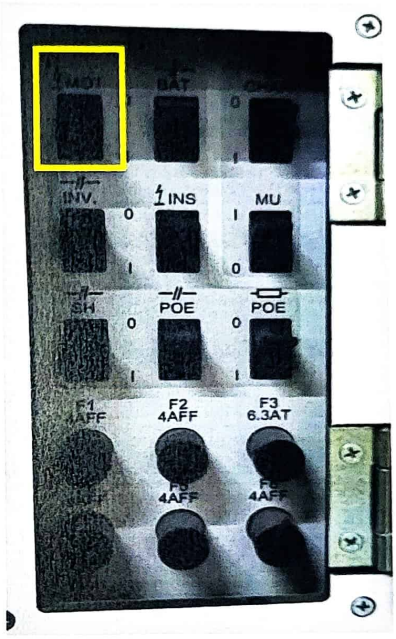
TY MTRX

Name – Tanishq Zade

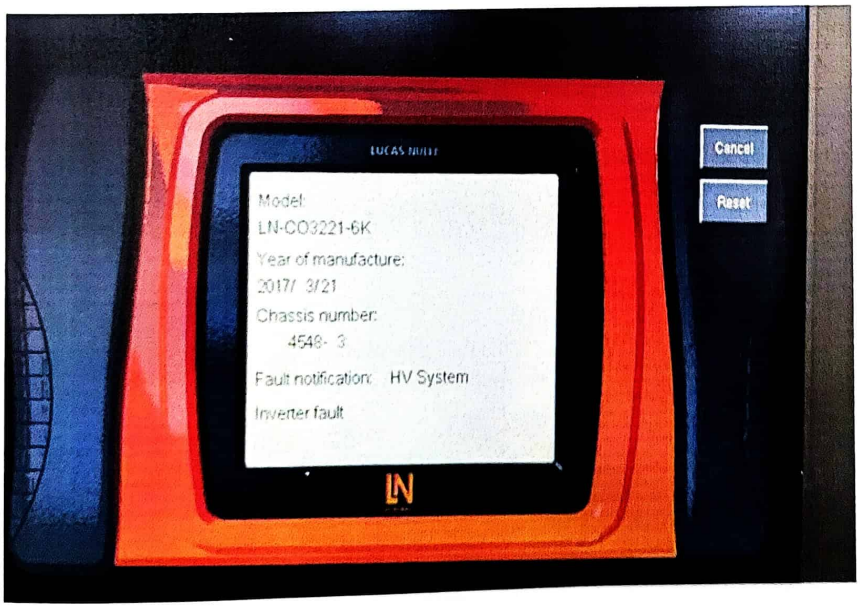
PRN – 2200601058

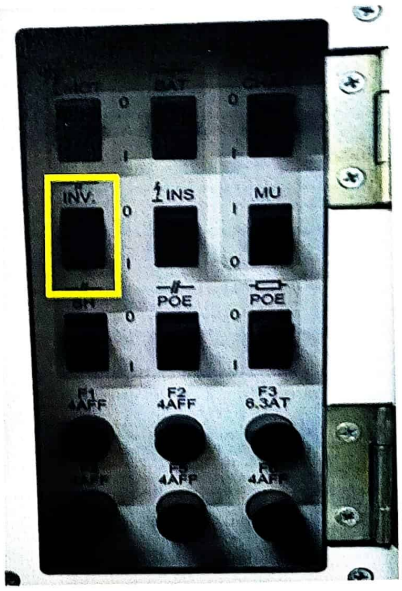
1. Serial hybrid drive - Parallel hybrid drive



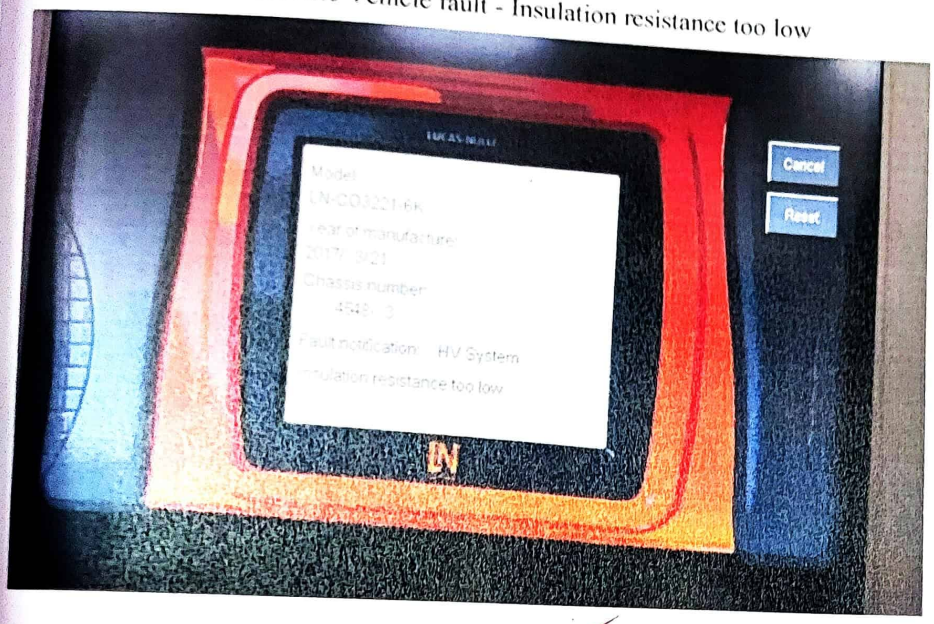


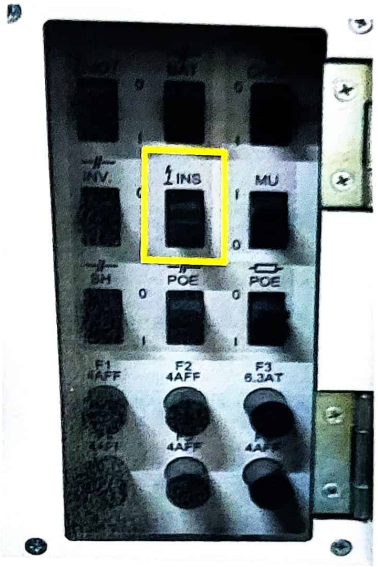
2. Fuel cell drive - Inverter Fault



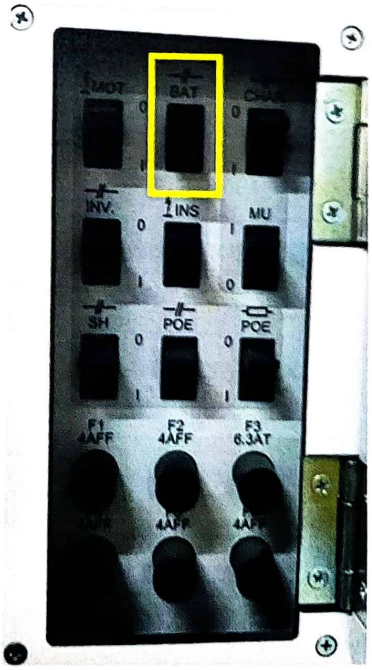


3. Electric Vehicle fault - Insulation resistance too low





4. Parallel hybrid drive - high voltage battery fault



① Fault in Hybrid - Serial :-

1. Diagnostic Steps : Customer details were insufficient to detect faults. Diagnostic Unit ruled it to be motor short-circuited.
2. Affected Components : HV System, Motor Generator 1&2.
3. Diagnosis : LM 2333 used for resistance check; 0.5 Ω individual short circuit.
4. Resolution : Repair / Replacement of the defective phase.

② Fault in Parallel Hybrid :-

1. Diagonostic 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 components show 8.5 V
4. Resolution : Repair / Replacement to restore functionality.

③ Fault in Fuel cell Vehicle :-

1. Diagnostic Steps : Using Jumpers connect to the system on overlay C03221-GREG & the diagonostic unit detects it to be Defective inverter
2. Affected Components : Inverter

3. Diagnosis : LM2333 confirms 0.5 V on the Inverter
4. Resolution : Repair / Replacement required.

(4) Fault in Electric vehicle :-

1. Diagnostic Steps : Use overlay C03221-6 KE 6. Fit Jumpers on high voltage battery & the Eight handside. Turn ON Ignition.

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

3. Fault Determination : Use LM2333 to measure insulation resistance by applying 100 V pulse to test.

4. Fault localization : Measurements confirmed the motor generator as the defective components.

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 : By using MATLAB & Simulink estimate SoC (State of Charge) using suitable Algorithm

Skills / competencies to be acquired :

1. Understand the various SOC estimation methods
2. Understand working & efficiency of each method
3. Implementation of any one method on MATLAB.
4. Understand the use of MATLAB & 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 O/P.

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 ?

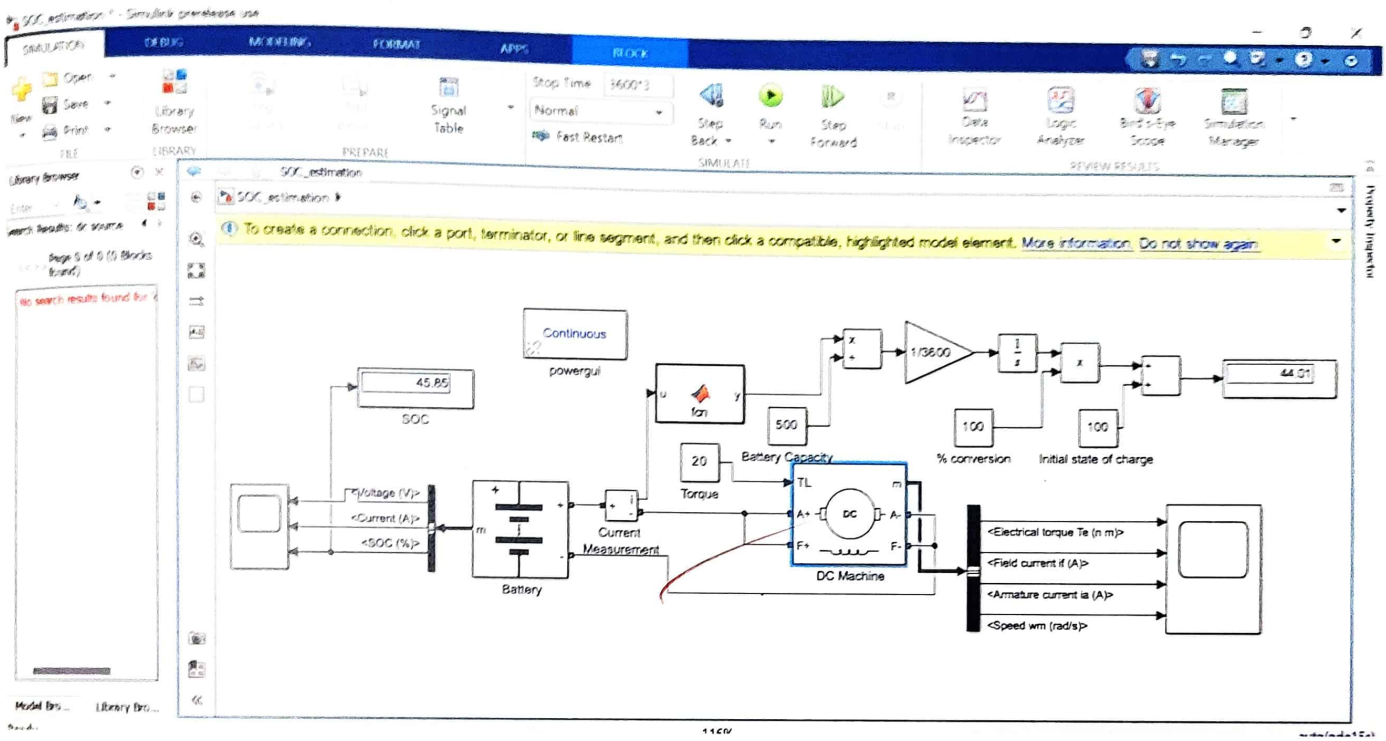
1. Understand the various soc est5imation methods
2. Understand working & efficiency& of each method.
3. Implementation of any one % metha on MATLAB.
4. Understand the use of MATLAB& & Simulink.

5. Time taken to complete the activity ? 4 hrs (hours)

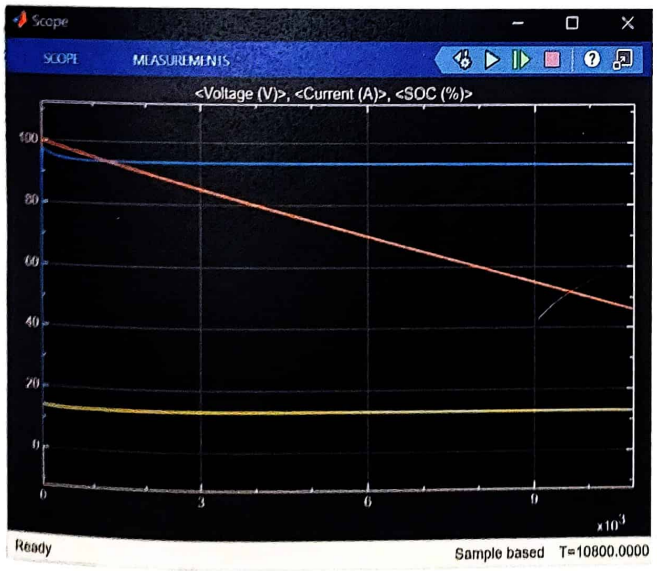
(Signature)
Instructor

(Signature)
Student

(To be filled by Instructor)



SOC ESTIMATION IN SIMULINK



Method	Description	Advantages	Disadvantages	Accuracy	Complexity
Coulomb Counting	Tracks changes by integrating current over time.	• Simple to implement • Low computational cost	• Requires initial SOC • Erroneous overtime	Moderate	Low
Open Circuit Voltage (OCV)	Estimates SOC based on voltage of batteries.	• High accuracy when battery is stable.	• Requires battery to rest. • Temperature sensitive	High (at rest)	Low
Kalmen Filter	Uses a mathematical recursive algorithm to estimate SOC.	• Corrects errors in real-time. • Immune to noise • Adaptive	• complex to implement • Intensive computation required	High	High
Impedance Measurement	Estimates SOC by analyzing battery impedance of specific frequency.	• Good for ongoing assessment • Works during operation	• Requires specialized hardware • Temperature sensitive	Moderate to High	Moderate to High

⑧ Reasons to choose Coulomb Counting :-

① Simple : • It is very easy method to understand & 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.

④ Coulombs Counting Method :-

The method calculates SOC by measuring current flowing into or out of the battery & 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 = SOC Initial + q~~

$$SOC = SOC_{initial} + \frac{q}{C_{nominal}} \times 100$$

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

* $C_{nominal}$ = Battery rated capacity in coulomb.

SKILL ACTIVITY NO: 6

(To be filled by the Instructor)

Date : 9/4/25

Title : Resolver

Skills / competencies to be acquired :

1. Understanding the working principle of resolver.
2. Learning about resolver app^n & in industries.
3. Identifying the components of a resolver
4. Analyzing resolver signals (sine & cosine o/p)

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 signals & their conversion into digital data for practical applications.

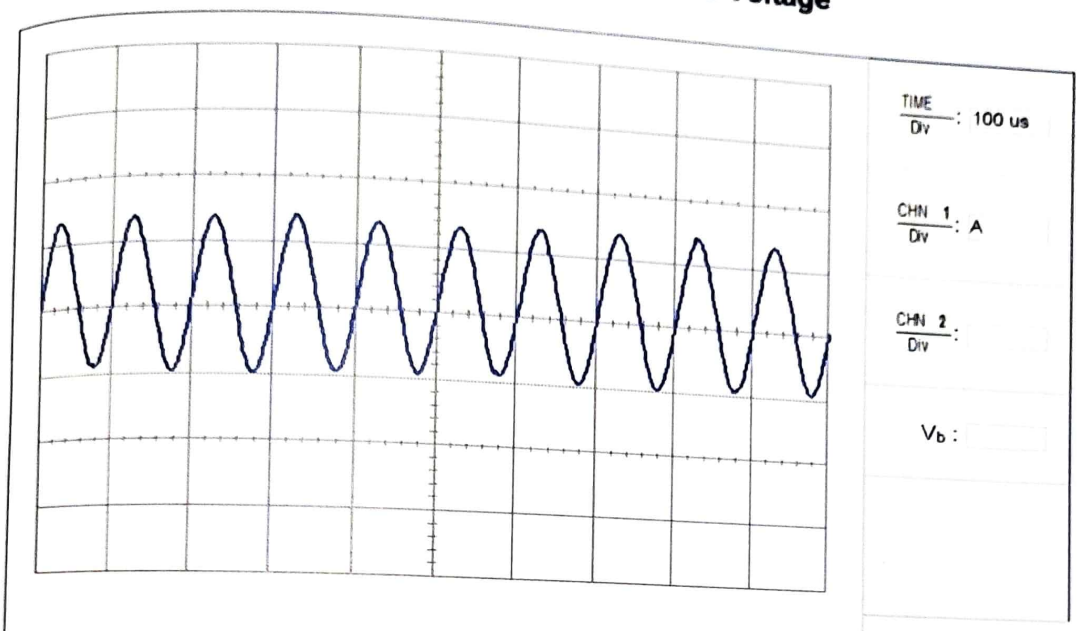
2. Steps performed in this activity (Explain in 5 - 6 lines)

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

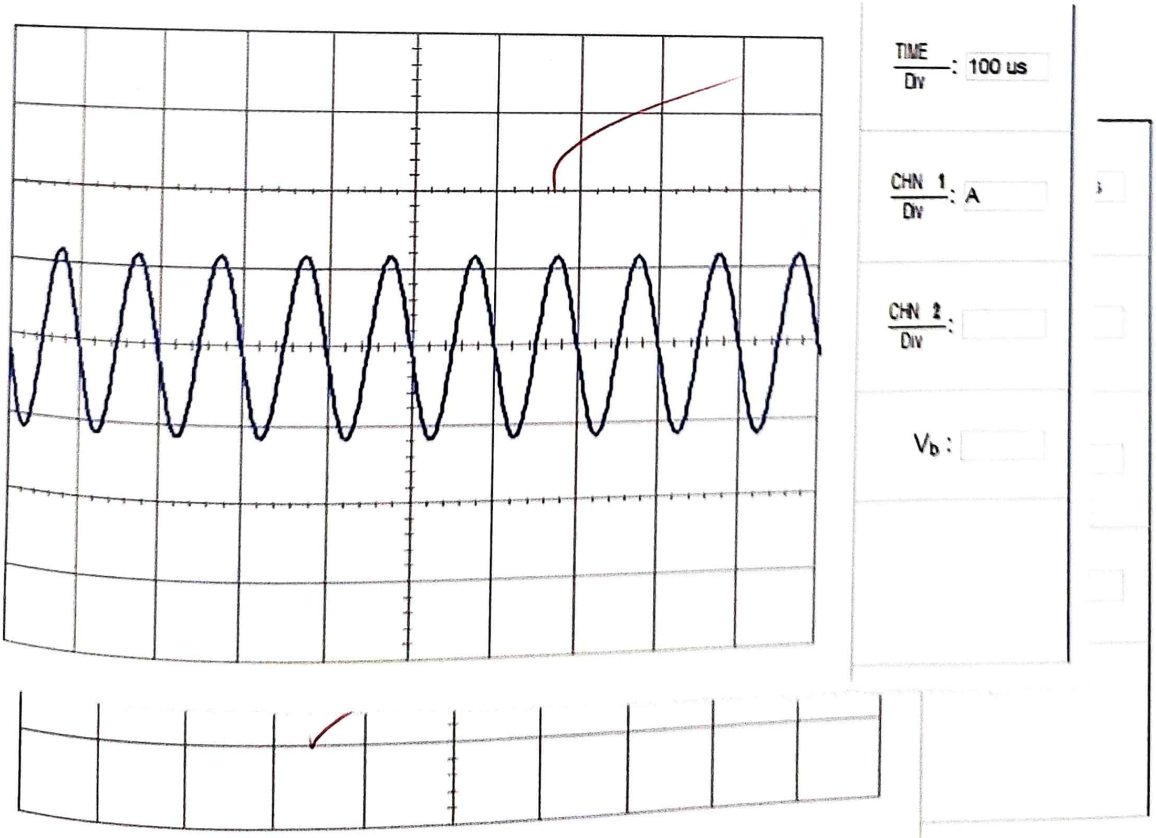
(To be filled by Instructor)

Cosine Wave

Measurement Reference Voltage



Sine Wave



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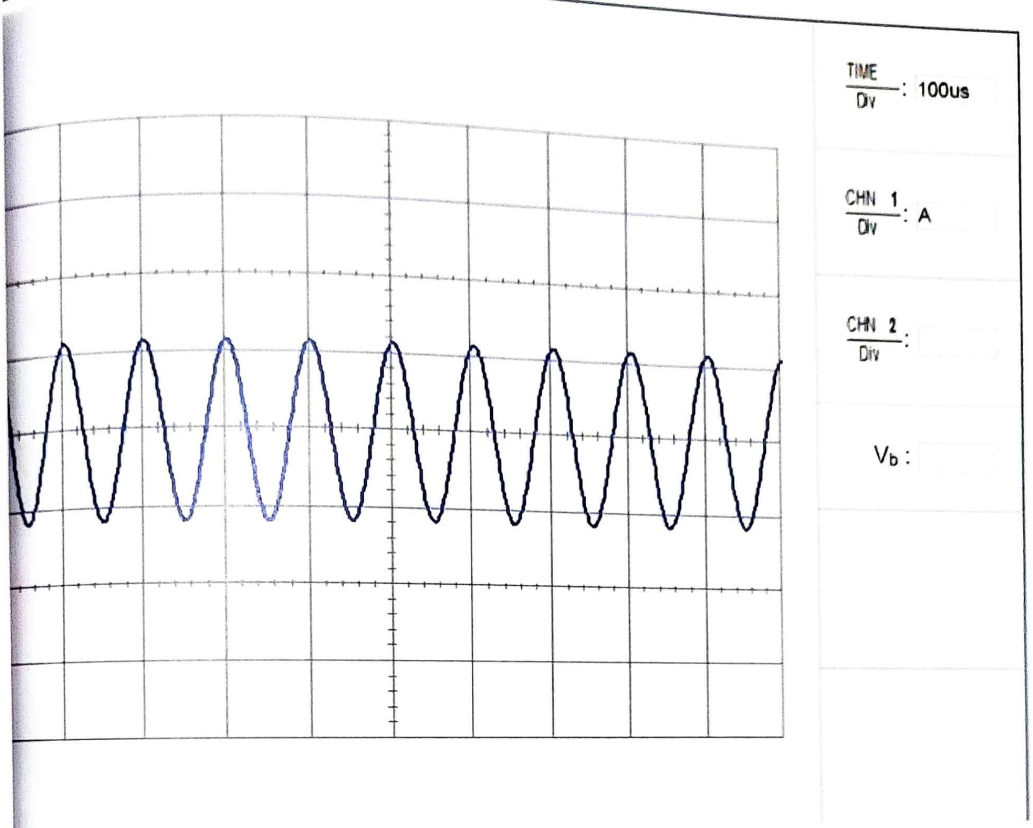
Cosine Wave



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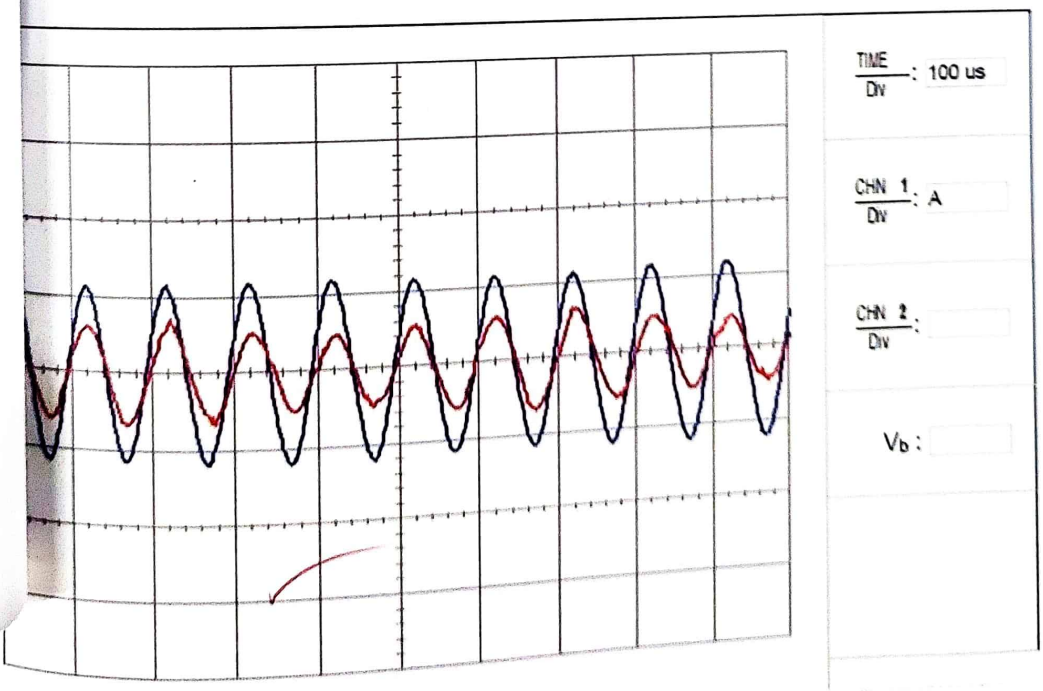
Bipolar Sine and Cosine Wave



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✡ What is Resolver ?

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

Resolver work based on electro magnetic induction & provide analog o/p signal that represents angular displacement unlike digital encoders resolver do not have discrete position but instead generate continuous signals corresponding to the rotor's position.

✡ Principle of Resolver :-

A resolver operates based on the principle of electromagnetic induction. It consist of the following components :

① Rotor : The rotating part, which is excited by an alternating current (AC) voltage.

② Stator : Contains two orthogonal windings (sine & cosine windings) that receive induced voltage from the rotor.

③ Excitation Source : Provides an AC i/p signal to the rotor windings.

✡ Working Mechanism :-

① An AC voltage is applied to the rotor winding, which induces voltage in the Stator windings due to electromagnetic induction.

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

③ The o/p signal 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 the resolver provide continuous & noise-resistance analog signals, they are highly reliable in applications where precise motion control is required.

⑧ Where is Resolver Used ? :-

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

⑨ Advantage 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 to not have limited resolution.

④ Resistant to electromagnetic interference : Suitable for aerospace & defence. appn

⑤ Operates in harsh conditions : Works well in extreme temperatures & vibrations.

SKILL ACTIVITY NO: 7

(To be filled by the Instructor)

Date : 16/4/25

Title : Battery Management System (BMS)

Skills / competencies to be acquired :

1. Understanding function of Battery Management System (BMS)
2. Learning about battery monitoring & protection mechanism.
3. Analyzing cell balancing & techniques
4. Understanding (SOC, State of Health)

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)

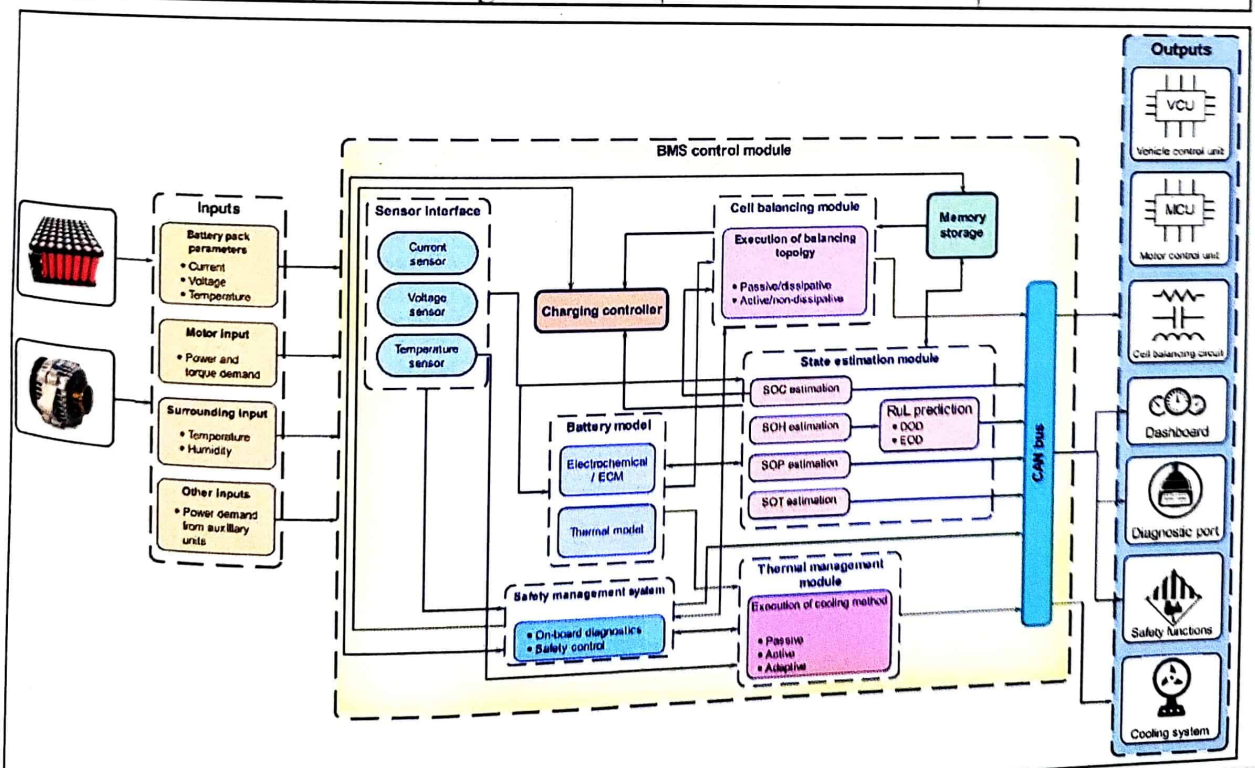
To understand working of BMS & its role in monitoring & protecting battery packs. The BMS ensures battery safety efficiency, & longevity by managing charge-discharge cycles, cell balancing & thermal regulations & learning the importance of BMS in electric vehicles, rewnable energy system & industrial applications.

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

① Studied the component & architecture of BMS.
② Analyzed how BMS monitors, voltage, current & temperature of battery cells.
③ Learned about cell balancing techniques used to meintain uniform charge distribution.
④ Explored different battery state estimation methods (SOC, SOH, SOP).

(To be filled by Instructor)

Centralized BMS	Master-slave BMS	Modular BMS	Distributed BMS
Cells are connected through huge number of wires, and a single controller controls the entire system	Cells are connected through wires and are controlled by slave boards	BMS boards are divided into limited banks and are connected together in a daisy chain. These boards are connected to each cell	Each cell is mounted by a BMS board
	The slave boards are distributed at different sites, and these are controlled by a single master controller	A central controller is connected to BMS boards through a cable	Communication between battery and its controller is done through a cable
The centralized BMS architecture is well suited to battery packs with a small number of cells	1. This architecture divides the tasks of software among the slave boards 2. No additional software requirement, reliabilty are the advantages	Difficult to achieve isolated master–slave communications in electric vehicles	The advantages of this design include its simplicity and high reliability



⭐ What is Battery Management System (BMS) :-

It is an electronic system that monitors, controls & protects battery pack to ensure safe & efficient operation. It is primarily used in Li-ion, Lead-Acid & other rechargeable batteries to optimize their performance prevent failure & extend lifespan. BMS is widely used in electric vehicles (EV's), renewable energy system, UPS systems & Industrial battery applications.

⭐ Important Features / Functions of BMS :-

① Cell Monitoring : Continuously measures the voltage, current & temperatures of individual battery cells.

② Over-Charge & over-discharge : Prevents battery damage by ensuring cells operate within safe voltage limits.

③ Cell Balancing : Ensures all cell in a battery pack are charged & discharged evenly to improve efficiently, efficiency & 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 & predicts it's lifespan.

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

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

⑦ Communication & Interference : Use protocols like CAN, SMBus, etc. to transmit battery data to external systems.

⑧ Fault Diagnosis & Alerts : Detects issue such as, overheating voltage imbalances, or cell failure and triggers safety mechanism.

⑨ Energy Efficiency Optimization : Ensures proper charging & Discharging strategies to maximize battery life.

⑩ Voltage Monitoring in BMS :-

- Sensor used : Voltage sensor or Differential voltage sensor
- Function : Continuously measures the voltage of individual cell & the overall battery pack.

⑪ Temperature Monitoring in BMS :-

- Sensor used : Thermistor resistance, temperature detectors (RTD's) or thermocouples.
- Functions : Measures the temperature at different points of battery pack.

⑫ Current Monitoring in BMS :-

- Sensor used : Hall effect, current sensor, Shunt resistors or Rogowski coils.
- Functions : Measures charge & Discharge current flowing in & out of the battery.

File Navigate View Options Tools Instruments Help

- CarTrain Hybrid and All Electric Vehicle Technology Trainer
- CarTrain: Motronic 2.8.2
- Hybrid/Electric Vehicle Specialist
  - Working on Electrically Propelled Vehicles
  - Equipment
  - The CarTrain Hybrid and all Electric Vehicle Trainer
  - Introduction to Hybrid/Electric Vehicles
  - Safe Handling of High Voltage Systems
  - Battery Systems
    - Purpose and Function
    - Typical Voltage Levels
    - Experiment: High Voltage Battery
    - Battery Hazards
    - Types of Materials
    - Types of Construction
    - Battery Management System
      - State Of Charge
      - Voltage Sensors
      - Current Sensors
        - Experiment: Battery Current
      - Temperature Sensors
      - Temperature Management
    - High Voltage Disconnect Relays
    - HEV or EV Jump Starting
    - Practical Task: Read HV Battery Scan Tool Data
    - Chapter Quiz: Battery Management Systems
    - High Voltage Battery Diagnostics
    - 12 Volt Battery Diagnostics
  - Power Electronics
    - Electrical Principles for Vehicles
    - Vehicle body as part of the circuit?
    - High Voltage Cables
    - Electric Motors
    - Inverters
    - Electrical Interlocks
    - Chapter Quiz: Inverter
    - Potential Equalisation
    - Charging
  - Internal Combustion Engine
  - Drive Systems
    - Continuously Variable Transmission
    - Power Split Device
  - Hybrid Supporting Systems
    - HVAC
    - Electronic Power Steering
    - Braking Systems
    - Chapter Quiz: Hybrid Supporting Systems
  - Glossary of Terms
  - Vehicle Case Studies
  - Appendix - Practical Task List
  - Copyright
- CarTrain Common Rail

Experiment: Battery Current

In this experiment, we will measure the current flow of the HV battery while driving

Experiment setup

Overlay	Serial hybrid CO3221-6KE2
Ignition	On
Vehicle speed	20 mph
Battery charge state	50%
Driving condition	Various

Measurement Device

Open the Ampere meter A under "Instruments" - "Measuring devices"

Device	Ampere meter A
Setting	DC
Range	10A
Shunt	1 Ohm

Now set up the experiment as shown below