PRACTICAL NO: 1

Date : 20/1/25

TITLE : To study & analyse performance of series hybrid configuration

AIM / OBJECTIVE: a) Physical configuration of series Hybrid concepts.
b) Technical specifications and components
c) Energy flow, modes of operation, pros & cons, etc.

APPARATUS / TOOLS / EQUIPMENT / RESOURCES USED:

HEV LN Setup
Cartrain Software
PC
Multimeter

CONCEPT / THEORY OF EXPERIMENT:

In a series hybrid system, vehicle uses an electric motor to power the wheels, with a gasoline engine that generates electricity to recharge battery. The engine only runs to produce electricity and can be bypassed. This helps so that it can run at a constant rate & be more efficient than a conventional.

PROCEDURE :

① Turn ON main switch.
② Use overlay CO324-GKEZ and move ignition key from setting 0 to 1.
③ The energy flow view can be enlarged by touching cockpit display
④ Set high voltage battery percentage as per requirement using knob provided.
⑤ Observe energy flow at different speeds.
⑥ Analyze energy flow scheme.

Config. of Series hybrid Systems :-

① Pure Series Hybrid : ICE acts as a generator & never directly drives the wheels.

② Series Parallel Hybrid : Combination of series & parallel hybrid modes where ICE can drive wheels directly if needed.

③ Range Extended Electric vehicle : Primary power source is the battery & internal combustion engine acts as a backup generator for extended range.

Different Components & concepts of Series hybrid :-

Series hybrid vehicle has a drivetrain where Int. Combustion Engine (ICE) is not directly connected to the wheels, instead works as a generator to charge the battery or power the motor.

Components :-

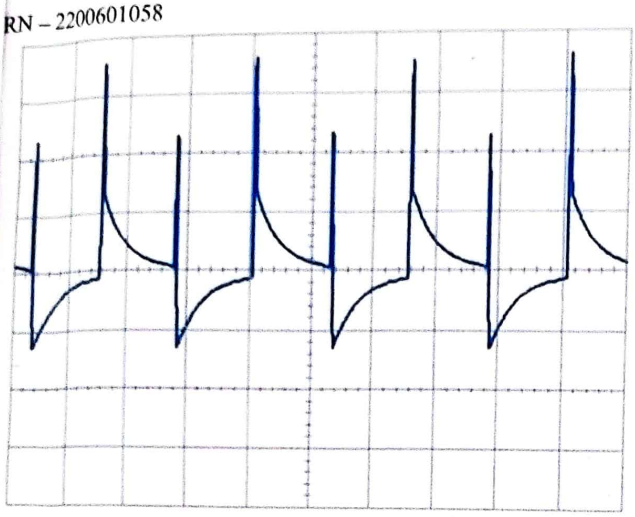
1. ICE : Acts as a generator to power electricity.
2. Electric Generator : Converts mechanical energy from ICE to electrical energy.
3. Battery pack : Stores electric energy for use by electric motor.
4. Electric motor : Drives vehicle directly.
5. Power Control Unit : Manages energy flow b/w generator battery & motor

OBSERVATIONS

MTRX

ame – Tanishq Zade

RN – 2200601058



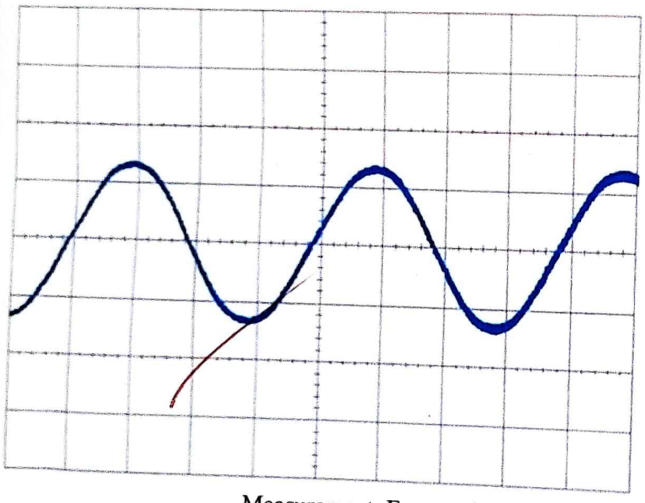
TIME/Div: 50*10^-6

CHN 1/Div: 100V

CHN 2/Div: _____

V_b: _____

Measurement: Electric driving mode



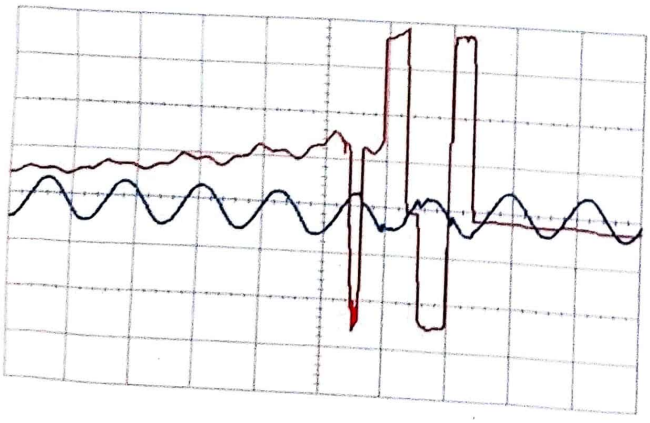
TIME/Div: 50*10^-6

CHN 1/Div: 100v

CHN 2/Div: _____

V_b: _____

Measurement: Energy recovery



TIME/Div: 10 ms

CHN 1/Div: 100V

CHN 2/Div: _____

V_b: _____

Coupling _____

:-

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Used during low

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supplies power

electric motor acts as
into electrical energy

, ICE turns off to
rew if needed.

;-

efficiency, fuel

, leading to fewer
conventional vehicles.
instant torque &

during braking
ive efficiency -
b/w ICE & wheels,
oving parts.

:

- due to the batteries
- initial costs.
battery range.
require ICE for
stance.

OBSERVATIONS

(#) Energy flow & modes of operation :-

1. Battery (EV) Mode : Electric motor is powered directly by the battery & ICE remains off. Used during low speed driving or short trips

2. Series hybrid Mode : When battery charge drops, ICE starts running the generator which supplies power to the motor.

3. Regenerative Braking : While braking, electric motor acts as a generator converting Kinetic energy back into electrical energy & storing it in battery.

4. Idle mode : When the vehicle is stopped, ICE turns off to save fuel, and power is drawn from battery if needed.

(#) Features of Series hybrid systems :-

a) High fuel efficiency : Since ICE runs at optimal efficiency, fuel consumption is reduced.

b) Low emissions : ICE runs less frequently, leading to fewer emissions compared to conventional vehicles.

c) Smooth Driving Experience : Electric motor provides instant torque & seamless acceleration.

d) Regenerative Braking : Captures Kinetic energy during braking & reuses it to improve efficiency.

e) Reduces Mechanical complexity : No direct connections b/w ICE & wheels, leading to fewer moving parts.

(#) Pros, Cons & Appⁿ :

1. Pros :
   a) Higher fuel efficiency
   b) Reduced emissions
   c) Smooth driving experience
   d) Lower maintenance costs.

2. Cons :
   a) Heavier due to the batteries
   b) Higher initial costs.
   c) Limited battery range.
   d) May require ICE for assistance.

CALCULATIONS

3. Appⁿ :

a) Used in cars like Chevrolet volt & Nissen e-power vehicles.
b) Used in Urban transit vehicles.
c) Used in military & industrial vehicles.

(4) Specifications :

1. Electric Generator : Power rating 20-100 KW
2. Type : Permanent magnet synchronous generator
3. Battery pack : Li-ion OR Nickel metal hydride (NiMH)
4. Capacity : 10-50 KWhr
5. Range : 300-800 V
6. Charging time : Fast Charging (DC) 30-60 mins
   Standard Charging (AC) 4-8 hours
7. Life Cycle : 1000-3000 cycles.

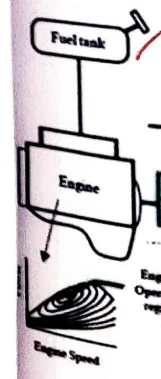
RESULTS :

(4) Performance Specifications -

1. Acceleration : 0-100 KW/h in 6-12 sec.
   Electric torque provides instant accelerations.
2. Fuel Efficiency : Around 20-40 KM/l
3. Range : Battery only mode = 50-150 KM
   Hybrid Mode = 500-1000 KM

CONCLUSION :

Hence, we studied various parameters & operating modes related to series hybrid configuration of HEV.



Assessment Parameters (To be filled by Instructor)

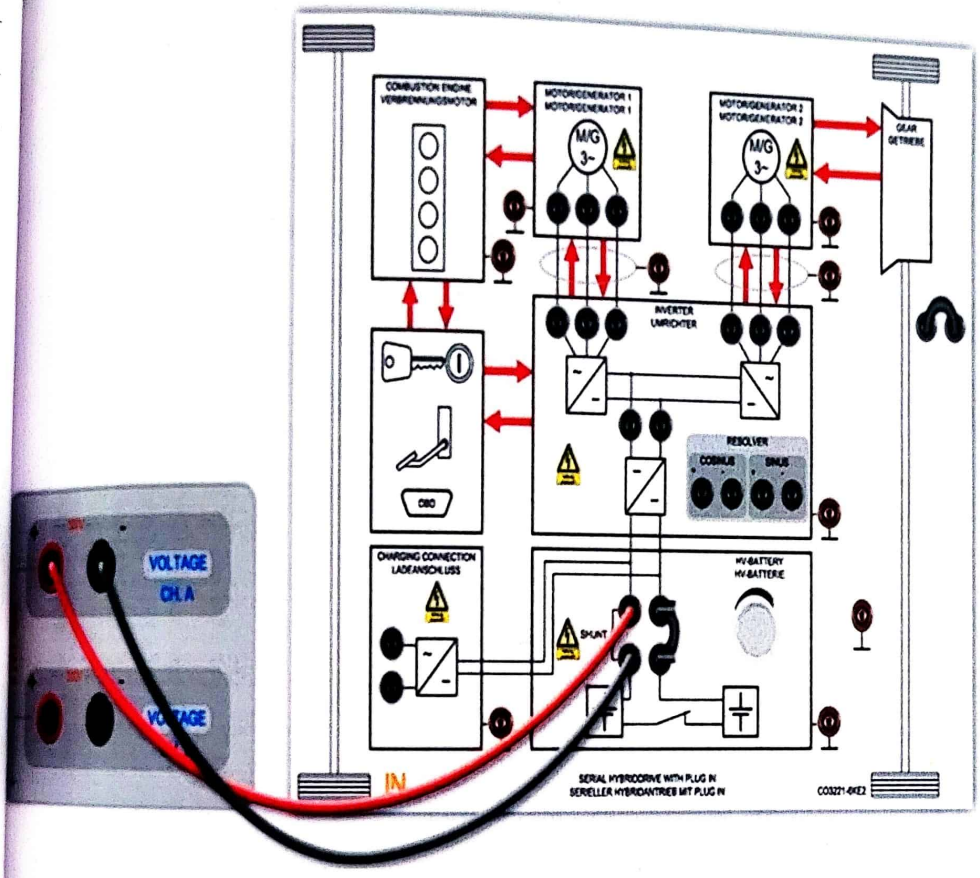
1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hrs

MTRX

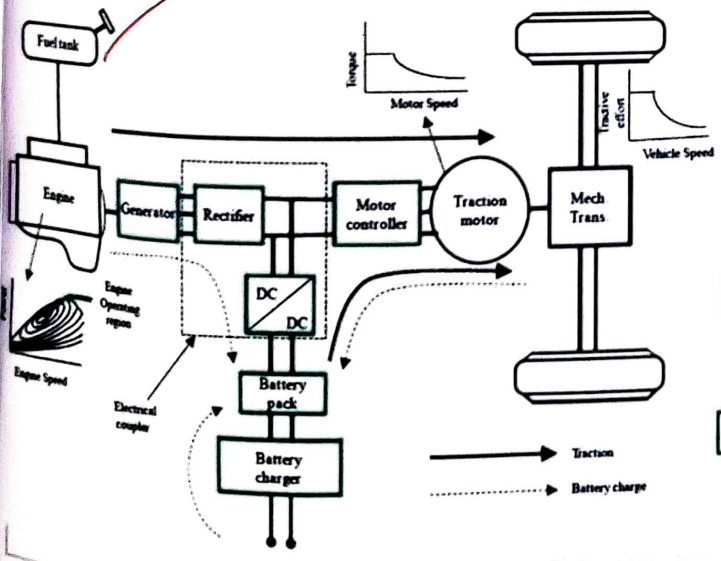
ne – Tanishq Zade

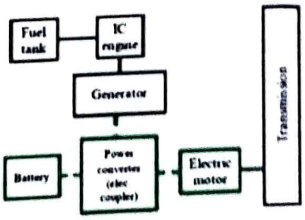
N – 2200601058

Outcome
d / Not Acheived)



Configuration of a series hybrid electric drive train





Sign of Instructor
Date : 06/03/25

Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hrs

3. List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Acheived)
1.	Understood working of series hybrid configuration.	Y
2.	Awareness of energy flow and modes of operation.	Y
3.	Practical knowledge of configurations & features.	Y
4.	Features, trends & Advancements.	Y

Remarks :

Total marks 08 out of 10.

Sign of Instructor
Date : 06/03/23

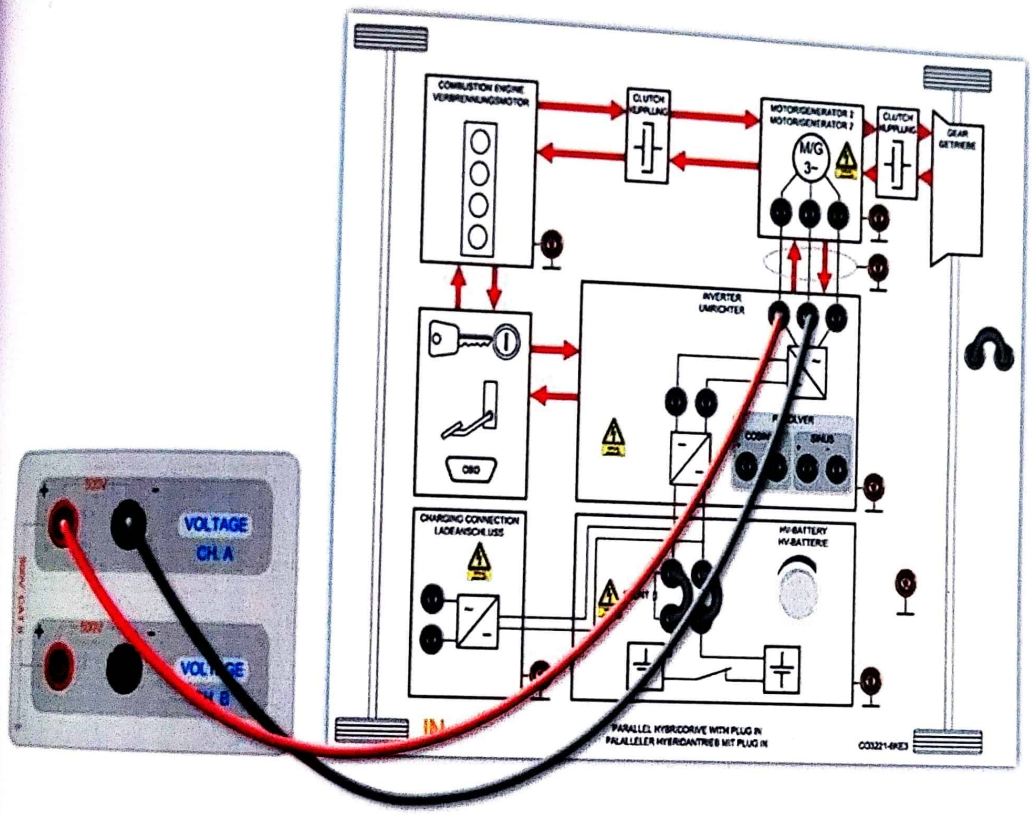
PRACTICAL NO: 2

Date : 27/1/25

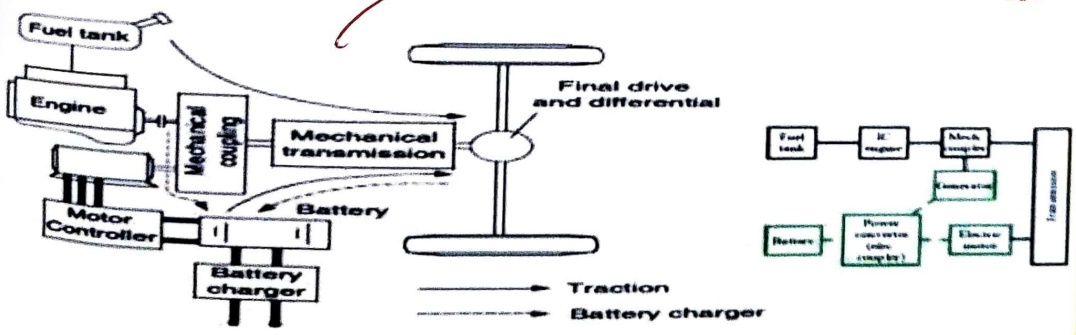
TY MTRX

Name – Tanishq Zade

PRN – 2200601058



Configuration of a parallel hybrid electric drive train



Parallel Hybrid Drive

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figuration

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quirements.

PRACTICAL NO: 2

Date : 27/1/25

TITLE : To Study, analyze performance of parallel hybrid system.

AIM / OBJECTIVE: 1. Different components of parallel hybrid configuration
2. Energy flow, modes of operation
3. Pros & Cons & Applications

APPARATUS / TOOLS / EQUIPMENT / RESOURCES USED:

HEV LN Setup
LN Labsoft
PC
Multimeter

CONCEPT / THEORY OF EXPERIMENT:

Parallel HEV allows both ICE & EM to deliver power to drive the wheels since both the ICE & EM are coupled to the drive shaft of wheels via two clutches, propulsion power may be supplied by ICE alone.

PROCEDURE :

(1) Turn ON the system.
(2) Use overlay & move ignition Key from setting 0 to 1.
(3) Energy flow view can be enlarged by touching cockpit display.
(4) ~~Energy flow view~~ Set high battery % as per requirements.
(5) Observe energy flow at different speeds.
(6) Analyze energy flow scheme.

Configuration of parallel hybrid systems :-

1. Single motor parallel hybrid : One electric motor assists the ICE and handles regenerative braking
2. Dual Motor parallel hybrid : One motor assists ICE, while another handles regenerative braking.
3. Plug-in parallel hybrid : Larger battery capacity allows extern charging for extended EV range.
4. Mild Hybrid (MHEV) : A small electric motor (48V) syst provides minor assistance, mainly for start stop.

Components & Concepts of parallel hybrid :-

→ A parallel hybrid has a drivetrain where both the internal combustion engine (ICE) & electric motor can directly drive the wheels. This allows the vehicle to operate using ICE alone, electric motor alone or combination of both.

→ Components :-

1. ICE : Main power source connected to drivetrain.
2. Electric Motor : Assists the ICE or drives vehicle independently
3. Battery Pack : Stores electric energy for the motor
4. Transmission System : Integrates both powersources like CVT, Automated manual or Dual clutch.
5. Power Control Unit (PCU) : Manages power distribution b/w ICE, battery & motor.
6. Regenerative Braking System : Converts braking energy into electrical energy and recharges the battery.

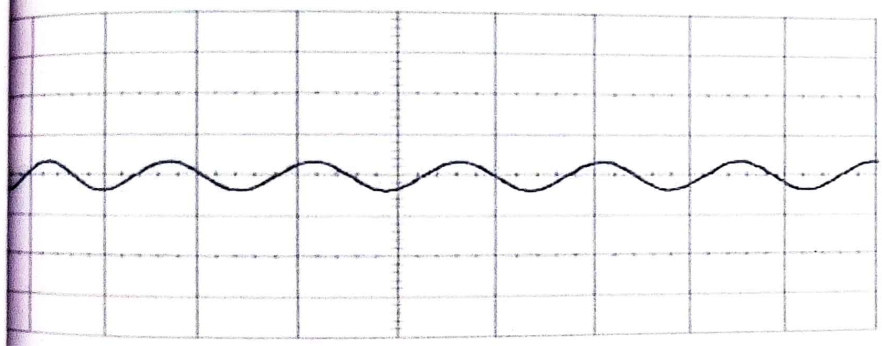
OBSERVATIONS

Energy Flow & Modes of operation :-

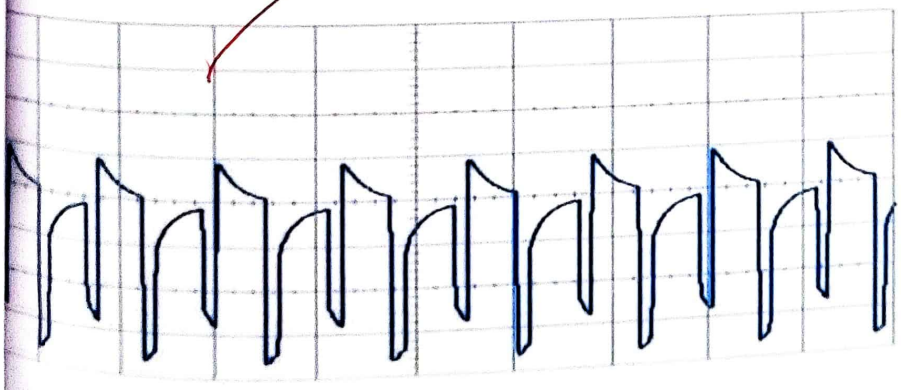
Name - Tanishq Zade

Roll No - 2200601058

Measurement : Boosting



Measurement: Electric driving mode



Measurement: Energy recovery

due to ICE backup.

e) More affordable than Fully Electric cars.

OBSERVATIONS

Energy Flow & Modes of operation :-

a) HEV Mode (Low speed) : Both ICE & electric motor work together for higher power o/p.

b) EV Mode (Hybrid) : Vehicle runs on battery power & ICE remains OFF.

c) ICE Mode (High Speed) : ICE directly drives the wheels for max^m efficiency.

d) Regenerative Braking Mode : Motor captures braking energy & converts it into battery power.

e) Idle Stop Mode : Engine turns OFF when the car is stopped (Eg : At a traffic light)

Features of Parallel hybrid System :-

a) Higher Fuel efficiency : Optimized power sharing b/w ICE & motor.

b) Lower Emissions : Reduces Fuel consumption & CO_2 o/p.

c) Better Performance : Offers a balance b/w power & efficiency.

d) No Range Anxiety : Since ICE is always available for long distance travel.

e) Regenerative Braking : Enhanced battery life & energy efficiency.

f) Fast Refuling : Unlike fully electric vehicles, hybrids do not require charging downtime.

Pros, Cons & Applications :-

1. Pros :

a) Higher efficiency due to both power soure working together.

b) Better Acceleration & performance than series hybrid.

c) Lower Emissions compared to pure ICE vehicles

d) More reliable than Battery Electric Vehicles (BEVs) due to ICE backup.

e) More affordable than Fully Electric cars.

CALCULATIONS :

2. Cons :

a) Less Fel-efficient than series hybrid at low speeds.

b) More mechanical complexity than series hybrids.

c) Battery capacity is smaller compared to full EVs.

3. Applications :

a) Passenger Car's : Toyota Prius, Honda Accord Hybrid, Hyundai Ionic

b) Sports Hybrids : Acura NSX, BWM i8, Ferrari sf90

c) SUV's : Ford Escape Hybrid, Lexus RX Hybrid

(*) Specifications :-

a) Electric Motor ; Power o/p : 20-150 KW

b) Torque : 100-400 Nm

RESULTS :

c) Efficiency : 90-95 %.

(*) Battery Pack :-

a) Types : Li-ion (Lithium ion)
NiMH (Nickel Metal)

b) Capacity : 1 - 20 KW (Varies with Hybrid Types).

c) Voltage : 200 - 400 V

d) Charging : Regenerative Braking or External Charging (for PHEVs only)

CONCLUSION :

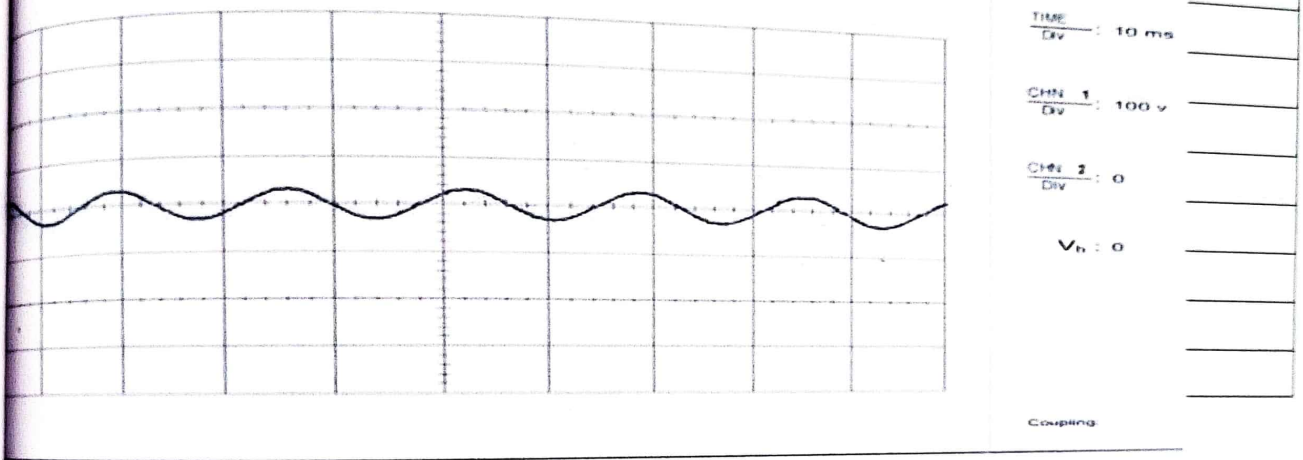
Hence, we studied the various parameters & operating modes related to parallel hybrid configuration of HEVs.

Assessment Parameters (To be filled by Instructor)

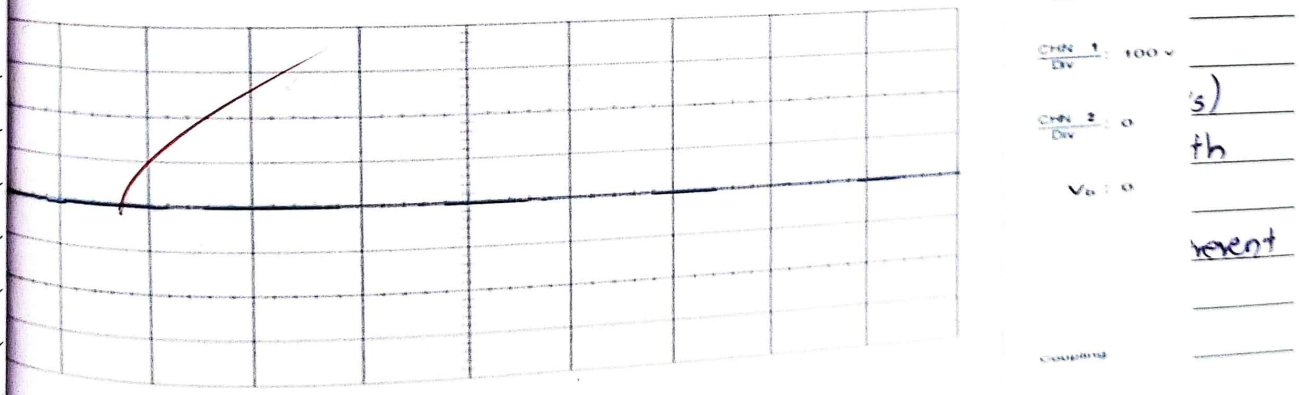
1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hrs

3. List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Acheived)
1.	Understood the working of Parallel hybrid configuration.	✓



Measurement: Regeneration by the combustion engine



Measurement: Active combustion engine

Sign of Instructor
Date : 06/03

Total marks 08 out of 10.

Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hrs

3. List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Acheived)
1.	Understood the working of Parallel hybrid configuration.	Y
2.	Awareness of Energy Flow & operating Modes.	Y
3.	Practical knowledge of configurations & Features	Y
4.	Trends & Advancements in Parallel Hybrid Systems.	Y

Remarks :

④ Environmental & safety Specifications :-

a) CO_2 Emissions : 40-80 g/Km (Hybrid Mode)
0 g/Km (EV Mode for PHEVs)

b) Crash Safety : Similar to conventional vehicles with reinforced battery protection.

c) Fire & Thermal Protection : Battery cooling system to prevent overheating.

Total marks 08 out of 10.

06/05

Sign of Instructor
Date :

PRACTICAL NO: 3

Date : 7/2/25

TITLE : To study & analyze performance of series-parallel hybrid configuration & concepts

AIM / OBJECTIVE:
1. Diff. components of series parallel hybrid config
2. Energy flow modes of operation
3. Pros & Cons & applications

APPARATUS / TOOLS / EQUIPMENT / RESOURCES USED:

HEV LN Setup
LN Labsoft
PC
Multimeter

CONCEPT / THEORY OF EXPERIMENT:

The system can operate in series mode, where the ICE generates electricity to power the electric motor, which drives the wheels. It can also operate in parallel mode, where both the ICE & electric motor provide mechanical power directly to the wheels. The power split device enables seamless switching b/w these modes based on drive conditions, optimizing efficiency & performance.

PROCEDURE :

(1) Turn on the main switch
(2) Use overlay C0304 - E2 & move the ignition key from 0 to 1.
(3) The energy flow view can be enlarged by touching the cockpit display.
(4) Set the high voltage battery t. as per requirements.
(5) Observe the energy flow at different speeds
(6) Analyze the energy flow scheme.

⛤ Configuration of Series-parallel hybrid System :-

Series parallel hybrid system combines the features of both series & hybrid configuration to optimize performance, efficiency & flexibility it is commonly used in hybrid electric vehicles (HEVs) & other applications where energy efficiency & power management are critical.

⛤ Components of Series- Parallel Hybrid System :-

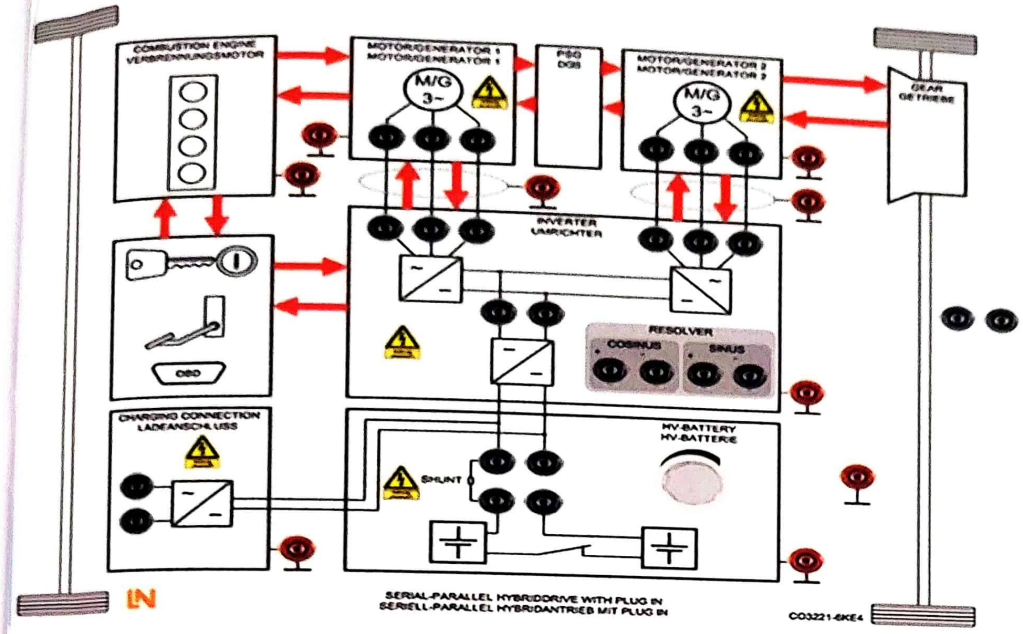
1. Internal Combustion Engine (ICE)
2. Electric Motor / generator
3. Battery Pack
4. Power split device (planetary gear set)
5. Power control Unit (PCU)
6. Inverter
7. Transmission.

⛤ Energy flow & Modes of operation :-

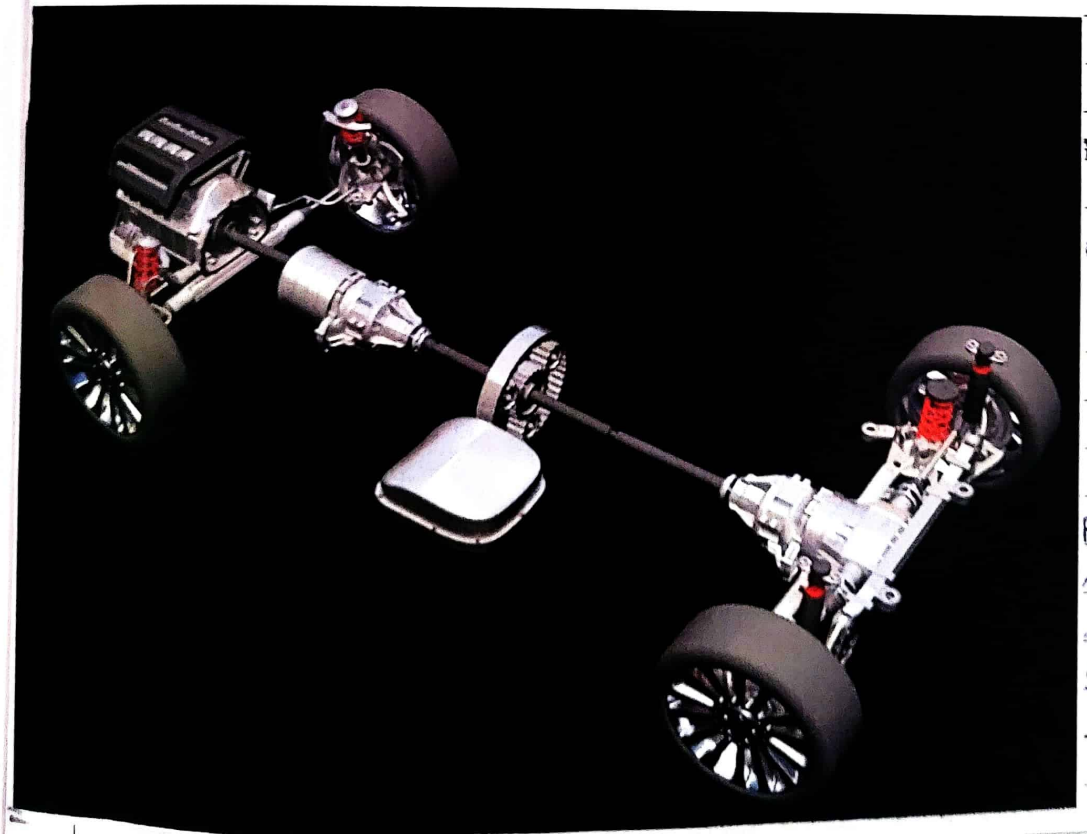
1. Series Mode : ICE generates Electricity via generator - electric motor drives the wheels using electricity from battery or generator.
2. Parallel Mode : Both ICE & electric mode provide mechanical power to the wheel.
3. Regenerative Braking : Electric Motor acts as a generator converting kinetic energy into electrical energy to recharge the battery
4. Electric mode : The vehicle runs solely on the electric motor using energy from the battery
5. Hybrid mode : Combines ICE & electric motor power for optimal performance & efficiency.

OBSERVATIONS

Training System



Design



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OBSERVATIONS

(*) Features of series-parallel hybrid systems :-
1. Flexibility : Can operate in multiple modes to suit driving conditions.
2. Efficiency : Optimize fuel consumption & reduces emission
3. Regenerative braking : Recovers energy during braking.
4. Smooth Transmissions : Seamless switching b/w modes for a comfortable driving experience.

(*) Pros :-
1. High efficiency : Combine the best of series & parallel system for optimal fuel economy.
2. Versatility : Suitable for a wide range of driving conditions
3. Reduced Emission : Lower greenhouse gas emission compared to conventional vehicles.
4. Improved performance : Electric motor provides instent torque for better acceleration.

(*) Cons :-
1. Complexity : More components & control system increases complexity & cost.
2. Higher cost : Expensive to manufacture & maintain due to advanced technology.
3. Weight : Additional components (battery, motor) increase vehicle weight.

(*) Applications :-
1. Hybrid Electric Vehicles (HEVs) : Toyota Prius, Ford Fusion hybrid
2. Plug-in Hybrid Electric Vehicles (PHEVs) : Toyota Prius
3. Commercial vehicles : Buses, delivery trucks
4. Marine & Aerospace : Hybrid propulsion system in boats & aircraft.

CALCULATIONS :

(A) Specifications :-

1. Battery Capacity : 1-20 kWh depending on applications.
2. Electric Motor power : Range from 20-200 kW depending on vehicle size & performance.
3. ICE power : Varies based on vehicle type.
4. Fuel efficiency : significantly higher than conventional vehicles.
5. Emission : Reduced CO_2 & NO_x emission compared to traditional ICE vehicles.

(B) Environmental & safety standards :-

1. Emission Standards : Hybrid vehicles comply with stringent emissions standards such as Euro 6 (Europe) & Tier 3 (USA).

2. Safety Standards : Hybrid vehicles meet global safety stands as :-
   Euro NCAP (Europe)
   NHTSA (USA)

RESULTS :

3. Reduced Greenhouse gas emission.
4. Lower Fuel consumption
5. Reduced Air pollutants
6. Noise pollution Reduction
7. Battery Safety : to prevent overheating, short circuits & explosions
8. Crash Safety : Designed to meet stringent crash safety standards.
9. Stability & Control : Improve vehicle stability & control through regenerative braking & electric motor torque.

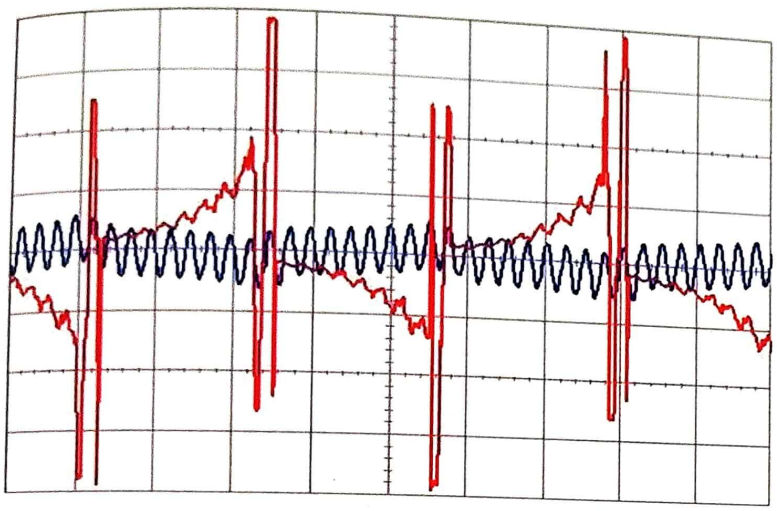
CONCLUSION :

Hence, we studied the various parameters & operating modes related to series parallel hybrid config of HEVs.

Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)

Travel on Flat Terrain



TIME/Div : 50ms

CHN 1/Div : 100v

CHN 2/Div : 100v

V_b : 64v

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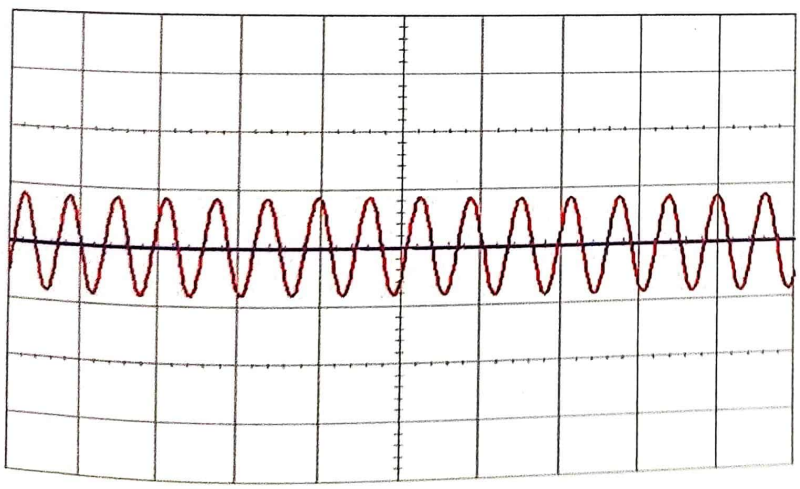
Travel on a decline



TIME/Div : 20ms

CHN 1/Div : 50v

CHN 2/Div : 50v

V_b : 80v

Total marks _____

Sign of Instructor

Date : 29/04

Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hrs

3. List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Acheived)
1.	Understood the working of series parallel hybrid configuration.	
2.	Awareness of energy flow & operating modes	
3.	Practical knowledge of configura-tional & features.	
4.	Features, Trends & advancement in series parallel hybrid configuration.	

Remarks :

Total marks 09 out of 10.

Sign of Instructor
Date : 29/04/24

PRACTICAL NO: 4

Date : 21/12/25

TITLE : To study & analyze performance of fuel cell based Hybrid electric configuration

AIM / OBJECTIVE: To study & analyze the performance of a fuel cell based hybrid electric config by examing its working principle, energy flow & electricity

APPARATUS / TOOLS / EQUIPMENT / RESOURCES USED:

HEV LN Setup
LN Labsoft
PC

CONCEPT / THEORY OF EXPERIMENT:

A fuel cell is a technical system. As is typical of such system the fuel cells awaits an i/p it can process & o/p the result in the form of energy & water. Accordingly a fuel cell is a system which converts material & energy this config. is commonly used in HEVs, stationary power system & other app requiring clean energy solution.

PROCEDURE :

1. Open LN course 'Measurement with fuel cell active'.
2. Setup exp. as given.
3. Measure the V of the Motor/generator using the oscillation.
4. Do the oscillation [oscilloscope setting.
5. Observe waveform.
6. Drag & drop the oscilloscope trave.

Active Fuel Cell :-

→ The fuel cell is actively converting chemical energy (from H to O) into electrical energy.

→ It supplies power to the electric motor & charges the battery supercapacines.

→ Operates during high-power demands or when the battery's state of charge (SoC) is low.

Inactive Fuel Cell :-

→ The fuel cell is temporarily shut down or operates at a minimal level.

→ The battery or supercapacitor supplies power to the electric motor.

→ Used during low-power demands or when the battery's SoC is sufficient.

- Combined Energy Recovery

Regenerative Braking :-

→ The electric motor acts as a generator during braking converting kinetic energy into electrical energy.

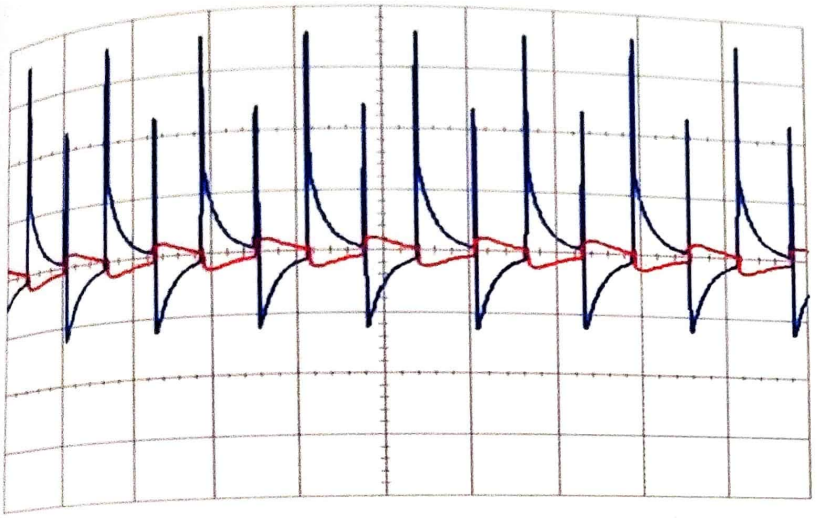
→ This energy is shared in the battery or supercapacitor for later use.

OBSERVATIONS

• Fuel cell Specifications :-

Type : P - 10cm) Rel cell.

Fuel Cell Inactive



TIME/Div : 100us

CHN 1/Div : 100V

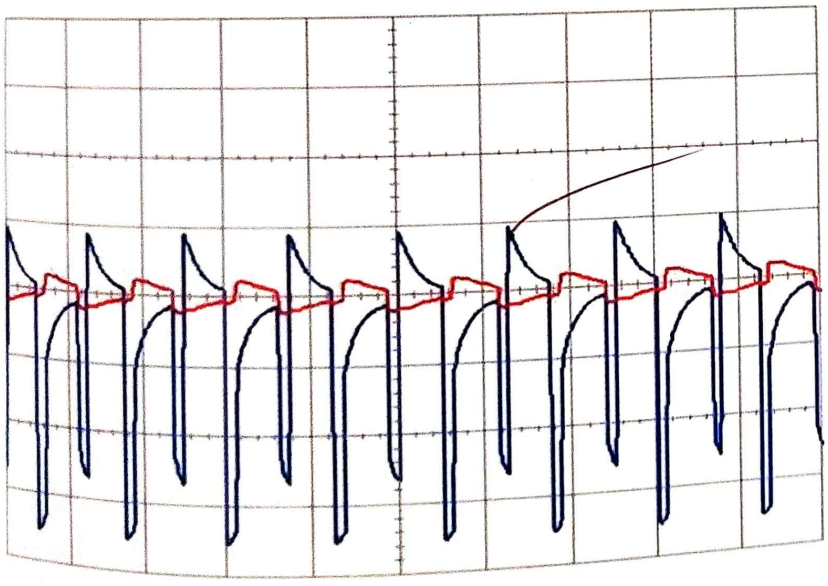
CHN 2/Div : 100V

V_b : 0V

sion)

oxygen

Fuel Cell Active



TIME/Div : 100us

CHN 1/Div : 100V

CHN 2/Div : 100V

V_b : 0V

Coupling

n is supplied

rotons & electrons.

nbrane, while

rcuit, generating

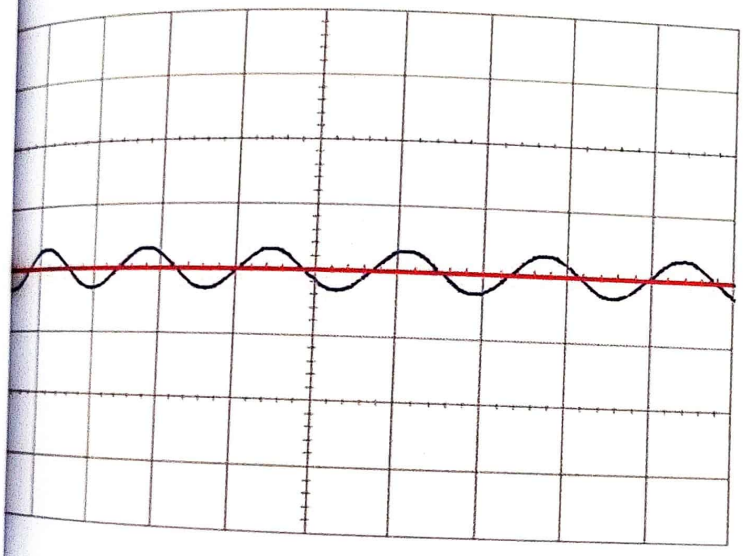
, combine to

OBSERVATIONS

• Fuel cell Specifications :-

Type : Proton Exchange Membrane (PEM) Fuel cell.
Power o/p : 50-150 kW
Efficiency : 40-60 % (electrical energy conversion)
Operating Temp. : 60-80 °C
Fuel : Hydrogen (H_2)
Oxidizer : Oxygen (O_2) from the air or pure oxygen

• Q... **Combined Energy Recovery**



is supplied

ions & electrons.

brane, while

uit, generating

electric current.

→ At the cathode, protons, electrons & oxygen combine to form water as a by-product.

• Pros :-

→ High efficiency
→ Zero emission
→ Energy Recovery
→ Fast Refueling

OBSERVATIONS

• Fuel cell Specifications :-

Type : Proton Exchange Membrane (PEM) Fuel cell.
Power o/p : 50-150 kW
Efficiency : 40-60 % (electrical energy conversion)
Operating Temp. : 60-80 °C
Fuel : Hydrogen (H_2)
Oxidizer : Oxygen (O_2) from the air or pure oxygen

• Battery Specifications :-

Type : Li-ion or Nickel-Metal Hydride
Capacity : 5-20 kWh
Voltage : 200-400 V

• Electric Motor Specifications :-

Power : 50-200 kW
Torque : 150-400 Nm

• Working Principle / Fuel cell operations :-

→ H_2 is supplied to the anode, & oxygen is supplied to the cathode
→ At the anode, H molecules splits into protons & electrons.
→ Proton pass through the electrolyte membrane, while electrons flow through an external circuit, generating electric current.
→ At the cathode, protons, electrons & oxygen combine to form water as a by-product.

• Pros :-

→ High efficiency
→ Zero emission
→ Energy Recovery
→ Fast Refueling

CALCULATIONS :

- Cons :-

→ High Cost
→ H storage
→ Limited infrastructure
→ Durability
→ Safety concern.

- Applications :-

→ Transportation : HEVs, buses, trucks & trains
→ Stationary power : Backup power system, remote power generation & grid stabilization
→ Marine & Aerospace : Hybrid propulsion system for ships & aircraft.
→ Portable Power : Emergency power supplies & portable generator

- Safety Specifications :-

→ BMS : Monitors temperature, Voltage & current.

RESULTS :

→ High-Voltage Safety : Insulated cables & automatic shut-off in case of collision.
→ Hydrogen Shortage : High pressure tanks (350-700 bar) with safety valves.

- Refuling / Recharging :-

→ Hydrogen refuling time : 3-5 mins
→ Battery charging time : 1-8 hrs (depending on charger type & capacity).

CONCLUSION :

Hence we studied & analyzed performance of Fuel cell based hybrid electric configuration.

Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hrs

3. List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Acheived)
1.	Understand the operation of active & inactive Fuel cell in hybrid system	
2.	Explore the combined energy recovery mech, including regen braking.	Y
3.	Investigate the app of Fuel cell technology in Hybrid eletric config.	
4.	Demonstrate the integration of Fuel cell with battries & eletric motor for optimal power management.	

Remarks :

Total marks 10 out of 10.

Sign of Instructor
Date : 29/9/21

PRACTICAL NO: 5

Date : 7/3/25

TITLE : To study & analyze the performance of pure electric vehicles

AIM / OBJECTIVE: The objective is to study & analyze performance of pure electric vehicle (EV's) in terms of efficiency, range, power consumption

APPARATUS / TOOLS / EQUIPMENT / RESOURCES USED:

LN Cartrain Setup
Labsoft
PC
Multimeter
Connecting Wires

CONCEPT / THEORY OF EXPERIMENT:

Pure electric Vehicles (EVs) use high-energy density Li-ion or solid-state batteries to power electric motor, eliminating internal combustion Engines. Their performance depends on battery capacity Kwh motor, power electronics, regenerative braking and drivetrain losses.

PROCEDURE :

(1) Turn ON the system using main switch, wait until boot is completed.
(2) Now move the ignition Key setting from 0-1.
(3) The energy flow can be enlarged by touching cockpit display.
(4) Use overlay on the system.
(5) Now further based on given steps for task do the connection with battery & pv shunts accordingly.
(6) Set the RPM using Potentiometer.
(7) Use oscilloscope to view graph & observe energy flow.

① Pure Electric Vehicle (EV) Key Components :-

1. Battery Pack :
   Stores & supplies electrical energy.

2. Electric Motor :
   Converts electrical energy into mechanical motion.

3. Power Electronics :
   Includes the inverter & DC-DC converter for motor control & voltage regulation.

4. Regenerative Braking :
   Recovers energy during braking to recharge the battery.

5. Thermal Management System :
   Maintains optical temperature for battery & motor efficiency.

6. On-board charging :
   Converts AC power to DC for battery.

7. Vehicle control Unit (VCU) :
   Manages power distribution & vehicles operation.

8. Drive Train :
   Transfers motor power to wheels via single speed transmission.

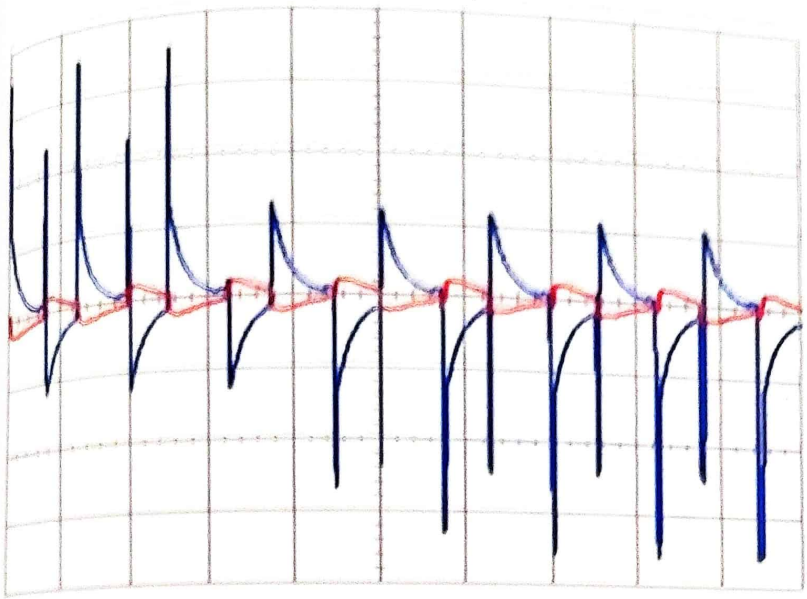
② Modes of Operation in Pure Electric Vehicles (EV)

1. Idle Mode :
   The vehicle is powered on but not moving ; minimal energy consumption.

2. Acceleration Mode :
   The motor draws power from the battery to increase speed.

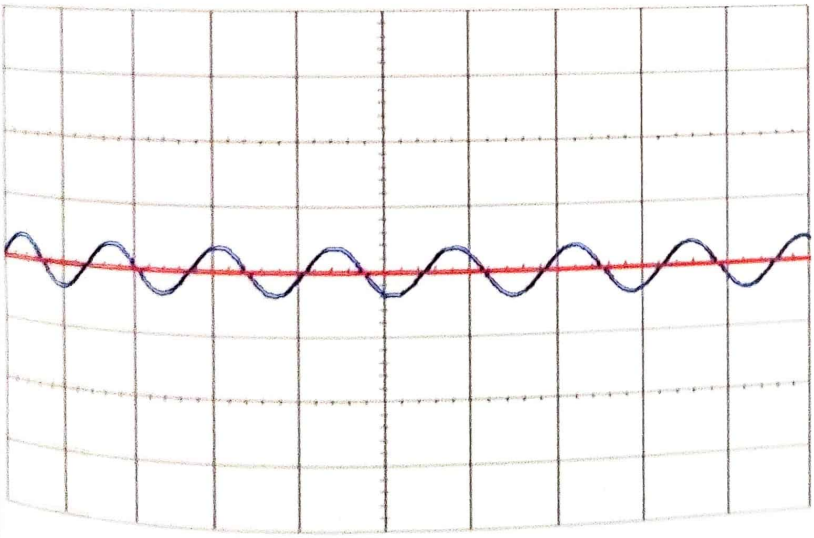
OBSERVATIONS

Electric Driving Mode



TIME/Div : 10ms
CHN 1/Div : 100V
CHN 2/Div : 100V
V_b : 20V

Energy Recovery



TIME/Div : 10ms
CHN 1/Div : 100V
CHN 2/Div : 100V
V_b : 0V
Coupling DC

17% Optimized
kinetic
the battery.
active braking
impact.
composed to
using braking
prices.
s.
vehicles.
year due to
factors like fast charging, extreme temperature, etc.

OBSERVATIONS

3. Cruising Mode :
The vehicle maintains a constant speed with optimized energy consumption.
4. Regenerative Braking Mode :
The motor acts as a generator, converting kinetic energy into electrical energy to recharge the battery.
5. Deceleration Mode :
The motor reduces power o/p while regenerative braking may assist in energy recovery.

(3) Pros :-
1. Zero Emissions :
No tailpipe pollution, reducing environmental impact.
2. High Efficiency :
Electric motors have over 80% efficiency compared to Internal Combustion Engines.
3. Lower Operating Costs :
Reduced fuel & maintenance costs.
4. Regenerative Braking :
Enhances efficiency by recovering energy during braking.

(4) Cons :-
1. High Initial Cost :
Expensive battery technology increases upfront prices.
2. Limited Range :
Battery capacity restricts long-distance travels.
3. Charging Time :
Longer Refuling time compared to gasoline vehicles.
4. Battery Degradation :
Battery loses 1-2% of its capacity per year due to factors like fast charging, extreme temperature, etc.

CALCULATIONS :

⑤ Applications :—

1. Passenger Vehicles :
Used for personal transportation (cars, SUVs & Sedans)

2. Public Transport :
Electric buses & taxis for urban mobility.

3. Commercial Fleets :
Logistics & delivery vehicles for sustainable transport.

4. Two & Three Wheelers :
Electric scooters & rickshaws for short distance travel.

⑥ Key Features / Specifications of Pure Electric Vehicles (EVs) :-

1. Battery & Range :
20 KWh - 120 KWh capacity, providing 150Km - 600Km per charge.

2. Motor & Power :
50KW - 500 KW electric motors (PMSM, BLDC or Induction), with instant torques.

RESULTS :

3. Charging Time :
AC (6-12 hours) and DC fast charging (30-60 minutes) for 80 % charge.

CONCLUSION :

Hence, we performed the experiment to understand the parameters & operating modes for pure electric vehicles.

Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hours

3. List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Achieved)
1.	Understand the working of pure electric vehicles.	
2.	Practical Knowledge of Configuration & Features	
3.	Awareness of electric vehicles	

Remarks :

Total marks 09 out of 10.

Sign of Instructor
Date : 29/1/22

PRACTICAL NO: 6

Date : 22/3/25

TITLE : To study & understand & analyze the performance of CRDI Actuators

AIM / OBJECTIVE: 1) To study about actuators & CRDI performance
2) To study construction, working, features of various actuators & Applications.

APPARATUS / TOOLS / EQUIPMENT / RESOURCES USED:

Laptop / PC
LN Labsoft
Connecting wires
CRDI System (Car-train)

CONCEPT / THEORY OF EXPERIMENT:

The CRDI system is an intelligent technology where the highly pressurised fuel is supplied to injection through a common rail. As the name indicates it is a direct injection system where the injection sprays fuel.

PROCEDURE :

1. Open the LN-Labsoft & then the machine car train
2. Open the theory section & study the theortical part of the actuator used in CRDI system.
3. Do the necessary wire connections
4. Note down the voltages & graphs obtained from the experiment
5. Obtain the voltmeter readings

⑧ Rail Pressure Regulator :-

Construction : It involves a solenoid valve connected to a pressure sensor & spring loaded piston.

- It is connected to the common rail in a CRDI system
- It includes an electronic control system to adjust pressure

Working : ① The pressure sensor monitors the fuel pressure in the common rail.

② Based on the sensor the ECU sends signal to the solenoid valve.

③ The solenoid valve adjusts the pressure by controlling the fuel returning to the fuel tank.

④ The spring loaded in piston helps regulate the flow of pressure within the desired range.

Features :
- Maintains optimal fuel pressure.
- Ensures efficient combustion & fuel economy
- Helps reduce emissions & engine knocking

Readings : V = 13.5 V

⑨ Low pressure Supply Pump :-

It consist of an electric or mechanical pump. It includes a fuel filter & a pressure regulator. It is mounted near the fuel tank (Construction).

Working : ① It Draws fuel from the tank & sends it to the high-pressure pump.

② Maintains a steady supply of fuel for injection. It operates at a low pressure compared to the high-pressure pump.

Features :
- Ensures a continuous fuel supply
- Prevents vapour lock issues.
- Enhances fuel system efficiency

Readings : V = 13 V

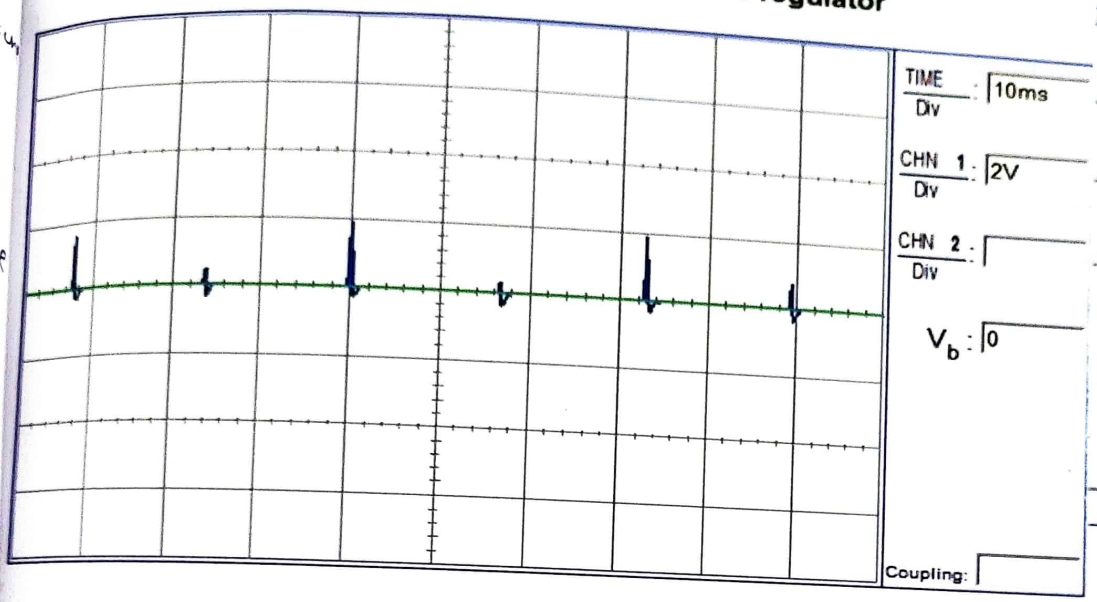
OBSERVATIONS

⑥ EGR (Exhaust Gas Recirculation) Control solenoid :-

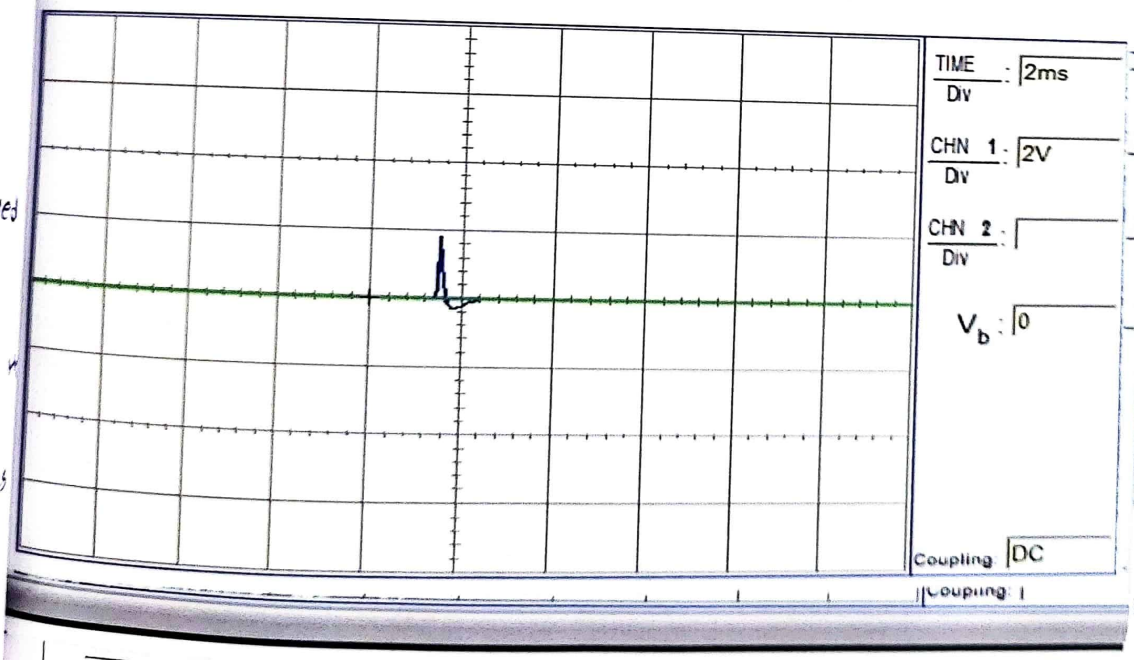
Construction : • Made up of an electronically controlled solenoid valve manifold

Oscilloscope reading - wastegate reading

Oscilloscope diagram - Rail pressure regulator



Oscilloscope diagram - EGR solenoid



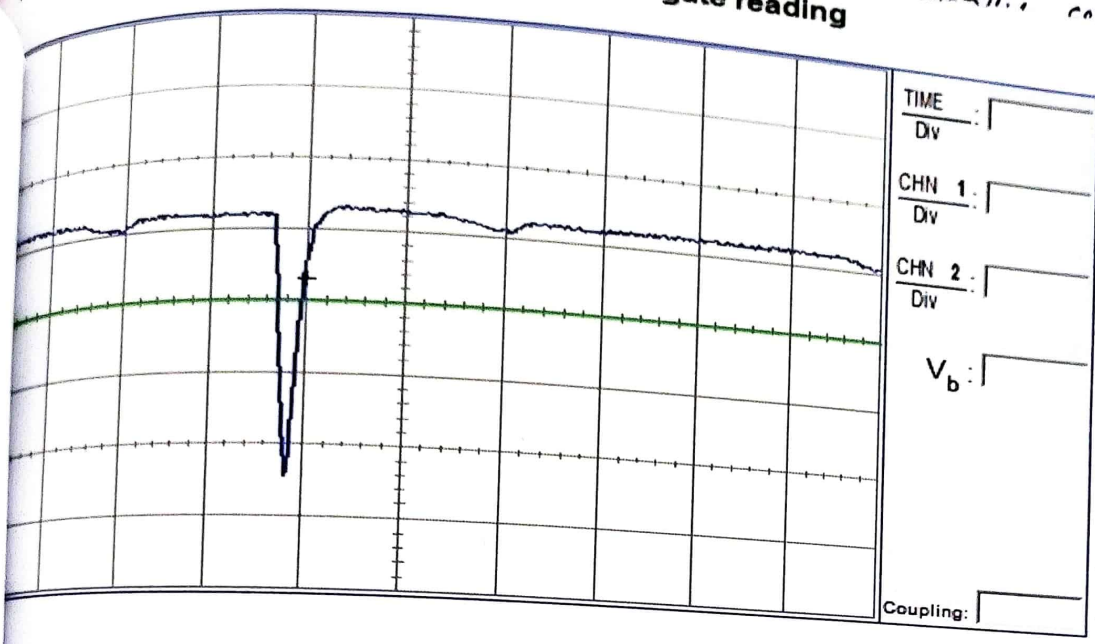
- Helps in avoiding turbocharger damage
- Engine Protection

Readings : V = 13.5 V

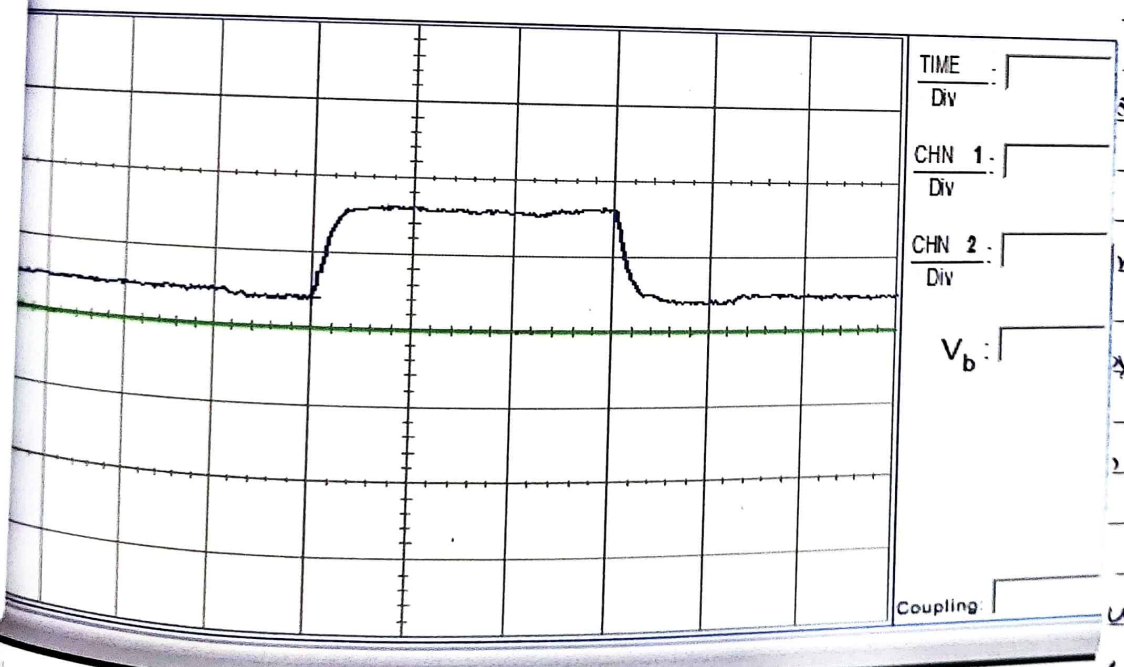
OBSERVATIONS

⑧ EGR (Exhaust Gas Recirculation) Control solenoid :-

Oscilloscope reading - wastegate reading



Oscilloscope diagram for injector control



- Helps in avoiding turbocharger damage
- Engine Protection

Readings : V = 13.5 V

controlled solenoid valve / manifold

gas recirculation temperature

temperatures.

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is

valve.

actuator.

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engine

ure

OBSERVATIONS

⑦ EGR (Exhaust Gas Recirculation) Control Solenoid :-

Construction : • Made up of an electronically controlled solen... the EGR passage.
• It is connected to the intake & exhaust manifold
• It is controlled by the ECU

Working : ① It regulates the amount of exhaust gas recirculated into the intake manifold.
② The solenoid opens / closes based on engine temperature & load conditions.
③ Reduces Nox emissions by lowering combustion temperatures.

Features : • Reduces Nitrogen oxide (NO_x) emissions.
• Improves fuel efficiency in some cases.
• Helps in meeting emission norms

Readings : V = 13.4 V

⑧ Wastegate Control Solenoid :-

Construction : • It includes an electric solenoid valve.
• Connected to the turbocharger wastegate actuator.
• Controlled electronically by the ECU.

Working : ① Regulates turbo boost pressure by controlling the wastegate actuator
② The solenoid opens to allow exhaust gases to bypass the turbine, reducing boost.
③ The ECU adjusts solenoid operation based on engine load & speed.

Features : • Prevents excessive turbo boost pressure
• Enhances engine efficiency & longevity
• Helps in avoiding turbocharger damage
• Engine Protection

Readings : V = 13.5 V

CALCULATIONS :

(*) Glow plug :-

Construction : • It is a heating element enclosed in a metal sheath
• It is installed in the cylinder head near the fuel injectors.
• Electrically powered for quick heating.

Working : (1) Heats up when electric current is supplied
(2) Assists in the ignition of diesel fuel in cold conditions
(3) Switches off once the engine reaches the operating temperatures.

Features : • It enables easy cold start in diesel engines
• It reduces white smoke emissions during startup.
• It improves combustion efficiency

Readings : V = 13.5V

RESULTS :

We obtained the waveforms of the various actuators & the voltage outputs of the actuators.

CONCLUSION :

Hence we studied & analyzed the performance of different types of actuators used in CRDI systems.

Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)
2. Time taken (hours / mintutes) : 2 hrs

3. List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Acheived)
1.	Understood different types of actuators in a CRDI system	✓
2.	To study Construction, working, features & various actuators & their Applications.	

Remarks :

Applications :- • Used in modern diesel engines for precise fuel Injection.
• Enhances engine performance, fuel efficiency, and emission control
• Ensures reliable operation under varying load conditions.
• Ensures optimal power output.

Total marks 10 out of 10.

Sign of Instructor
Date : 2/9/24

PRACTICAL NO: 7

Date : 29/3/25

TITLE : To study & analyse the working of CRDI system & sensor related to it.

AIM / OBJECTIVE: 1) To study working principle's of various sensors
2) To list various feature & specifications of various sensors.
3) To list applications of the sensors.

APPARATUS / TOOLS / EQUIPMENT / RESOURCES USED:

CRDI Apparatus
PC
LN Labsoft
Connecting Wires

CONCEPT / THEORY OF EXPERIMENT:

The CRDI is an intelligent technology where the highly pressurized fuel is supplied as injection through a common rail. As the name indicates it is a direct injection system where the injectors spray fuel directly to the system.

PROCEDURE :

1. Turn on LN Labsoft (Cartrain) & navigate to CRDI Course.
2. Read the course & understand the working of CRDI system.
3. Perform the experiment on the various sensors on the CRDI systems
4. Measure the Important parameters at the sensor such as o/p voltage, signal type, etc.

③ Acceleration Pedal Sensor :-

Working : The APS sends the position data to the ECU which uses the signals to adjust Fuel injection & air intake for engine power.

Types of Accelerator Pedal sensor :

① Potentiometer Based Sensor : Variable resistor to change voltage.

② Hall Effect sensor : Uses magnetic field changes to determine pedal position

Readings : V(DC) = 5V
V at min^m ideal condition = 0.4V
at max^m = 3.25 V

④ Camshaft sensor :-

Function : Used to monitor the camshaft position & the speed in the engine.

Working : It detects camshaft rotation, generating electrical signals. The ECU uses these signals to determine camshaft position relative to crankshaft variable valve timing.

Readings :- DC voltage at Idle = 5V

⑤ Coolant Temperature Sensor :-

Function : Used to measure the temp^r of the engine coolant, ensuring the engine operations with its optimal temp^r range.

Working : The sensor typically uses a thermistor to measure the coolant temp^r. As temp^r changes the resistance of thermistor changes, allowing the sensor to send varying voltage signal to the ECU.

Readings : Low Speed DC Voltage = 2.96V

OBSERVATIONS

✱ Crankshaft Sensor :-

Function : Determines the position & speed of the crank-shaft, essential for proper fuel injection timing & ignition timing.

Working : There are various types of crankshaft sensors, including hall-effect sensor, magnetic reluctance sensor & optical sensor, They generate signals as teeth of the crankshaft passes by.

Readings : AC V = 1.3V (Idle)
at 50% = 3.7V
at 100% = 4.1 V

✱ Air Intake Temperature Sensor :-

Function : Measures the temperature of the incomming air, allowing the ECU to adjust fuel injection quantity & timing for optimal combustion

Working : Similar to the coolant temperature sensor, the intake sensor uses a thermister to measure temperature changes in the intake air.

Readings : Voltage DC at Low speed = 0.12V
Voltage DC at High speed = 3.32V

✱ Mass Airflow Sensor [MAF] :-

Function : Measures the mass of air entering the engine crucial for calculating the appropriate amount of fuel needed for consumption

Working : The MAF sensor basically uses a heated wire or film to measue airflow. As air flow over the sensor, it cools the heated element causing changes in electrical resistor.

Readings : V = 13V (DC)

CALCULATIONS :

⊛ Rail Pressure Sensor :-

Functions : Monitors the Rail pressure in the common rail ensuring consistent & accurate fuel delivery to the injection.

Working : The rail pressure sensor measures the pressure inside the common rail & sends pressure data to the ECU allowing it to adjust injector pulse width & timing.

Readings : 0 to 5V (DC)

⊛ MAP [Manifold Absolute Pressure] Sensor :-

Functions : 1) The MAP sensor detects the air pressure (vacuum) inside the intake manifold.
2) It converts this pressure into an electrical signal.

Working : • The sensor sends a voltage signal to the ECU
• The voltage varies based on pressure

RESULTS :

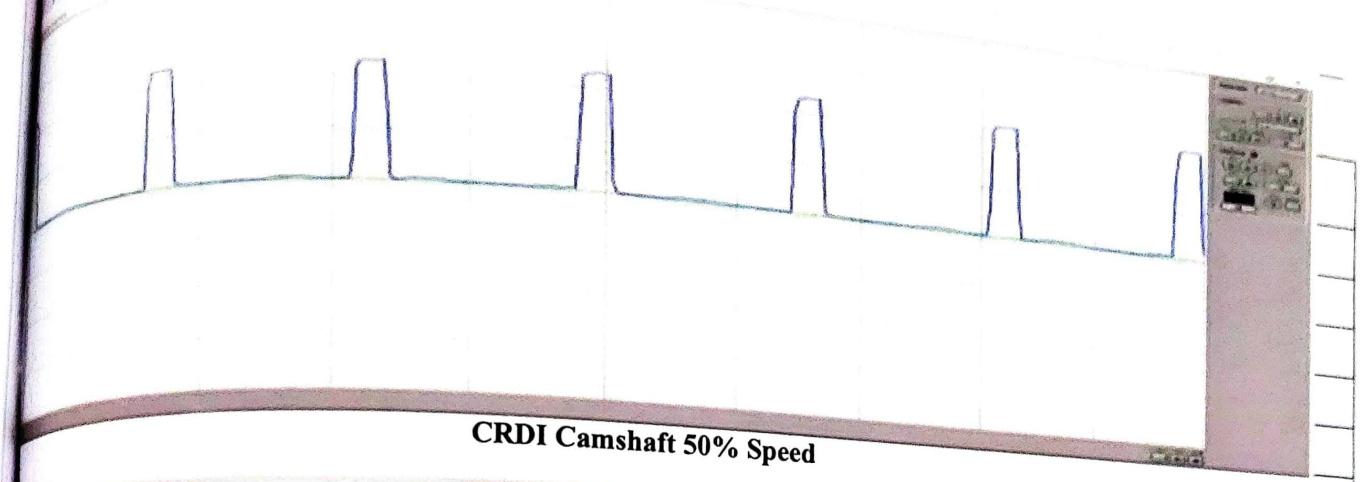
Types : 1) Analog MAP sensor
2) Digital MAP sensor

CONCLUSION :

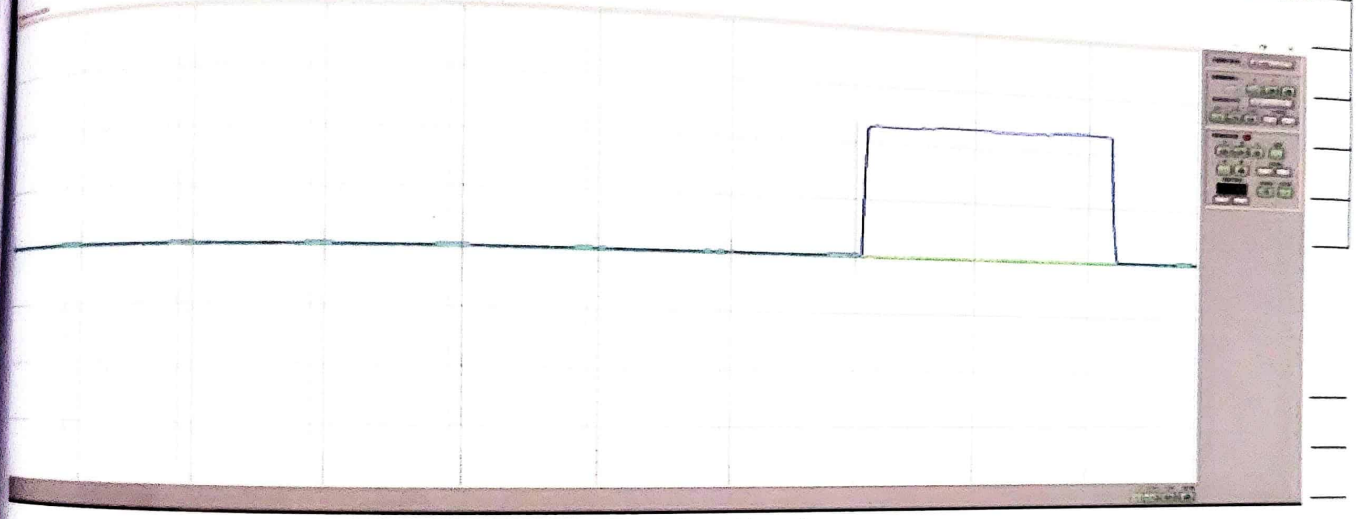
Hence we analysed the working & performance of various sensors used in CRDI system.

Assessment Parameters (To be filled by Instructor)

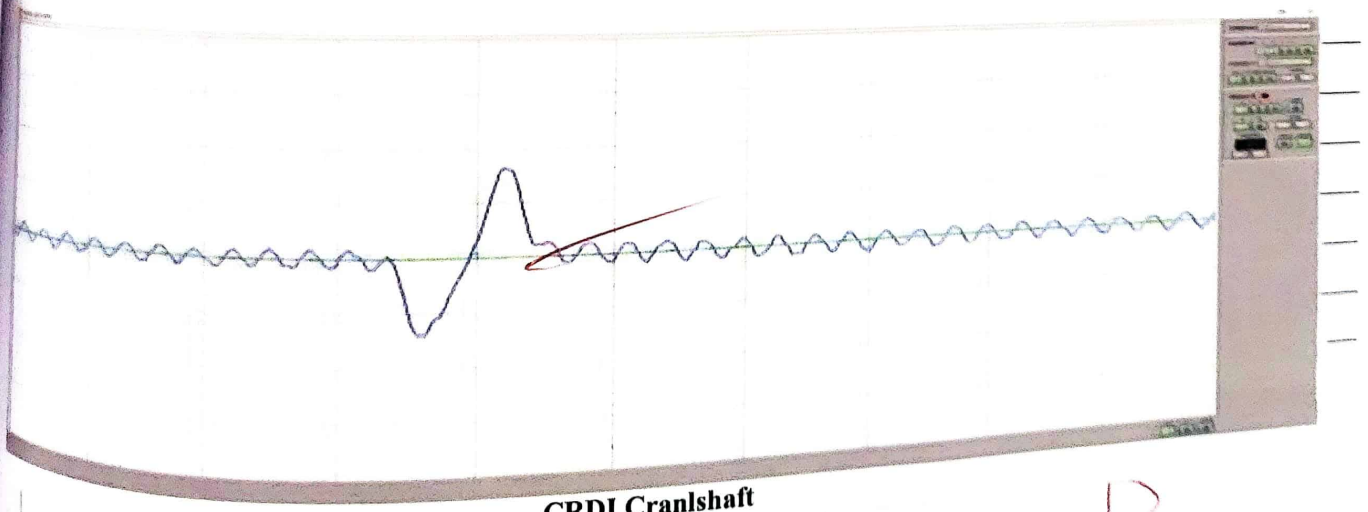
1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) :



CRDI Camshaft 50% Speed



CRDI Camshaft Low Speed



CRDI Cranlshaft

Total marks 10 out of 10.

Sign of Instructor
Date : 29/9/

Assessment Para... ...Instructor)

Successful completion of Practical (Y/N)

Time taken (hours / minutes) : _____

List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Acheived)
1.	Understood the working of CRDI System	
2.	Understood the sensor used in CRDI System	Y
3.	Understood various appn where the CRDI systems are used.	

Remarks :

Applications of CRDI Systems :-

① Automotive Industry :
Passenger Cars, Commercial Cars, Off Road Vehicles

② Agriculture & Construction Equipment :
Tractors & Harvestors, Excavator's & Loaders

③ Marine Appn :
Boats & Ships

④ Railways :
Diesel Locomotives

⑤ Power Generators :
Diesel Generators

Sign of Instructor
Date : 29/9/...

Total marks 10 out of 10.

PRACTICAL NO: 8

Date : 4/4/25

TITLE : To Study & analyze the performance of Power convertor, Inverters & Regen. Braking in EVs

AIM / OBJECTIVE:
1) Understand the performance of power converters
2) Understand the working of inverters & converters
3) Working & performance of Regenerative Braking

APPARATUS / TOOLS / EQUIPMENT / RESOURCES USED:

PC
LN Labsoft
connecting wires
Unitrain cards SO4203-4A, 4F, 7T

CONCEPT / THEORY OF EXPERIMENT:

Inverters : They convert DC to AC by using electronic switches like transistors. They typically use PWM to shape the o/p.

Regen. Braking : This concept is used to recharge a battery or capacitors in an HEV/EV. It converts KE from the motor or generator into electrical energy.

Converter : It is electronic device that adjusts voltage levels, converts DC to AC & AC to DC for motor drive/regeneration & optimizes energy flow for efficiency & system stability.

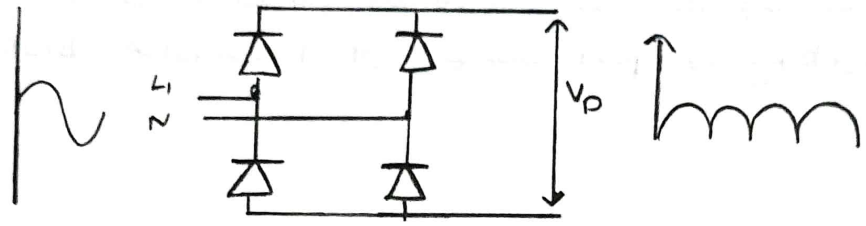
PROCEDURE :

1. Open LN Labsoft software & navigate to & utilize unitrain & hybrid in Automobile course.
2. Follow the instruction as given in the course & perform accordingly.
3. Observe the waveform on oscilloscope & voltages on the virtual voltmeter as instructed
4. Verify the o/p.

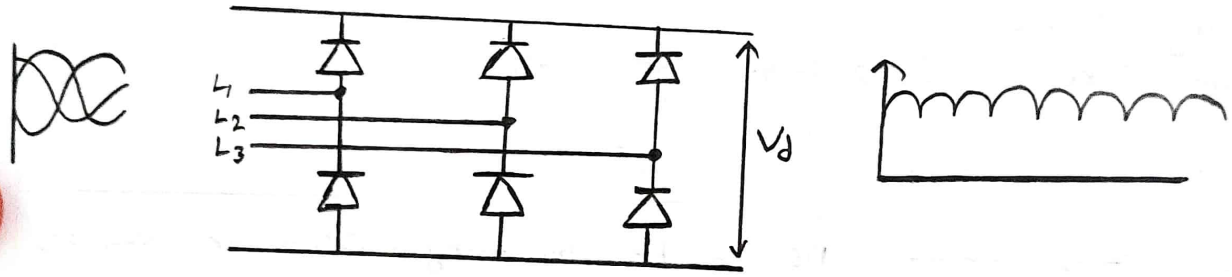
① Rectifier :-

A rectifier is an electrical ckt that converts AC to DC. As some of the components & system in a vehicle require DC for their operation. There are 2 types of rectifiers based on the i/p supply voltage phase.

1. Single-Phase Feed :



2. Three-Phase Feed :

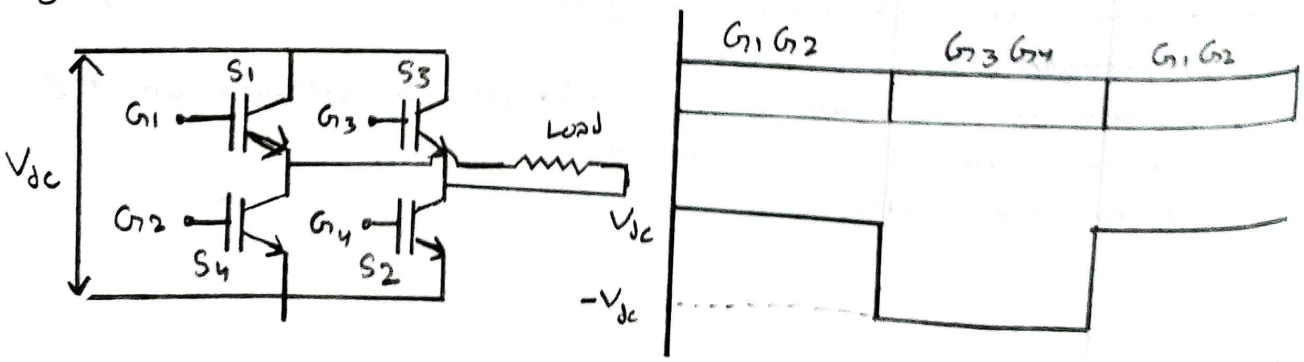


- This type of rectifier has a 3 phase i/p voltage supply. They also do not have a zero point hence the o/p power is much higher than for single phase i/p.

② Inverter :-

An inverter is an electrical ckt that converts DC to AC. As the motor in vehicles requires AC for their operation. There is a need of an inverter ckt. The inverter uses PWM to turn on & off the PED devices.

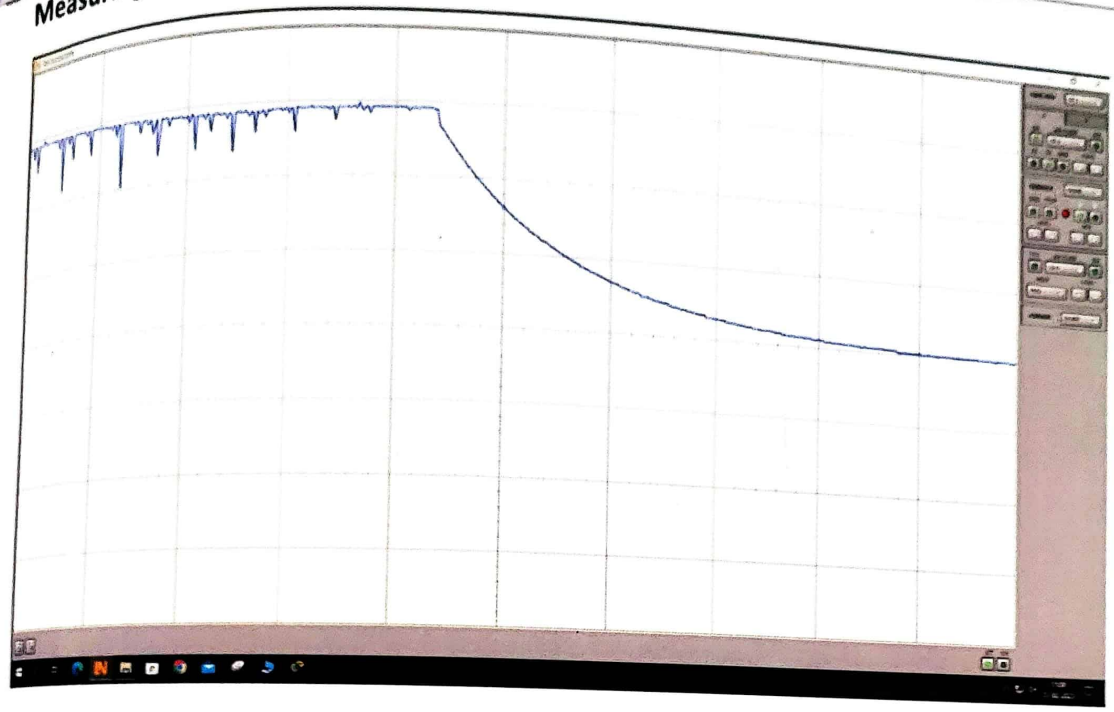
1. Single phase o/p :



OBSERVATIONS

① Rectifier :-

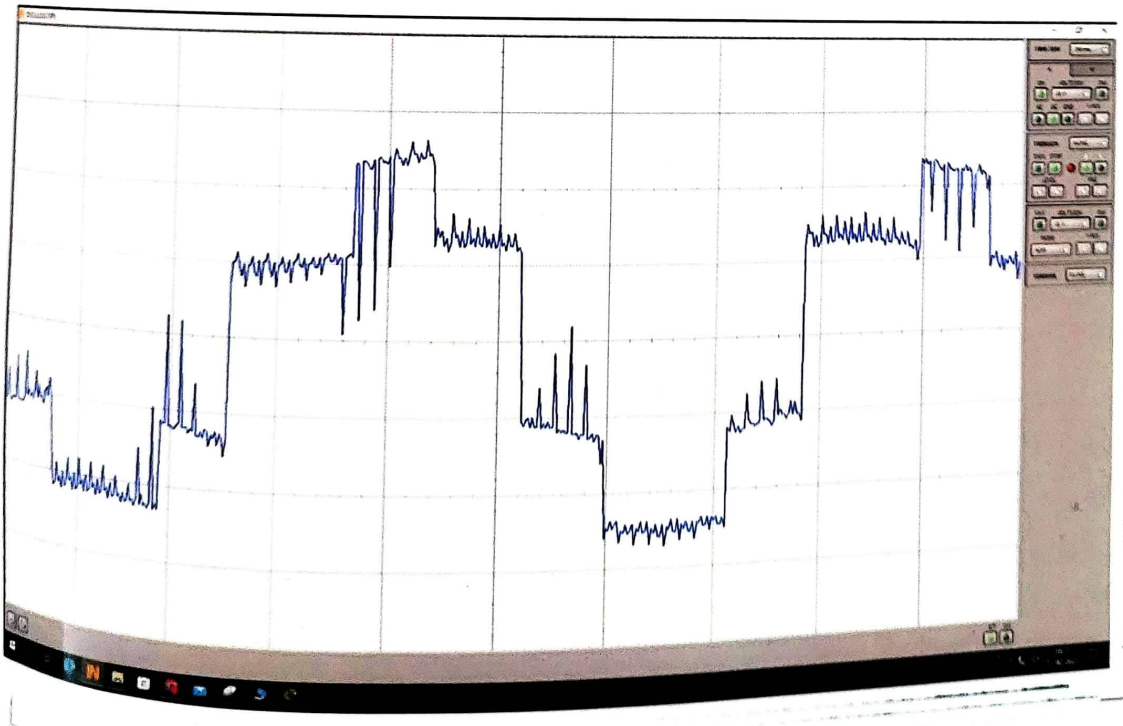
Measuring Capacitor Voltage



.8V

.7V

Inverter Measurements (U1U2)



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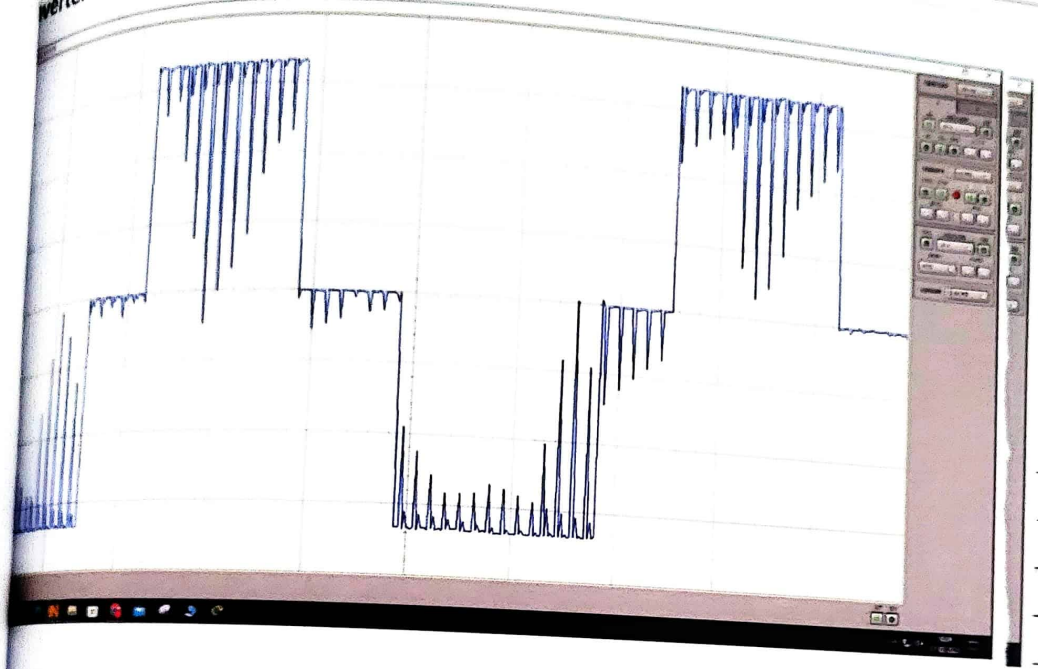
OBSERVATIONS

① Rectifier :-

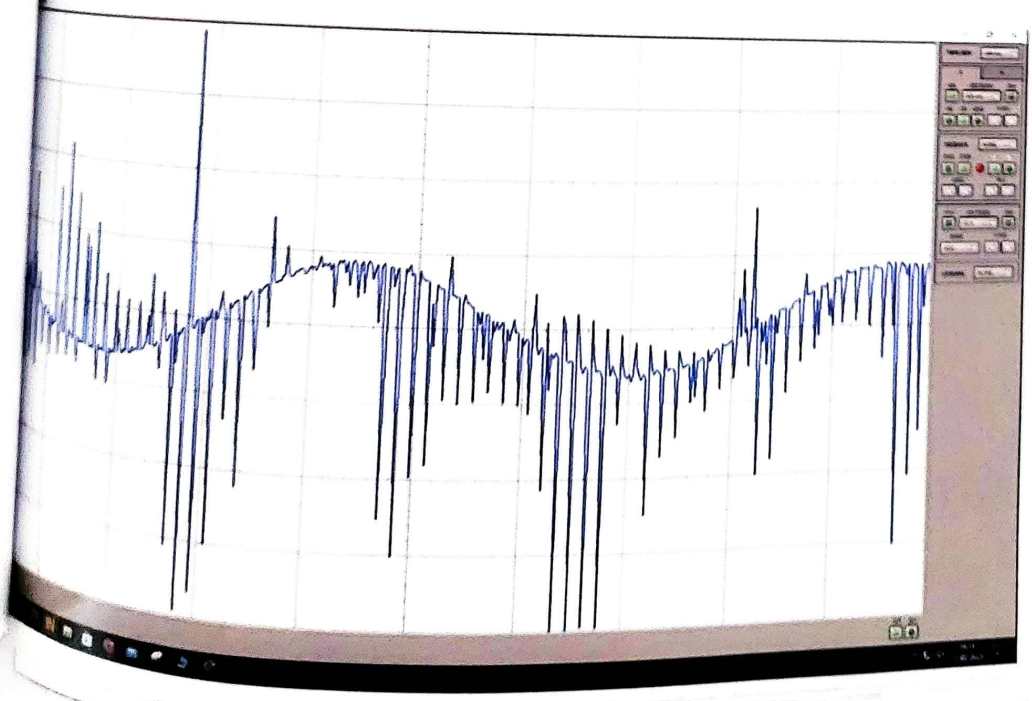
werter Measurements



1.8V

1.7V

rter Measurements (R1)



voltage.

remain ON
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① Rectifier :-

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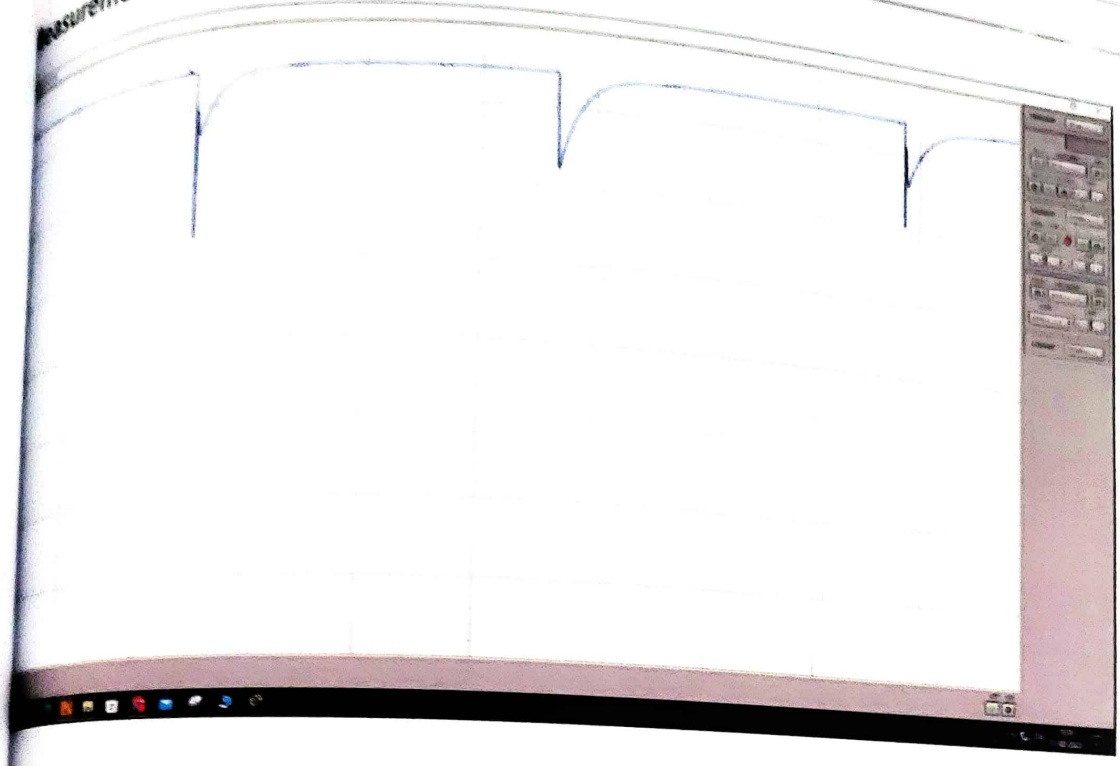
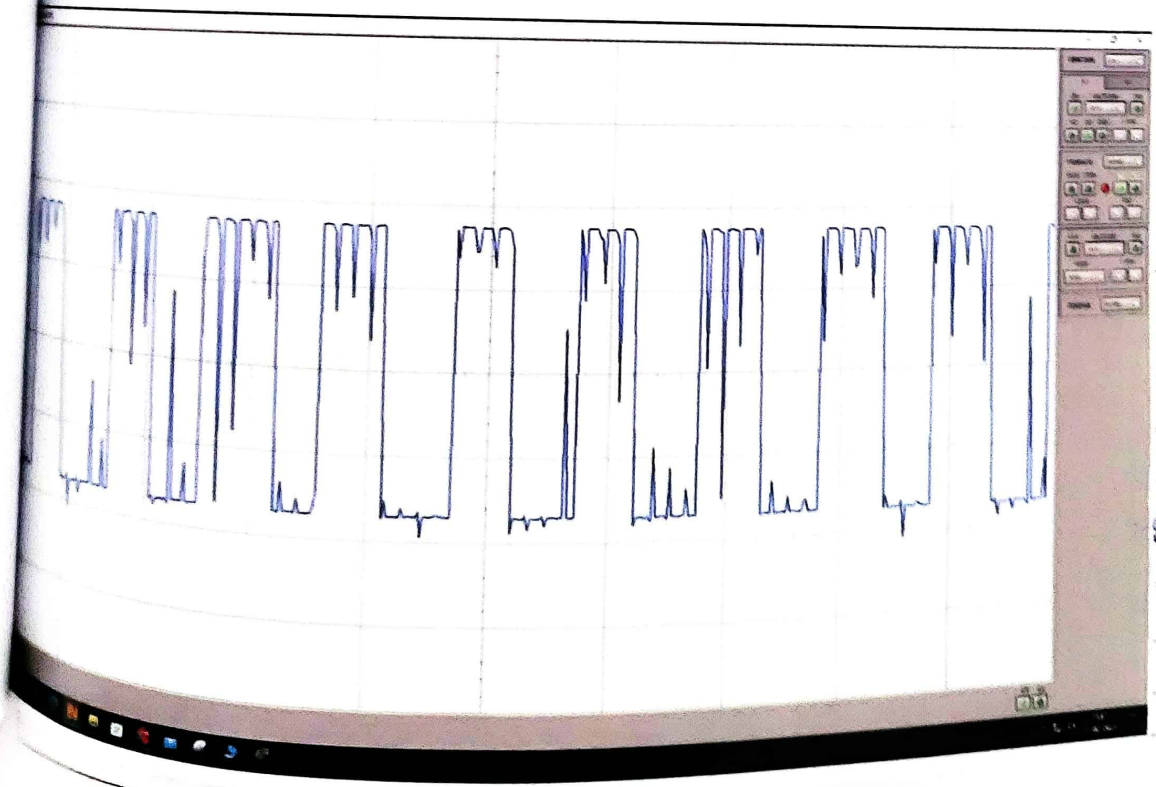


8V

7V

asurement of Output Voltage



voltage.

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OBSERVATIONS

① Rectifier :-

i) Single Phase Supply :
- The i/p voltage at ~~G~~ V1 to Com (V_{VICON}) = 13.8 V
- The link voltage at V_D = 16.3 V
- The motor voltage V_{MW} = 9.5 V

ii) Three Phase Supply :
- The i/p voltage at V_1 to V_2 (V_{V1V2}) = 23.7 V
- The link voltage at V_D = 29.3 V
- The motor voltage V_{MW} = 20 V

② Inverters :-

i) Measurement of i/p voltage :
- The i/p voltage of inverter = 34 V
- The i/p voltage is a DC voltage

ii) Measurement of o/p voltage :
- The value of +ve voltage is 18 V.
- The value of -ve voltage is -18 V.
- A transistor remains conductive for 600 ms

iii) Inverter ~~Mana~~ Measurement :
- The i/p voltage is 30 V
- The o/p voltage by the inverter is AC voltage.

→ The IGBTs S_1 & S_2 are triggered on & they remain on from 0 to π, The IGBTs S_3 & S_4 are triggered on & they remain on from π to 2π. This gives an AC voltage at o/p.

CALCULATIONS :

③ ~~Rectifier~~ & Regenerative Braking :-

i) Energy Recovery Efficiency :
- 15-70% of KE is recovered
- Induced voltage is 0.5 V

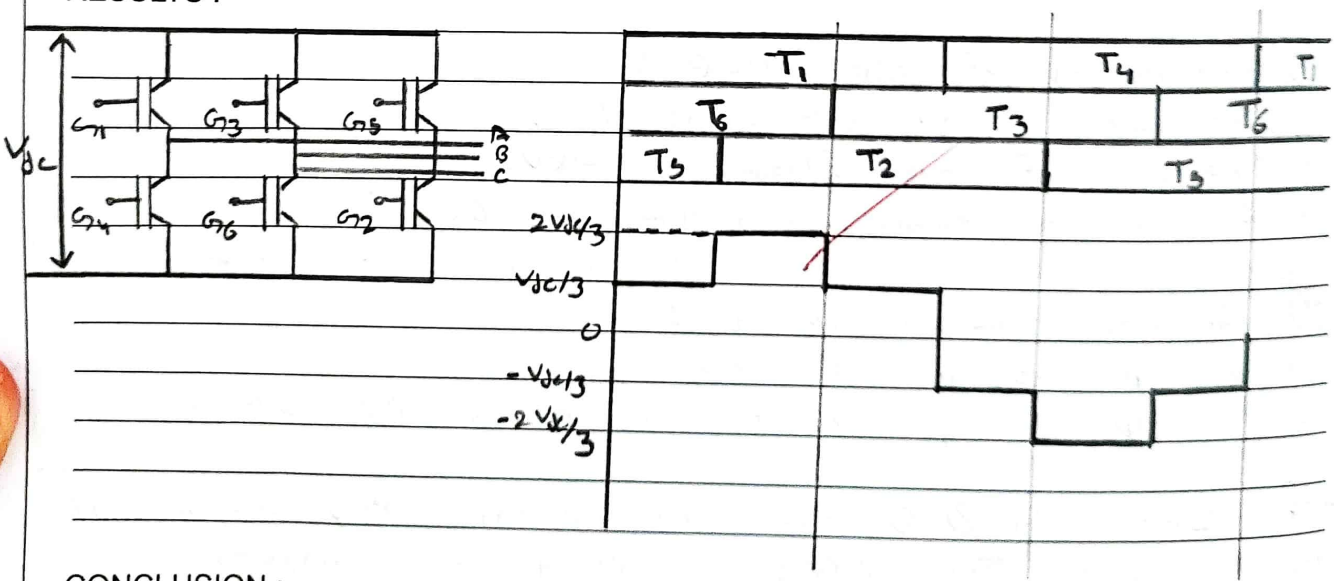
ii) Power :
- Peak regen Power = 50 - 300 kW
- V matches battery package voltage

iii) Integration
- Coordination with friction brakes
- Simulates engine braking.

2. Three phase O/P :

→ The IGBTs are Triggered on & off in a specific pattern to achieve a 3Φ O/P voltage.

RESULTS :



CONCLUSION :

Hence, we have studied & analyzed the performance of power converters, inverters, & regenerative braking.

Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hrs

3. List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Acheived)
1.	Understand performance of power converters & inverters	Y
2.	Understand working of power converters & inverters.	
3.	Understand about the working of regenerative braking.	

Remarks :

③ Regenerative Braking :-

As the rotor of the motor is driven, sinusoidal voltages are induced in the stator windings. This voltage generated is used to charge the battery. The three pole placed in the stator are displaced by 120° which correspondingly gives a 120° phase shift b/w the individual voltages.

Total marks 09 out of 10.

Sign of Instructor
Date :

PRACTICAL NO: 9

Date : 11/4/25

TITLE : To Study & Analyze the performance of Keyless Entry system in Automobiles

AIM / OBJECTIVE: 1) To understand concept of Keyless entry
2) To understand wireless entry
3) To understand RFID concepts used in automobiles

APPARATUS / TOOLS / EQUIPMENT / RESOURCES USED:

Unitrain Keyless Entry Apparatus
LN Labsoft
Connecting Wires
PC

CONCEPT / THEORY OF EXPERIMENT:

Keyless entry in automobiles allows drive to unlock & start a vehicle without a physical key a remote key fob or smartphone that communicates wirelessly with the car's system. It relies on radio frequency signals or encrypted digital codes to authenticate the user & activate the locks or ignition.

PROCEDURE :

① Open LN labsoft software & navigate the UniTrain Keyless Entry Course.
② Follow the instructions as given in the course & perform accordingly
③ Observe the O/P as instructed.
④ Verify the O/P.

THEORY :-

① Active Safety :
Meant to help, prevent Accidents.

② Driving Safety :
ASR | ISP, Precise Steering, Optimal road behaviour.

③ Perception Safety :
All round view, Heatable windows, Actural mirrors

④ Condition Safety :
Driver seat Adjustment, Suspension, Interior ventilation

⑤ Operational Safety :
Peebil's Design, Arrangement of control elements, instruments

⑥ Passive Safety :
Meant to minimize consequences of accidents.

⑦ Interior Safety :
Deformation, Strong Passenger compustment, fine protection.

→ Comfort Technology :-

① Central locking
② Immobilizers
③ Electric Window
④ Adjustable Seats
⑤ Ventilation
⑥ Freating Climate Control
⑦ Alarm Safety
⑧ Adjustable external window & mirror
⑨ Driver Assistance System
⑩ Mobile telephony

OBSERVATIONS

① Keyless Entry System :-

A] Vehicle Key programming :

- Multiple Keys can be assigned to every vehicle.
- A vehicle Key has to be programmed to establish comm^n b/w the Key & the vehicle & to ensure that the Key is able to communicate only with that particular vehicle in Future.

B] Vehicle Key Identification :

- Every key can be uniquely identified

C] Unlocking & locking the driver's door :

- we are able to lock & unlock the door

② Design & Functions :-

A] Wake-up Signal :

- A signal of approximately 125 KHz is recorded.
- As if transmission frame is involved in this scenario

B] Communication via high frequencies :-

- Signal Intensity

- When the Key is far away from the controller the signal intensity changes notably
- When the Key is moved away from the controller the RF signal stays ready to transmit & receive for a long time & the LF stays ready to transmit & receive for a very short time.

C] Communication Process :-

- Car Monitoring : The seat adjustment, Mirror adjustment, heater settings & steering wheel adjustment control options are represented by the CAR monitors.

CALCULATIONS :

• Saving Comfort Setting :
- Comfort data can be saved in the transmission Key.
- Enhanced comfort is meant to improve active safety.

RESULTS :

CONCLUSION :

Hence, we have studied & analyzed the performance of Keyless entry system in automobiles.

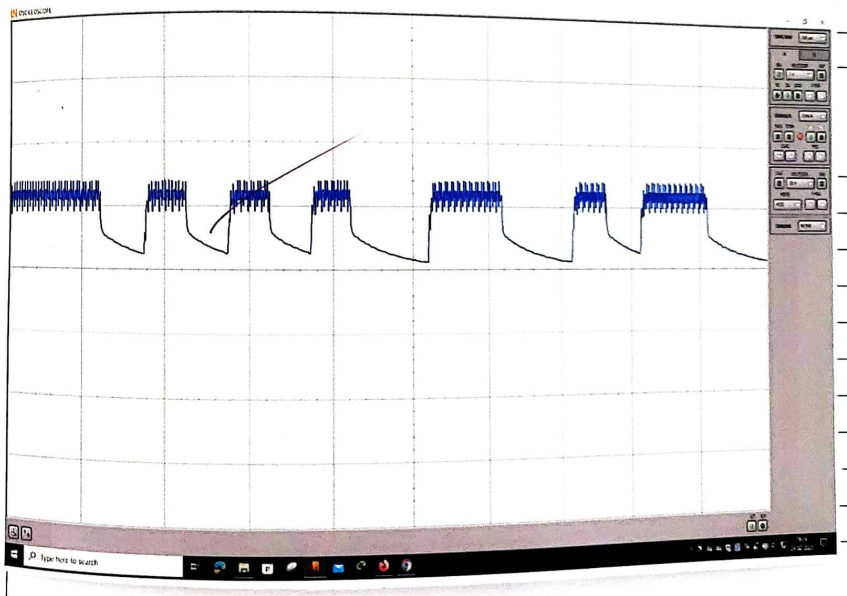
Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hrs

3. List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Acheived)
1.	Understanding Concept of Keyless entry	
2.	Understanding working of contactless Key	
3.	Understanding of RFID used in Automobiles.	

Wake-Up Signal



Total marks 09 out of 10.

Sign of Instructor
Date :

PRACTICAL NO: 10

Date : 18/3/25

TITLE : To study & analyze the performance of various motors used in EVs.

AIM / OBJECTIVE:
1. To understand working principle of motor
2. To know & understand working principle of diff. motors
3. To understand efficiency of each motor.

APPARATUS / TOOLS / EQUIPMENT / RESOURCES USED:

Unitrain Hybrid Drives S04203-4A, 4F, 7T
LN Labsoft Software
Unitrain Experimend
Connecting Wires

CONCEPT / THEORY OF EXPERIMENT:

An electric convertrs electrical energy into mechenical energy by generating a magnetic field from electric current which interacts with another magnetic field to produce rotational motion. This is typically achieved using a roter & stator with electromagnetic forces driving the motion.

PROCEDURE :

① Open LN Labsoft software & navigate to Unitrain & hybrid in Automobiles courses.
② Follow the instruction as given in the course & perform accordingly
③ observe the waveform on oscilloscope & voltages on the virtual voltmeter
④ Verify the output.

① Electric Machine Design :-

1. Star Connection's current consumption :
   - The value of current I_{R_L} is 530mA

2. Delta Connection's current consumption :
   - The value of current I_{R_L} is 1300mA

3. Rotation Reversal :
   - At 45Hz the machine rotates clockwise
   - At 45Hz both connections reversed the machine rotates anticlockwise.
   - At 45Hz, connections reversed & CW/CCW pressed the machine rotates CW as the change in control configuration has the same effect as interchanging two phases.

② Electric Machine (Motor) :-

- An electric machine comprises of a stationary part (Stator) & a rotor part (rotor)

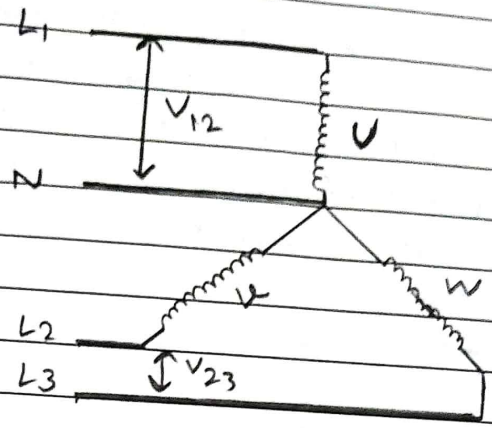
1. Stator :
   It is the stationary part of the electric motor & is responsible for producing the rotating magnetic fields. It is made up of several energized coils & ce packages of stator laminations are needed for this purpose.

2. Rotor :
   The rotor is mounted on the motor shaft which transfers the torque to the machine. Rotors come in designs which ultimately determine the 3Φ machines type & operational characteristics : with or without coils, with or without slip rings, squirrel caye, permanent magnet.

- Each electric field is phase shifted by 120°. Hence, the magnetic field space vector of each field space vector of each is at 120° phase difference wrt the next.
- Now, these magnetic fields are present inside the stator & hence due to 3Φ electric field a rotating.
- The stator winding is connected in a delta or star configuration.

OBSERVATIONS

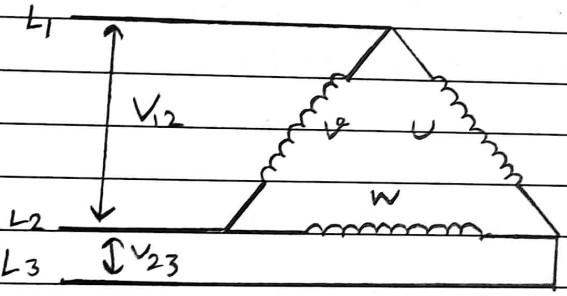
③ Star Connection :-



Here

1. Phase voltage (V_p) = $\sqrt{3}$ x line voltage
2. Phase current (I_p) = line current (I_L)

④ Delta Connection :-



Here

1. Phase Voltage (V_p) = line Voltage
2. Phase current (I_p) = $\sqrt{3}$ x line current

⑤ Asynchronous Machines :-

• An asynchronous machines rotor can have a squirrel cage or slip ring design. This type of rotor comprises a number of conductors short circuited at both ends by means of a conductive ring.

CALCULATIONS :

- A squirrel cage rotor has :

i) Shaft

ii) A package of mutually insulated dynamo plates with prepared cavities for accomodating the rotor bars.

iii) Aluminium, Rotor bars, and short circuit rings

If a machine operates under no load, the idle speed approximates the synchronous speed.

$$\text{slip}(s) = \frac{n_0 - n}{n_0}$$

⑥ Synchronous Machines :-

- A synchronous machine rotor turns synchronously with the field, i.e., at the same speed as the field.
- A rotor with permanent excitation has a permanent magnetic fitted in the motor.

1. Starting a squirell cage rotor
   - The rotor starts smoothly

RESULTS :

2. Starting a permanent - magnet rotor
   - The rotor jerks on start.

CONCLUSION :

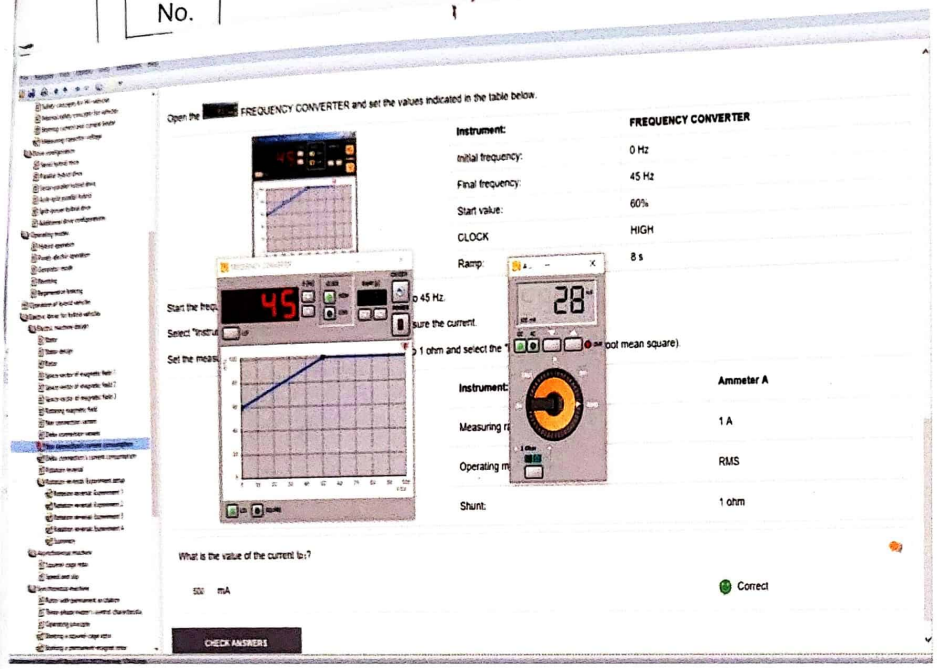
Hence, we have studied & analyzed the performance of various motors used in EVs.

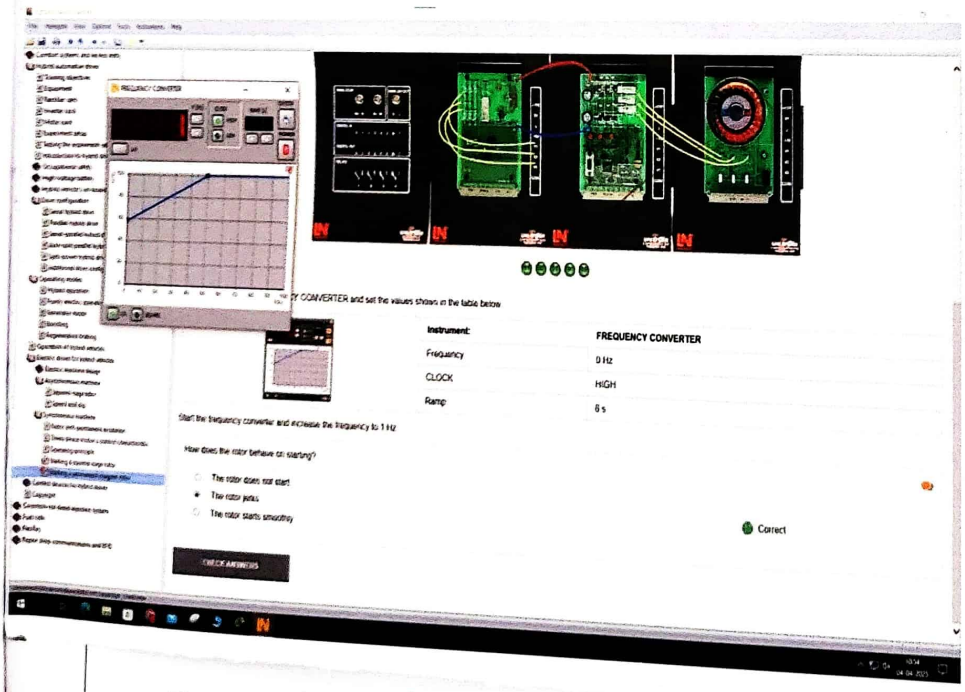
Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hrs

3. List other Parameters & Outcomes :

Sr. No.	Parameter	ıe Acheived)





Total marks 09 out of 10.

ı of Instructor

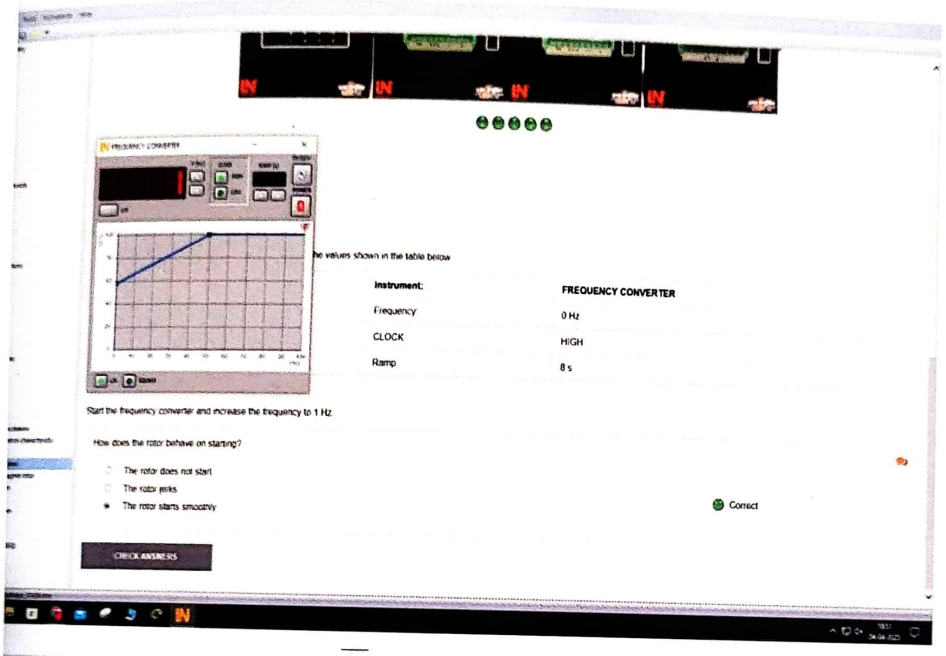
Date : 29 Apr

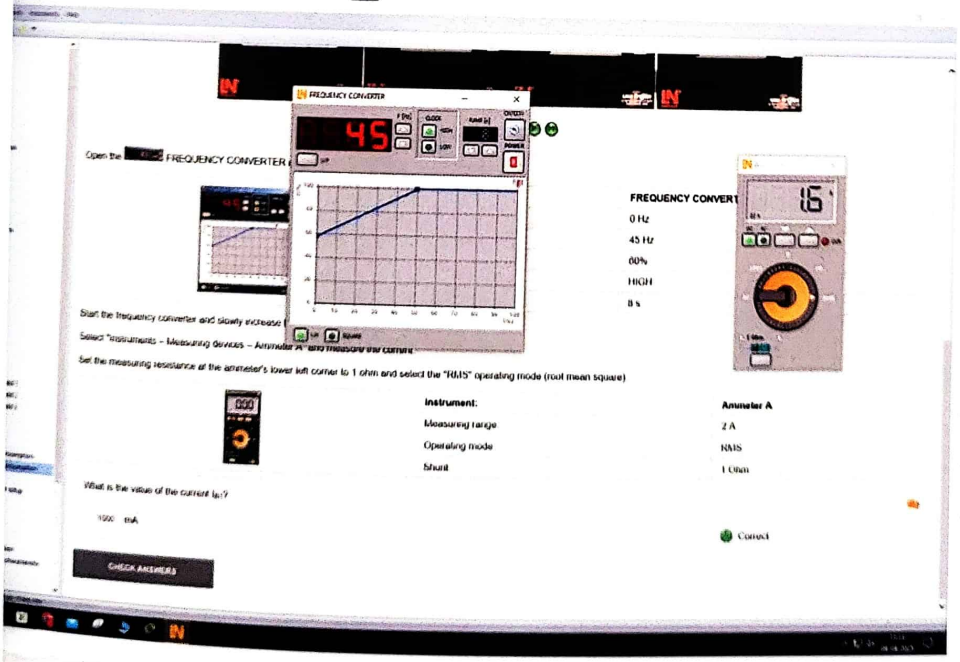
Assessment Parameters (To be filled by Instructor)

1. Successful completion of Practical (Y/N)
2. Time taken (hours / minutes) : 2 hrs

3. List other Parameters & Outcomes :

Sr. No.	Parameter	Outcome (Achieved / Not Acheived)





Total marks 09 out of 10.

Sign of Instructor
Date : 29/9/24