The Shirpur Education Society's

R. C. Patel College of Engineering and Polytechnic, Shirpur
Department of Electrical Engineering

NOTES

Programme Code: Electrical Engineering | **Year/Scheme:** EE5K | **Semester:** 5th

Course Abbr.: EVT | **Course Code:** 315335

Course Title: Electrical Vehicle Technology

Subject Teacher :- Ms. H.A.Badgujar

UNIT-01 – (10 MARKS)

BASICS OF ELECTRIC VEHICLES

CO Coverage: - Identify components and subsystems used in electric vehicles.

Unit -01 Content (Syllabus)

1.1 History and evolution of electric vehicles (EV), need of EV, Electric vehicles and internal combustion engine vehicles: Comparison on the basis of environmental impact, power source, maintenance, gear change, noise level, vibrations level, capital cost, and running cost.

1.2 Electric vehicle architecture, Types of EV: Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV).

1.3 Comparison of different electric vehicle types on the basis of Driving Component, Energy Source used, Features, Problems and models available in market.

1.4 Block diagram of EV subsystems: energy source subsystem, Propulsion subsystem and auxiliary subsystem.

1-1 History and evolution of electric vehicles (EV) :→

→ The invention of electric vehicles can not be credited to a single person or country.

→ Instead, various inventions during the 1800's laid the foundation for the electric vehicles.

→ EV's were first developed in the 1800's. At that time, these vehicles were prefered because of their quiet operation and ease of use.

→ At the begining of the 20th century, Internal Combustion Engine (ICE) vehicles became more popular due to their longer driving range and lower fuel costs.

→ In the late 20th and early 21st centuries, interest in EV increased again because of growing environmental concerns and advances in battery technology.
→ Companies such as Tesla, Nissan Leaf, and other manufacturers helped bring EVs into the mainstream.
→ During the oil crisis of 1970's, interest in electric vehicles revived because of crisis highlighted vulnerability of the global economy to shortages of fossile fuels.
→ Consequently, various governments and researchers began exploring alternative propulsion technologies, and a number of limited experimental EVs were developed for industrial and specialized applications.
→ In 2008, Tesla's Roadster transformed the electric vehicle (EV) market.
→ By 2010-15, models like the Nissan Leaf and chevrolet Volt helped mainstream EV's, supported by govt. subsidies and improved charging infrastructure.
→ EV Adoption has increased significantly since 2020. Many Countries have announced plans to phase out or ban Internal Combution engine vehicles.
→ Continuous advancements in battery technology are improving EV performance and efficiency.
→ Charging infrastructure is expanding worldwide.
→ EVs are steadily becoming the future of transportation due to their environmental and technological advantages.

1.1.1 Need of Electric Vehicle :→

1) Electric vehicles help reduce greenhouse gas emissions, ~~from~~ contributing to environmental protection and climate change mitigation
2) Reduced dependency of fossile fuels.
3) Government initiates for cleaner transportation.
4) EV's operate quitely, reducing urban noise pollution significantly.
5) EV's are ideal for short distance urban travel and are compatible with smart city infrastructure.
6) Fewer moving parts (no engine, no oil changes, fewer mechanical failures)
7) Promoting innovation in transport sector.

1.1.3 Comparison of electric vehicles and Internal combustion engine vehicles :-

Sr. No.	Comparison Criteria	Electric Vehicle (EV)	Internal Combustion Engine Vehicle (ICE)
1	Environmental Impact	Zero emissions, no direct pollution.	High CO_2 and pollutant emissions.
2	Power Source	Battery-powered electric energy.	Petrol, Diesel, or CNG (Fossil Fuels).
3	Maintenance	Low maintenance due to fewer moving parts.	High maintenance due to engine, oil, filters, and other components.
4	Gear Change	Gearless or automatic transmission.	Manual or automatic gearbox.
5	Noise Level	Very low noise operation.	High engine noise.
6	Vibration Level	Minimal vibrations.	High vibrations due to engine and drivetrain.
7	Capital Cost (Initial Cost)	Higher initial purchase cost.	Lower initial cost compared to EVs.
8	Running Cost	Low running cost; electricity is cheaper per kilometer.	High running cost due to expensive fuel.
9	Energy Efficiency	Higher energy efficiency.	Lower energy efficiency due to energy loss in combustion.
10	Dependence on Fuel	Uses electricity; reduces fossil fuel dependence.	Depends heavily on fossil fuels.

1.2.1 Electric Vehicle Architecture :-

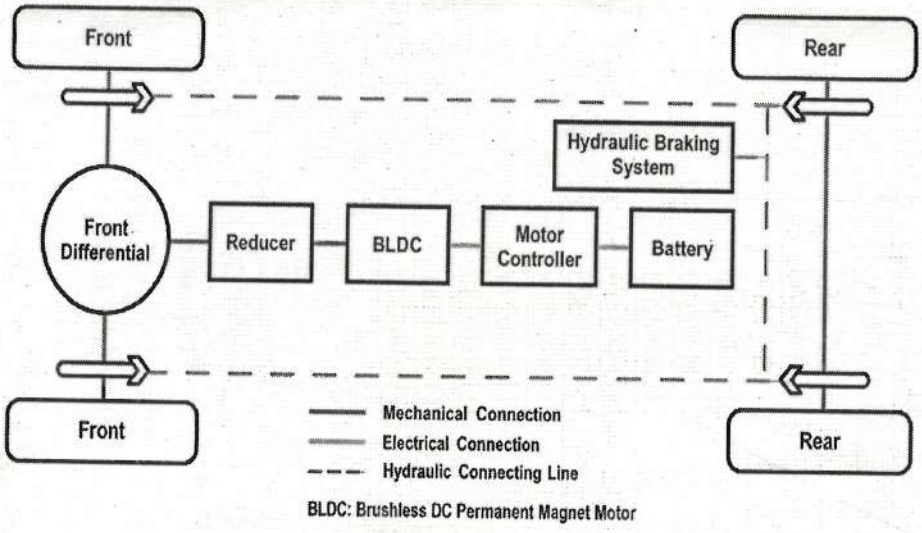


Fig. **Electric Vehicle Architecture**

1) Energy Source :- Battery or fuel cell :-

→ The energy source is heart of an electric vehicle (EV), providing the power required for all vehicle operations.

→ In battery electric vehicle energy is stored in a battery in chemical form and is later converted into electrical energy. common battery types includes Lithium-ion, nickel-metal hydride, lead acid etc.
→ In fuel cell Electric vehicles fuel cell is used to generate electricity through an electrochemical reaction between hydrogen and oxygen.

⇒ Power converter :-

→ A power converter manages the flow of energy from the energy source to the motor and auxiliary systems of an electric vehicle.
→ The power converter ensures efficient energy management by converting and distributing electrical power to different vehicle systems while also enabling energy recovery through regenerative braking.

3) Electric motor :→

→ An electric motor converts electrical energy into mechanical energy, which is used to drive vehicles wheels.
→ Common types of electric motors used in EVs includes Induction motor, PMSM motor, BLDC motor.. etc.
→ These motors provide high torque at low speeds, eliminating the need for a multispeed gearbox in most electric vehicles.
→ Electric motors plays a crucial role in EV performance by providing smooth, efficient and reliable propulsion.

4) Transmission :→

→ The transmission in EV's transmits power from the motor to the wheels.
→ EVs generally utilize a single speed transmission due to the electric motors ability to deliver torque across varied speeds.
→ Compared to ICE vehicles, EV transmissions are simpler, more compact, require less maintenance and are more efficient due to fewer moving parts.

5) Controller :→

→ The controller is the central unit of the EV propulsion system, managing the power flow from the battery to the motor based on inputs from the accelerator, brake and sensors.
→ It monitors motor speed, torque demand, and temperature while facilitating driving modes like Eco mode for energy efficiency and sports mode for performance.
→ Additonally it prevents faults, ensures safe operation, co-ordinates with BMS and communicates with Electronic control unit for comprehensive vehicle control.

* 1.2.2 Types of EV :→

Following are types of EV :-

1) Battery Electric Vehicle (BEV)
2) Hybrid Electric Vehicle (HEV)
3) Plug in Hybrid Electric Vehicle (PHEV)
4) Fuel Cell Electric Vehicle (FCEV)

* 1) Battery Electric Vehicle :→ (BEV)

→ An EV that powers it's drive train solely through a Battery Electric vehicle.
→ these vehicles rely entirely on the energy stored in their battery packs.
→ Therefore, the driving range of a BEV depends on it's battery capacity.
→ Generally, BEV's can travel 100km to 250km on a single charge.
→ Once the battery is discharged, recharging may take a considerable amount of time, depending upon type of charger and battery.
→ main components of BEV are electric motor, Battery Pack, Control module.

* Advantages :-

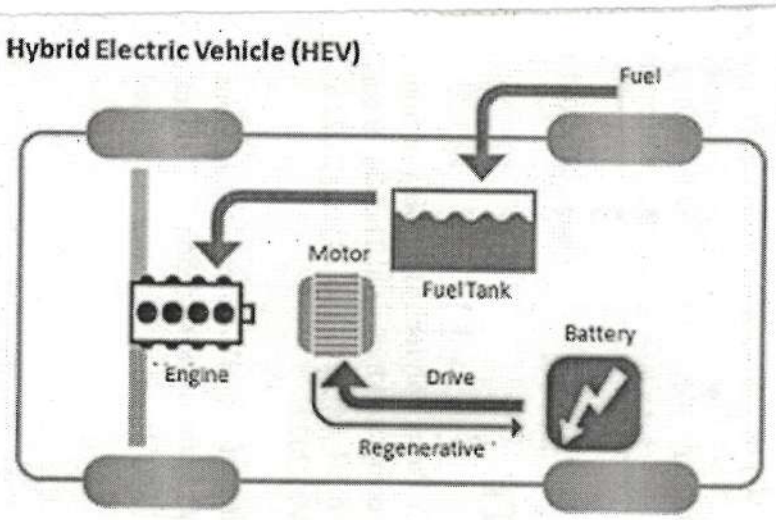
1) No emissions.
2) No gas or oil changes.
3) Ability to conveniently charge at home.
4) Fast and smooth operation.
5) Low cost of operation.

* Disadvantages :-

1) Shorter range than gasoline vehicles.
2) Slightly more expensive than their gasoline vehicle.

* 2) Hybrid Electric Vehicle :→ (HEV)

→ Hybrid Electric Vehicles (HEV's) have two complementary drive systems -
   i) A gasoline engine with a fuel tank.
   ii) An electric motor with a battery.
→ Both the engine and the electric motor can turn the transmission at the same time and the transmission then turns the wheels.
→ HEV's can not be recharged from the electricity grid - all their energy comes from gasoline and from regenerative braking.



* Advantages :-

1) Longer range than BEV.
2) Less gas consumption than gas only vehicle.
3) Fewer emissions than gas only vehicles.

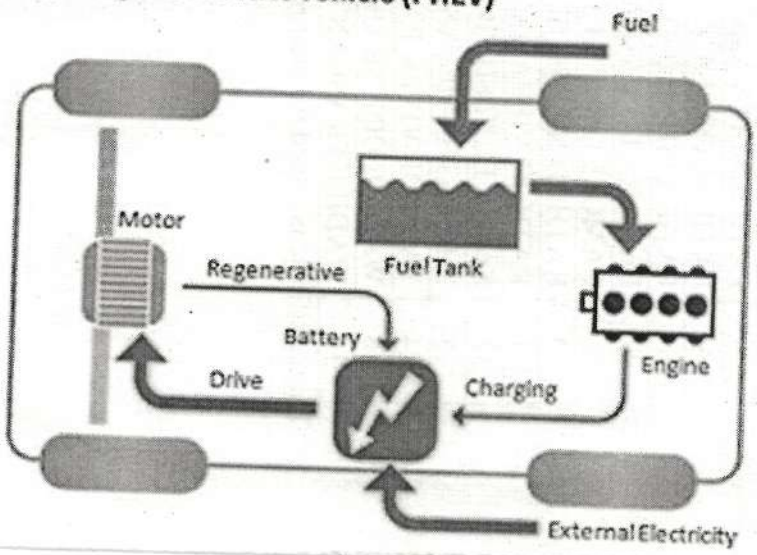
* Disadvantages :-

1) Produces emissions.
2) Complese mechanics - Gasoline + Electric
3) Expensive to operate.
4) No ability to conveniently charge at home.

*3) Plug-in-Hybrid Electric Vehicle :-

→ The PHEV concept was developed to increase the all electric driving range of HEV.
→ Like HEV's, PHEV use both an Internal Combution Engine. (ICE) and an electrical power train.
→ These two systems work together to propel the vehicle.
→ A PHEV initially operates in All-Electric mode, where the vehicle runs entirely on electricity.
→ When battery charge becomes low, the ICE is activated to provide additional power or recharge the battery pack.
→ In PHEV, ICE is mainly used for range esetension.
→ PHEV's can charge their batteries directly from the electric grid, which is not possible in Conventional HEV's.
→ They also incorporate regenerative braking, which recovers energy during braking and stores it in the battery.

Plug-in Hybrid Electric Vehicle (PHEV)



* Advantages :-

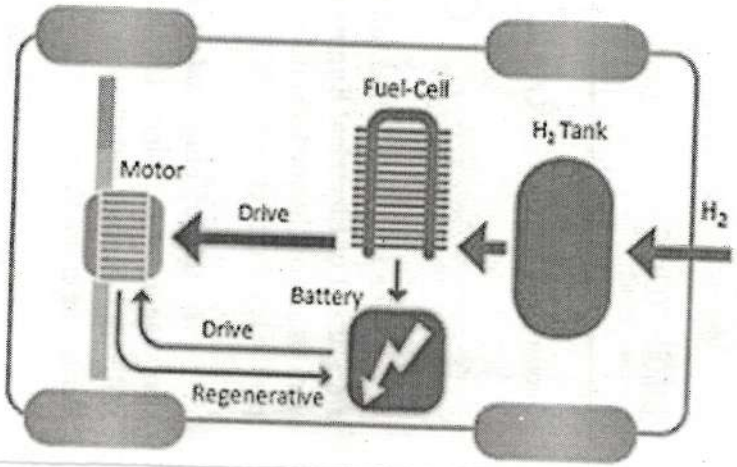
1) Longer range than BEV
2) Less consumption than gas only vehicle.
3) Fewer emissions.
4) Very simple mechanics, less to go wrong.

* Disadvantages :-

1) Produces exhaust pipe emission.
2) Needs gas and oil changes.

*4) Fuel Cell Electric Vehicle :-

Fuel-Cell Electric Vehicle (FCEV)



→ FCEV are also called as fuel cell vehicles (FCVs). They are given this name because the main component of these vehicles is the fuel cell. which generates electricity through chemical reactions.

→ In this process, hydrogen is used as primary fuel. Therefore, these

vehicles are also known as Hydrogen fuel cell vehicles.

→ In FCV, hydrogen is stored in high pressure tanks. Another essential component required for power generation is oxygen, which is taken from the surrounding air.

→ The electricity generated by the fuel cells is sent to an electric motor, which drives the vehicle.

→ FCV produce only water as a by product and generate their own electricity with zero carbon emissions during operation, resulting in a lower carbon footprint compared to many electric vehicles.

→ Another key advantage of these vehicles is their quick refuling process, which only takes about 3-5 minutes, similar to conventional fuel powered vehicles.

→ This rapid refueling could facilitate wider adoption of the technology.

→ However, a major challenge remains the limited availability of hydrogen fuel stations.

* Advantages :-

1) Zero tailpipe emissions.
2) Long driving range.
3) Quite operation and instant torque.
4) Fuel cells are efficient than combution engines.
5) Suitable for long distance travel.

* Disadvantages :-

1) Costly due to manufacturing and maintenance cost.
2) Hydrogen and transport require high levels of safety measures to ensure safe handling and operation.

* 1.3 Comparison of different electric vehicle types on the basis of Driving Component, energy source used, features, problems and models available in market.

EV Type	Driving Component	Energy Source Used	Features	Problems	Popular Models
Battery Electric Vehicle (BEV)	Electric Motor	Battery (must be charged externally)	• Zero tailpipe emissions• Low noise • Low running cost	• Limited range• Long charging time • Expensive battery	Tata Nexon EV, MG ZS EV, Tesla Model 3
Hybrid Electric Vehicle (HEV)	Internal Combustion Engine (ICE) + Electric Motor	Petrol/Diesel + Electric Battery (charged through regenerative braking)	• Good fuel efficiency (high mileage) • Battery does not require external charging	• Complex design • Higher maintenance cost	Toyota Camry Hybrid, Honda Accord Hybrid
Plug-in Hybrid Electric Vehicle (PHEV)	Internal Combustion Engine (ICE) + Electric Motor	Petrol/Diesel + Battery (can be charged externally)	• Can operate in EV mode• Dual energy source	• High cost • Heavier than conventional EVs	Volvo XC90 Recharge, BMW X5 xDrive45e
Fuel Cell Electric Vehicle (FCEV)	Electric Motor	Hydrogen Gas + Fuel Cell System (Hydrogen Fuel Cell)	• Zero emissions • Fast refueling	• Costly system • Limited hydrogen fuel infrastructure	Toyota Mirai, Hyundai Nexo

Abbreviations

BEV – Battery Electric Vehicle
FCEV – Fuel Cell Electric Vehicle
HEV – Hybrid Electric Vehicle
ICE – Internal Combustion Engine
PHEV – Plug-in Hybrid Electric Vehicle
EV – Electric Vehicle

* Comparison of different types of vehicles *

* 1.4 Block diagram of EV subsystems :

1) Energy source subsystem
2) Electric propulsion subsystem.
3) Auxiliary subsystem.

→ In electric subsystem, driver input is converted into logic signals by an electronic converter, then sent to a power converter to drive the motor, which connects to the transmission and differential systems.

→ Energy source subsystem features an Electronic management unit (EMU) that manages energy flow between the battery and power converter, while an auxiliary power supply energizes other vehicle components.

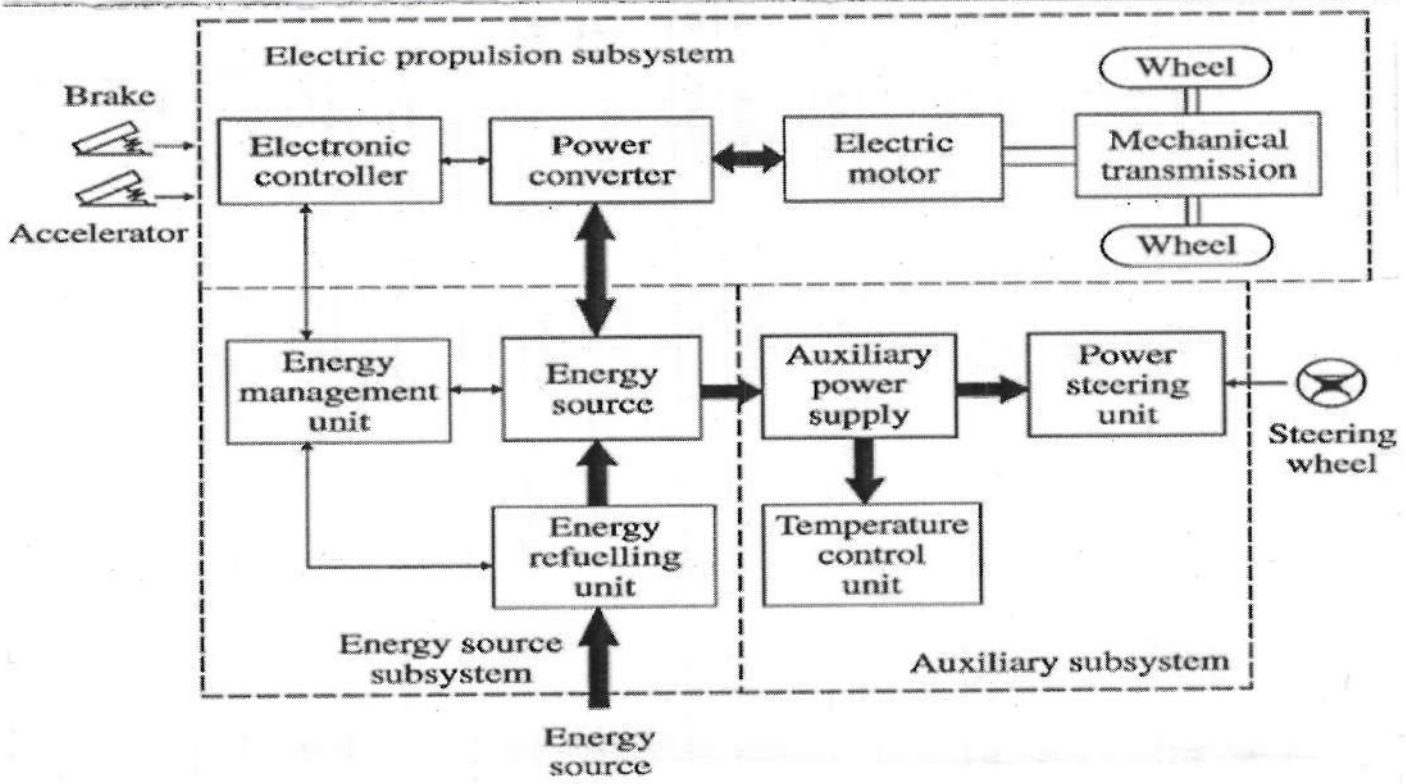


Fig. Block diagram of EV subsystem

* 1) Energy source subsystem :- The energy source subsystem is ~~responsible~~ responsible for storing electrical energy and supplying it for propulsion and ~~as~~ auxiliary functions of the electric vehicle.

It consist of following components :-

a) Battery Pack :- It is a energy storage unit in EV and made up of lithium ion cells.

b) Battery management system :- monitors and manages battery parameters

such as voltage, temperature and state of charge. This ensures safe operation of battery.

c) Charging port and on-board charger :-
Used to charge battery from external power source and on board charger converts AC input into DC output.

d) dc-dc converter :-
The DC-DC converter steps down high voltage o/p of battery to lower voltage level.

2) Propulsion subsystem :→ The propulsion subsystem converts the electrical energy received from the battery into mechanical energy to propel the vehicle. The main components of this system is as follows :-

a) Electric motor :- converts electrical energy into mechanical torque. Commonly used types are induction motor and pmsm motor.

b) Power Controller :- Converts DC supplied by battery into AC.

c) mechanical Transmission :- Transfers the mechanical power generated by the motor to the drive wheels.

d) Braking system :- Regenerative braking system converts kinetic energy produced during braking back into electrical energy and store it in the battery use.

3) Auxiliary subsystem :-

Auxiliary subsystem includes all supporting systems that enhance the vehicles efficiency, control and passenger comfort.

1) HVAC system :- maintains a comfortable and safe cabin temperature of passengers.

2) Lighting and Signaling systems :- Improves visibility & help communicate the drivers intentions to other road users.

3) Infotainment system provides ϕ information and entertainment for both driver and passengers.

4) Power steering & Brake Assist :-
Provide electric assistance for steering and braking, making vehicle control easier and safer for the driver.

QUESTION BANK/ASSIGNMENT -01

Course & Code: EE-5K **Semester:** Fifth

Name of Subject: Electrical Vehicle Technology **Subject Code:** 315335

Que. No.	Unit 1 Power Electronics Devices (10 Marks)
1	State the Need of Electric Vehicles (EVs).
2	Differentiate between an Electric Vehicle (EV) and an Internal Combustion (IC) Engine Vehicle.
3	List the Different Types of Electric Vehicles (EVs).
4	Draw the Architecture of an Electric Vehicle (EV) and Explain the Functions of All Its Parts.
5	Draw and Explain a Battery Electric Vehicle (BEV) in Detail.
6	Draw and Explain a Hybrid Electric Vehicle (HEV) in Detail.
7	Draw and Explain a Plug-in Hybrid Electric Vehicle (PHEV) in Detail.
8	Draw and Explain a Fuel Cell Electric Vehicle (FCEV) in Detail.
9	Compare a Battery Electric Vehicle (BEV) and a Hybrid Electric Vehicle (HEV).
10	Compare a Plug-in Hybrid Electric Vehicle (PHEV) and a Fuel Cell Electric Vehicle (FCEV).
11	Draw the Block Diagram of an Electric Vehicle (EV) Subsystem and Explain It.