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 Title: Electrical Vehicle Technology | **Course Abbr.:** EVT | **Course Code:** 315335

Subject Teacher :- Ms. H.A.Badgujar

UNIT-04 – (16 MARKS)

CONVERTERS AND EV CHARGERS

CO Coverage: - Apply the concept of converters and charging system in EV.

Content (Syllabus) :

4.1. Introduction to power electronics used in EV, Block diagram of typical EV: Description and Functions of DC-to-DC Converter, DC to AC Converter, AC to DC Converter (Rectifier) and filters.

4.2. Charging methods: Home charging, Trickle charging, Household AC charging, Public charging (DC Fast charging).

4.3. Charging System: Classification- Wireless, On board and Off board charging, V1G (Uni-directional smart charging), V2B/V2H (Vehicle-to-Building/ Vehicle-to-Home), V2X (Vehicle-to-Everything), V2G (Vehicle-to-Grid, Bi-directional smart charging).

4.4. Charging Stations: Types of charging station, Public charging station: Selection and sizing, components and, single line diagram. Calculation of charging time and concept of battery swapping. Precautions observed while charging.

4.1.1 - Introduction to power electronics used in EV :-

→ Electric vehicles are crucial for sustainable transportation, relying on power electronics for efficiency and reliability.

→ A high voltage DC battery is central to EVs, with power electronics Converters, managing electrical power throughout the vehicle.

→ Inverters Convert DC battery power to AC for the electric motor and revert AC Back to DC during regenerative braking to recharge the battery.

→ Power electronics are Integral to the BMS, ensuring safe battery operation, extending life, and optimizing energy use.

→ A DC-DC Converter reduces battery voltage for auxiliary systems like HVAC and lighting.

→ Advancements in Silicon Carbide (SiC) and Gallium Nitride (GaN) semiconductors enhance power electronics, offering higher efficiency, faster switching, and better thermal management than silicon devices.

→ These innovations lead to improved EV efficiency, faster charging, extended driving range, and advancement in clean transportation.

4.1.2 - Block diagram of typical EV :->

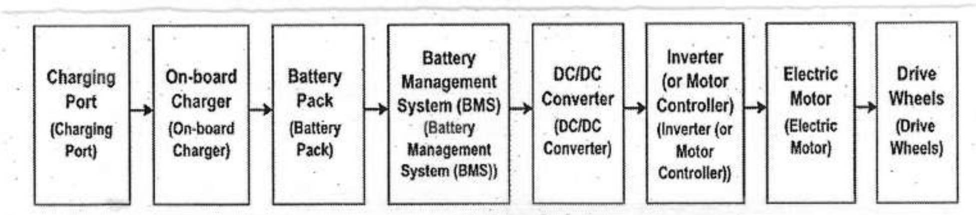


Fig. 4.1 Block diagram of EV.

→ The main components in EV block diagram include the charging Port, on board Charger, Battery pack, BMS, DC/DC Converter, Inverter, Electric motor and Drive wheels.

Function of above components is as shown below :-

1) Charging port :- It is the external interface through which electrical energy is supplied to the vehicle. It can accept AC from standard charging station or DC from fast charge.

2) On-Board Charger :- when vehicle is charged using AC, the onboard charger converts that AC power into DC power, which is suitable for high voltage battery.

→ It regulates voltage and current during charging to ensure safe and efficient charging.

3) Battery Pack :- The battery pack is the primary power storage unit of an EV, typically made up of lithium-ion cells. It stores the electrical energy required to drive the vehicle and provides a high-voltage DC output ~~voltage~~ used to power electric motor.

4) Battery Management System :- The BMS monitors and controls the efficiency and health of battery, ~~battery~~ it tracks voltage, current, temperature and state of charge (SOC) to ensure safe operation, protecting the battery pack from overcharging, deep discharging & overheating.

5) DC/DC Converter :- This component converts high voltage DC from the main battery pack into a lower voltage (i.e. 12V) to power vehicle accessories like lighting, infotainment, and electronic Control units.

6) Inverter Controller Unit :- The inverter transforms DC electricity from the battery into AC for AC motors or Adjusts it for DC motors, regulating speed & torque according to the accelerator pedal input.

7) Electric motor :- The electric motor converts the electrical energy received from the inverter into mechanical power. It acts as the primary propulsion device, converting electrical energy into rotational motion.

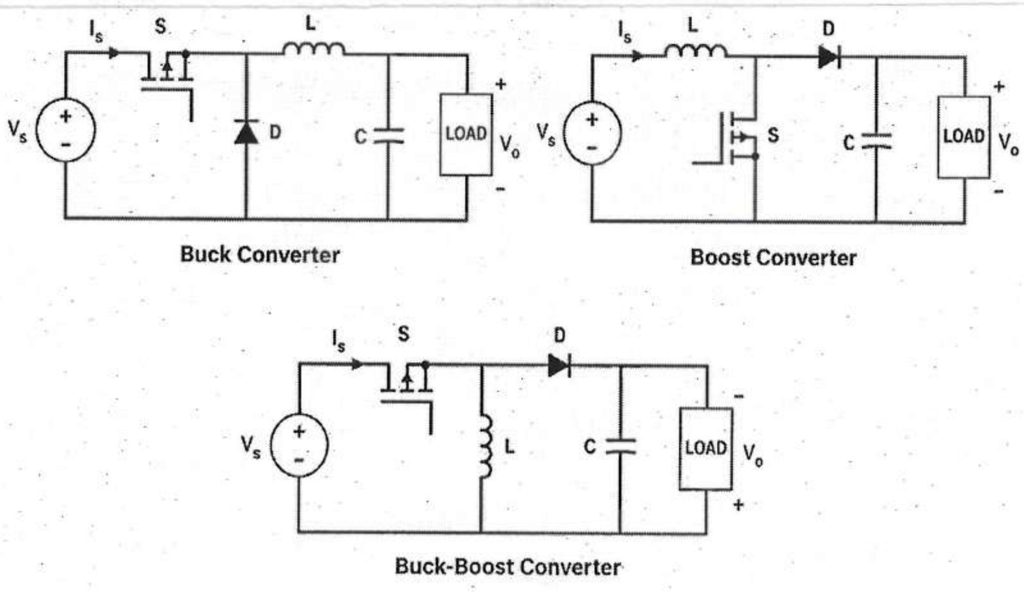
8) Drive Wheels :- The mechanical power generated by the electric motor is transmitted to the drive wheels, moving the vehicle forward and backward.

→ Depending on the design some EV's use a single motor to drive the wheels, while others use dual or multiple motors. for enhanced efficiency and control.

* 4.1.3-01 - Description and functions of DC to DC converter)

→ A DC-DC converter is an electrical or electronic circuit that Converts a DC voltage from one voltage level to another According to the requirements of the circuit.

→ It is used in low voltage applications (such as battery powered devices) as well as in high-voltage (HV) power transmission systems.



→

Fig. Types of DC-DC Converter.

→ DC-DC converter use switching techniques to change DC voltage levels.

→ The output voltage can be adjusted to be either higher or lower than the input.

→ Energy is temporarily stored during conversion in :
  1) Inductors & transformers (magnetic field)
  2) Capacitors (electric field)

→ This stored energy is essential for generating the desired output voltage.

→ Switching based conversion is more efficient than linear methods, minimizing energy loss as heat.

→ These converters are compact and energy efficient, utilizing high speed semiconductor devices for rapid switching.

→ A careful circuit layout is important to reduce switching noise & losses.

→ Field effect transistors (FET's) are preferred for switching due to their low ON Resistance & quick switching, improving efficiency and extending battery life in portable & electric systems.

2) DC to AC Converter :-

→ DC to AC converter is necessary in electric vehicles (EVs) to transform the direct current (DC) from the battery into

Alternating Current (AC) for the traction motor.

→ Most EV traction motors requires AC ~~Motor~~ power, making the conversion vital for vehicle propulsion.

→ The power output of the DC to AC Converter is aligned with the motors power rating, typically between 30kw and 400kw, based on the vehicle's size and performance needs.

→ Most EV's utilize one or two DC to AC Converters, but advanced designs with in wheel motor systems necessitate a seperate Converter for each motor.

→ This setup allows for independent wheel control, enhancing traction, handling & overall vehicle stability.

* AC to DC Converter and filters :-

→ In electric vehicles, the AC to DC Converter is an essential part of the On Bard charger (OBC) system.

→ It's primary function is to convert the alternating current (AC) received from an external power source (home power outlet) into Direct current (DC), which is then used to charge the vehicles high voltage battery.

→ AC-DC converter has following components :-

1) Rectifier - Converts AC-DC
2) Filters - smoth the rectified DC output by reducing the voltage ripple.
3) DC-DC Converter :- Regulates and controls the ~~regulated~~ required DC voltage level.
4) Control Circuitary :- Ensures safe & efficient battery charging by monitoring and controlling the charging process.

* Main functions of AC to DC converter in EV's :-

1) AC-DC converter :- Converts AC power to required DC for Charging
2) Voltage and current control :-
Regulates output DC voltage and current based on the battery management system (BMS) requirements.
3) Power factor Corrections :-
Enhances power quality, reduces losses and minimizes harmonic distortions for efficient power draw from the electrical grid.

4) Charging safety and communication :- Collaborates with vehicle control systems to monitor battery condition, temperature, and charging status for safe & reliable charging.

* 4.2 Charging Methods *

→ Electric vehicles can be charged using various methods based on power, speed and location.

1) Trickle Charging :- Utilizes a 120 V household outlet, taking over 20 hrs for a full charge.
2) Home charging :- often combines Trickle charging and faster household AC charging using a 240 V, Level 2 charger, enabling overnight full charging.
3) Public charging stations :- Provide DC fast charging, delivering high power DC directly to the battery, reducing charging time to under one hour, depending on the vehicle and charger capacity.
4) Each method balances convenience, cost & charging speed based on user needs.

* Home Charging Station :-

→ Home charging is most common and convenient method of charging an electric vehicle (EV). Allows EV owners to recharge their vehicles at home using the residential electrical supply.

→ Home charging can be carried out by Level-1 charging or Level 2 charging

* Level-01 Home charging (Slow Charging)

→ Uses a standard 120 V AC household outlet (North America) or equivalent domestic supply.

→ Requires no special charging equipment.

→ full charge takes 20-40 hours, depending on the battery capacity.

→ suitable for -

1) short travel distance.
2) PHEV's
3) Emmergency or occasional charging.

* Level-02 Home charging (fast charging)

→ Uses a dedicated 240 V AC supply.

→ Requires installation of a level 2 EV charging station.

→ full charge generally takes 4-10 hours.

* **Advantages** :-

1) Uses household 220 V plug - additional installation is not required.
2) Portable & suitable for emergency or occasional charging.

* **Disadvantages** :-

1) Charging speed is slow.
2) Not suitable for daily use.

2) Trickle Charging :-

→ In electric vehicles (EV's), trickle charging specifically refers to level-1 charging - plugging the vehicle directly into a standard 120V household wall outlet (or 230V standard outlet depending on your region)
→ Very slow charging and no special equipment or EV charger is required.
→ Typically used in emergencies or when no other options are available.
→ Does not require high current, hence safer & more accessible.
→ Not suitable for fully recharging large battery packs.
→ Prolonged use may not be ideal for long term battery health due to in efficient charging cycle.
→ Time required for full charging 20^+ hours.

3) Household AC Charging :-

→ For household charging, the AC wall box is the recommended option, connecting to a dedicated 230V outlet and charging 3 to 4 times faster than trickle charging, depending on the EV's acceptance
→ rate & charger specification.
→ Suitable for overnight charging; a 40 kwh battery EV takes about 6 hours for a full charge.
→ Installation requires a ~~full charge~~ professional electrician to set up a dedicated circuit & charger unit.
→ Ideal for homes with garages or driveways for safe wallbox mounting.
→ Financial incentive or subsidies may be available in many regions to lower costs for purchasing and installing a wall box.

* Advantages :-
1) Charges 3 to 4 times faster than trickle charging.
2) Highly convenient for daily use and overnight charging.
3) Fully charges a 40kwh battery in about 6 hours.
4) Subsidies or incentives may be available for installation costs.

* Disadvantages :-
1) Requires professional installation.
2) Requires dedicated space like a garage or driveway for the wall boxe.

* 4) Public Charging - DC fast charging method :-

→ Growth of extensive charging networks in cities & enhances the convenience of public charging stations for ev owners.
→ Public charging allows for easier long-distance travel.
→ charging options include AC charging via wall boxees and DC fast charging, both of which are faster than standard household charging.
→ AC public charging can be 3 to 10 times faster than household AC charging, depending on the stations power output and the EV's AC charging capacity.

* DC Fast chargers :-

→ DC fast charging is the fastest method for charging EV's, providing over 50kW of power.
→ stations operate at voltages exceeding 450V and currents upto 125A.
→ charging an EV battery from 20% to 80% takes about 40 minutes, which is efficient for long trips.
→ most DC fast chargers use the combine Charging System (CSS) or combo DC standard for compatibility with various EV models.
→ High speed charging may accelerate battery degradation and shorten the lifespan of high voltage batteries.
→ For daily use, slower AC charging is typically prefered.

* Advantages :-
1) Extremely fast charging.
2) Ideal for long distance travel.

→ Easily available in cities and along highways.

* Disadvantages :-

1) Frequent use accelerates battery degradation and reduces battery lifespan.

2) More exepensive than household charging.

3) Long ques for charging during peak hours.

4.3 Charging System: Classification

1) Wireless Charging :-

→ Wireless charging (Inductive charging), allows electric vehicles (EV's) to charge without a physical cable.

→ This system transmits electrical energy via electromagnetic fields from a ground-installed a charging pad to a receiver coil under the vehicle.

→ This system operates on the principle of electromagnetic induction and consists of two main components.

→ a) Ground - Based charging pad.

1) Connected to electric power supply
2) Generates an alternating electromagnetic field.
3) Transfers energy wirelessly to the vehicle.

b) Vehicle Receiver Coil

1) Installed on the underside of EV.
2) Receives the electromagnetic energy from the charging pad.
3) Converts the received energy back into electrical current to charge a ~~bat~~battery.

* Advantages :-

1) Convenience :- No need to plug in a charging cable; simply park the vehicle over the charging pad to start automatic charging.

2) Safety :- Eliminates the risk of electric shock and accidents to charging cables.

3) Durability :- Reduces wear & tear from frequent plugging & unplugging of charging connectors.

4) Weather Resistance - The absence of exposed connectors minimizes

the impact of rain, dust and moisture.

* Disadvantages :-

1) Lower efficiency :- Wireless charging has higher power losses compared to wired methods and typically requires more time to charge.
2) Higher Cost :- The costs associated with installation and equipment for wireless charging are relatively elevated.
3) Alignment sensitivity :- For effective power transfer, the vehicle must be precisely positioned above the charging pad.
4) Limited Availability :- The infrastructure for wireless charging is still developing & is not yet widely accessible.

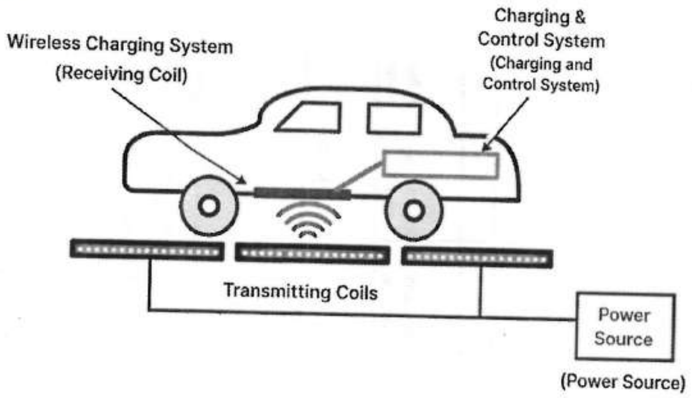


Fig No 4.6 Wireless Charging System

2) On ~~Boarding~~ Board Charging :- On board charging is a charging where AC to DC converter is fitted inside the vehicle. This setup allows an EV to be charged directly from an AC power source, such as a household plug or a public AC charger.

1) The EV is connected to an external AC power supply.
2) The on-board charger converts AC electricity into DC power, which is suitable for the vehicles battery
3) The charging speed depends on the capacity of the on board charger.

* Advantages :-

1) Charging can occur from normal AC outlets or AC public chargers
2) Simplified infrastructure due to AC-DC conversion within the vehicle.
3) Easy charging availability wherever AC power exists.

* Disadvantages :-

1) On board charger typically limited to 3.3kW to 22kW, restricting fast charging.

2) Increased weight and cost due to the installation of the charger inside the vehicle.

3) off board charging :-

→ off board charging is a system where AC-DC conversion occurs outside the vehicle, mainly in charging stations, particularly for DC fast charging.

→ Process :-

1) The EV connected to a DC charging station.
2) The station converts AC-DC power, supplying it directly to the EV battery.
3) Enables high power delivery, significantly reducing charging time.

* Advantages :-

1) Utilizes high capacity DC fast charging.
2) Reduces the EV weight & cost by eliminating the on board charger.
3) Suitable for public fast charging needs.

* Disadvantages :-

1) Requires costly & complex infrastructure for charging stations.
2) EV must be compatible with DC fast charging standards.

4) VIG - Unidirectional Smart charging :-

→ VIG or Unidirectional smart charging, allows electricity to flow solely from the grid to the electric vehicle (EV) during charging process.

→ It differs from bidirectional systems in that it does not permit return flow of electricity from the EV to the grid or other loads.

→ Smart charging technology in VIG manages the timing & rate of charging influenced by :

1) Grid demand and electricity prices.
2) Availability of renewable energy sources.
3) User preferences & battery status.

→ Communication between the EV charger and the grid enables VIG systems to adjust charging rates, slowing down during high grid demand and increasing during periods of abundant renewable or off-peak hours.

* Advantages :-

1) Grid friendly charging :- Controls EV charging to reduce grid load and prevent peak demand spikes.

2) Cost saving :- Enables users to benefit from lower electricity rates during off peak times or high renewable energy generation.

3) Simpler infrastructure :- Lower implementation costs due to unidirectional electricity flow.

4) Supports Renewable energy generation to increase green energy use.

* Disadvantages :-

1) No Energy Export :- lacks flexibility as electricity can not be sent back to the grid or other load.

2) Limited grid services :- Can only manage load timing, excluding participation in services requiring power export like energy storage or demand response.

* V2B/V2H - Vehicle to building / Vehicle to Home :-

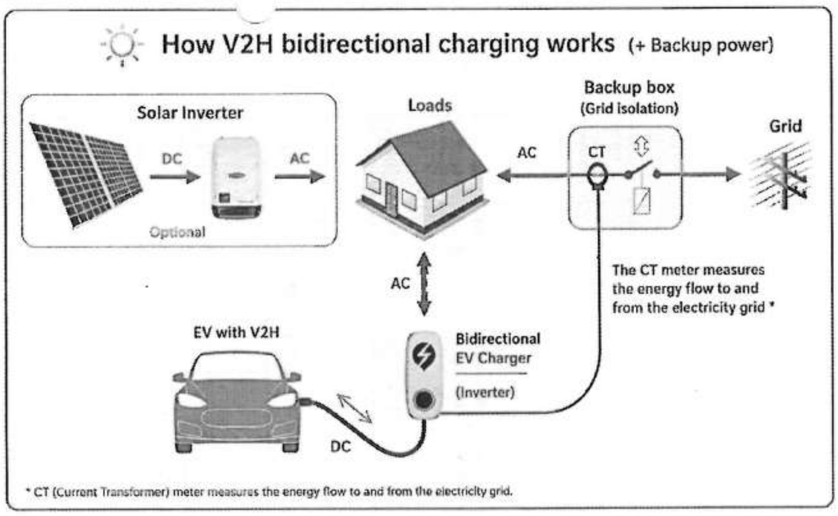


Fig No 4.8 V2H-Vehicle-to-Home

→ Vehicle to Home (V2H) allows electric vehicles (EVs) to serve as a mobile battery for household consumption, in contrast to vehicle to grid (V2G), which sends electricity to the grid.

→ V2H enhances energy self-sufficiency, especially when paired ~~whe~~ with rooftop solar systems.

→ key benefits include providing backup power during blackouts, ensuring essential household needs are met.

* Requirements for V2H :-

1) Bidirectional charger :- Enables electricity flow to and from the home.
2) Current transformer (CT) meter :- monitors electricity flow, allowing the system to manage discharge from the EV battery when the home draws from the grid and charge the battery using excess solar energy.

* Backup power and islanding :-
1) For backup power, V2H necessitates islanding, isolating the home from the main grid to ensure safety and prevent back-feeding.
2) A bidirectional inverter functions as an off grid power source once islanding is activated.
3) Automatic Transfer Switch (ATS) or Contactor is needed for the automatic transition to the back up power system, This setup is similar to

* Advantages :-

1) Provides electricity during grid outages, enhancing security & reliability.
2) minimizes grid reliance and can decrease electricity bills by Utilizing energy stored in EV batteries.
3) Enables storage of excess electricity from solar arrays in EV batteries.
4) lower peak demand & reduces overall costs by decreasing grid usage.
5) local discharging of electricity from EV's alleviates stress on the electrical grid.

* Disadvantages :-

1) High initial setup cost
2) Limited Compatibility
3) Battery degradation.
4) System is complex.

* Vehicle to Everything :-

→ Vehicle to everything (V2X) refers to the ability of electric Vehicles (EVs) to exchange energy and information with external systems.

→ This technology allows for more than just electricity supply, it facilitates smart energy management by connecting EVs

→ This technology allows for more than just electricity supply, it facilitates the smart energy management by connecting EV's to the grid, homes, loads, other vehicles and infrastructure.

→ V2X - Compatible vehicles use bidirectional chargers and advanced communication protocols to manage the flow of electricity & data.

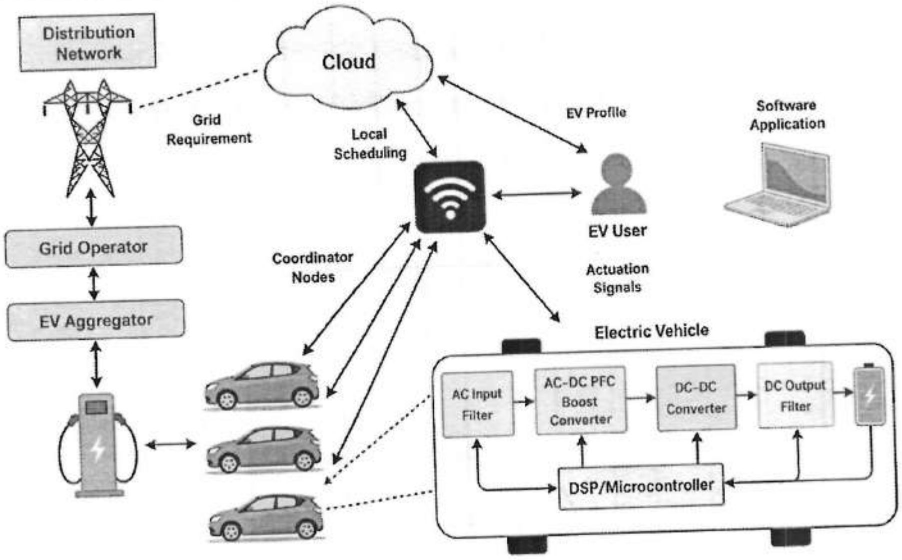


Fig. No. 4.9 V2X Vehicle-**to-Everything**

* Practical Applications of V2X :-

1) Enhances energy efficiency & grid residence.
2) Enables dynamic demand response and peak load management.
3) Provides backup power for homes or critical infrastructure during emergency situations.
4) Facilitates V2V communication - making roads safer and more efficient.

* vehicle to grid,

Bidirectional smart charging

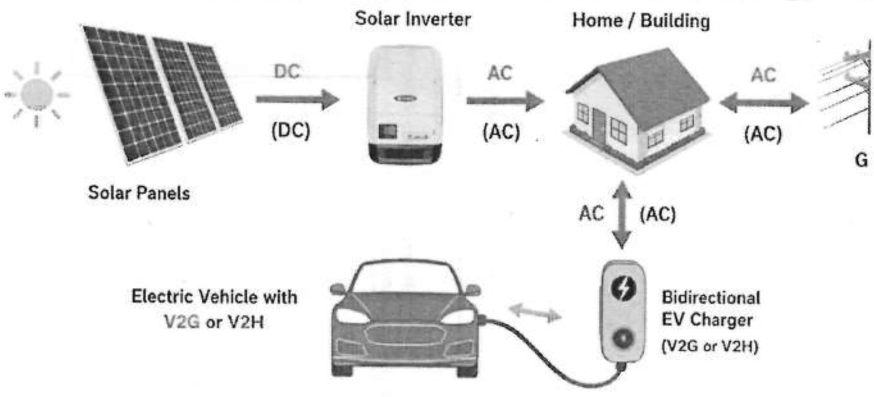


Fig. No. 4.10 vehicle to grid (V2G)

→ Vehicle to grid (V2G) technology allows energy from an electric vehicles (EV) Battery to be directed to the electricity grid based on specific service agreements.
→ Participation in V2G requires a bidirectional DC charger & EV's capable of both charging & discharging; financial incentives include bill discounts and credits.
→ EV owners can engage in Virtual Power Plant (VPP) programs, where aggregated electricity from multiple EV supports grid stability during peak demand.
→ Collective capacitive of many EV's has the potential to transform the power grid, reducing reliance on costly peaking power plants & fossil fuels.
→ Widespread V2G adoption is hampered by regulatory issues, such as the need for bidirectional chargers to adhere to stringent (strict) safety standards and the absence of uniform protocols.

* Advantages :-

1) Grid stability.
2) Financial Incentives.
3) Clear Energy Grids.
4) Efficient Utilization of EV battery.
5) Transformation of the power system.

4.4 Charging Stations *

4.4.1 Types of charging stations :-

1) Level 1 Charging Station :- It is most basic form of EV charging. It uses a standard 230V AC household socket.
a) Power output = 1.3 to 2.4 kw.
b) Charging time - 8 to 20 hrs.
c) Applications :- Suitable for charging at home or office.
d) Advantages - No additional installation needed.
e) Limitation - slow charging.
f) Suitable for users with short daily commutes.

2) Level-2 Charging Station :- Level 2 charging operates on 208-240V AC and provides significantly faster charging speeds than level 1, It requires dedicated charging equipment & professional installation.

→ Power output = 3.3 to 19.2 kw.
→ charging time = 4-8 hrs for full charge.
→ Applications - Homes, offices, public parking lots and commercial Complexes.
→ Advantages - Faster than Level 1, suitable for both residential & commercial use.
→ Limitations - Requires a dedicated circuits and professional installation.
→ Suitable for most widely used public charging station type.

3) DC fast charging station - Level 3 charging :-
DC fast charging supplies high power DC electricity directly to the vehicle's battery, bypassing the on board AC to DC converter.
→ Power output = 50 to 350+ kW
→ Charging Time - 80% charge in 20 to 60 times.
→ Applications - Highways, transit hubs, fleet depots, fast charging stations.
→ Advantages - Rapid charging, ideal for long distance travel.
→ Limitations - Expensive infrastructure requirements.
→ Suitable - DC fast charges are essential for intercity travel and high utilization commercial EV's.

4) Ultra-fast charging station :- Ultra fast charging is a sub-category of DC fast charging. This system is designed for next generation EVs that support ultra-high voltages of 800 Volts or more.
→ These chargers deliver high power in significantly less time.
→ Power output - 150 to 350+ kw.
→ Charging time - 80% charge in 10 to 30 minutes
→ Applications - intercity travel corridors, EV highways.
→ Advantages - ~~Charging~~ saves time & adds convenience.
→ Disadvantages - Extremely expensive infrastructure requirements.
→ Suitable for Expressways and Premium EV Networks

5) Wireless charging stations :-
Wireless or inductive charging is a system in which power is transferred through electromagnetic fields, from a coil embedded in the ground to a receiver on the underside of the vehicle.
→ Power o/p - 3.3 to 22 kw
→ Charging time - Similar to level 2.
→ Applications - Taxis, Autonomous vehicles, smart cities.
→ Advantages - Convenient, Automatic, Less wear & tear.

→ Disadvantages - Infrastructure cost and Battery ownership issues.

* 4.4.2 - Public Charging station :-

→ Public charging stations are vital for increasing electric vehicles adoption.
→ Effective planning, selection and design are required to meet user demand.
→ key considerations for selecting and sizing public EV charging stations include - 1) Efficiency 2) Cost effectiveness 3) Convenient user expeeience.
→ Ensuring grid stability & safety is also important in the process.

* key Considerations:-

→ User demand and traffic patterns - understand expected EV users, vehicle types (2w, 4w, buses) and peak hours.
→ Charging type & power levels - choose level 2 chargers.
→ site & Grid infrastructure :- Evaluate grid capacity, voltage levels.
→ Future scalability - Design for modular expansion to accomodate future EV adoption.
→ Calculate total load - combine rated power of chargers. (e.g. level 2 chargers at 7.2kw plus, 2 DC fast chargers at 50kw equals 128.8kw)
→ Apply Diversity factor :- Use a diversity factor (0.7 to 0.9) to avoid oversizing.
→ Back up & energy storage :- Consider integrating battery storage or generators for unintrupted service.

* Components of charging station :-

1) Grid utility connection :- Primary source for the EV charging station.
2) Transformer :- oil cooled or dry type
3) Main Distribution Panel :- Electricity coming from the transformer enters this panel.
4) Energy meter - Accurately measures the total electrical energy consumed by charging station.
5) Protection Devices - (OCPD) Prevents short circuits and overloads.
6) EV charging units - This serves as main operational system of charging station.
   → Level 2 AC chargerrs - upto 240V & 22kw.
   → Level 3 DC fast chargers - 50kw to 350+kw.
7) Charging cable and connector :- Connects the charger directly to the vehicle.

→ Connector types - Type 1 (North America, AC)
- Type 2 (Uropian AC)
- chademo - Japanese DC fast charging standard.

8) Communication Netork - Used for remote monitoring, software updates, and payment processing.

* Single Line Diagram :-

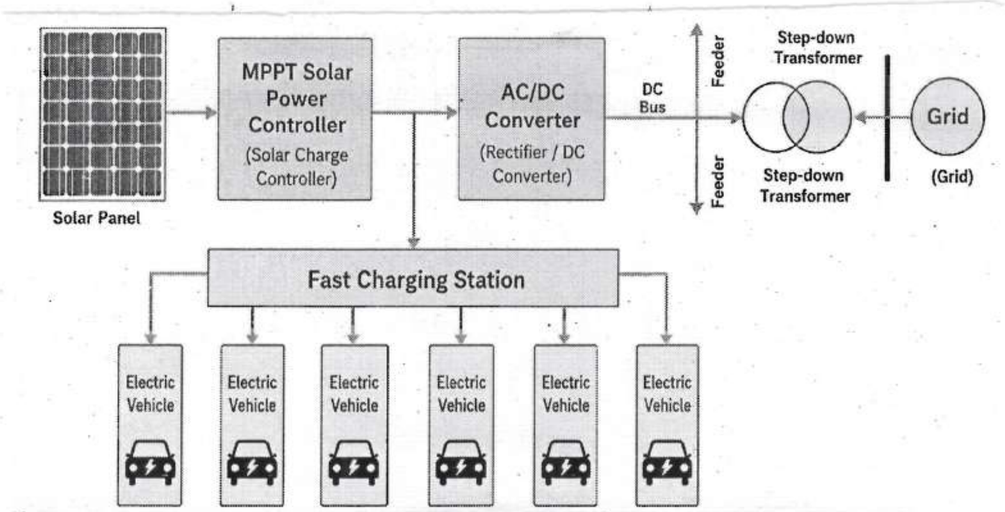


Fig. Single Line Diagram.

→ Electricity flow direction is shown in the system - starting from grid or transformer

1) Grid supply / on site transformer :-
11kv high voultage electricity supply is converted to a lower voltage level such as ~~at~~ 415 V, using stepdown transformer.

2) main distribution panel (MDP)
The MDP contains circuit breakers and protective devices that keeps the system safe and provide fault isolation when required.

3) EV Charger Distribution Panel :-
The electricity coming from the main distribution panel is supplied to the EVDP, from where it is distributed to multiple EV chargers.

4) AC/DC Chargers :-
Each charger is connected to the EVDP. It includes internal protection, metering & ~~a~~ a control system, which manages the charging process according to the vehicles charging requirements.

* 4.4.3 - Calculation of Charging Time *

charging time is a fundamental aspect of operating an Electric vehicle. It is important for user convenience as well as for planning charging infrastructure.

* key parameters affecting charging time :-

1) Battery capacity
2) charging Power
3) 1) Level-1 - Approximately 14.4 kw.
   Level-2 - Approximately 3.3kw to 19.2kw.
   Level-3 - (DC fast charging) - 50 kw, and in some cases more than 350kw.
3) charging efficiency :-

* Formula to calculate charging time :→

charging Time (Hours) = Battery capacity (kwh) ÷ [charging Power (kw) × charging efficiency]

* sample calculation :-

→ Given data :

1) Battery capacity = 60 kwh.
2) Charging power = 7 kw.
3) charging efficiency = 90% ≈ 0.9 (in fraction)

∴ Charging Time. = 60 ÷ (7 × 0.9) = 9.52 hours.

Therefore, it with take approximately 9.5 hours to fully charge the EV battery.

* Additional factors influence the charging time :-

1) Initial state of charge.
2) Battery charging characteristics.
3) Ambient temperature & battery health.
4) vehicle onboard charger limits.

* Concept of battery Swapping *

Battery swapping is an innovative alternative to conventional EV charging methods. In this system, a discharged battery is removed from the vehicle and replaced with fully charged battery.

→ The battery can be charged seperately, allowing quick vehicle service with minimal downtime.

→ This process enhances the operational efficiency.

→ Battery swapping is ideal for two wheelers (2ws) & three wheelers (3ws) due to smaller, lighter batteries.

→ four wheelers and electric buses face challenges in battery swapping because of larger, heavier batteries.

→ modern solutions are in development to address these challenges.

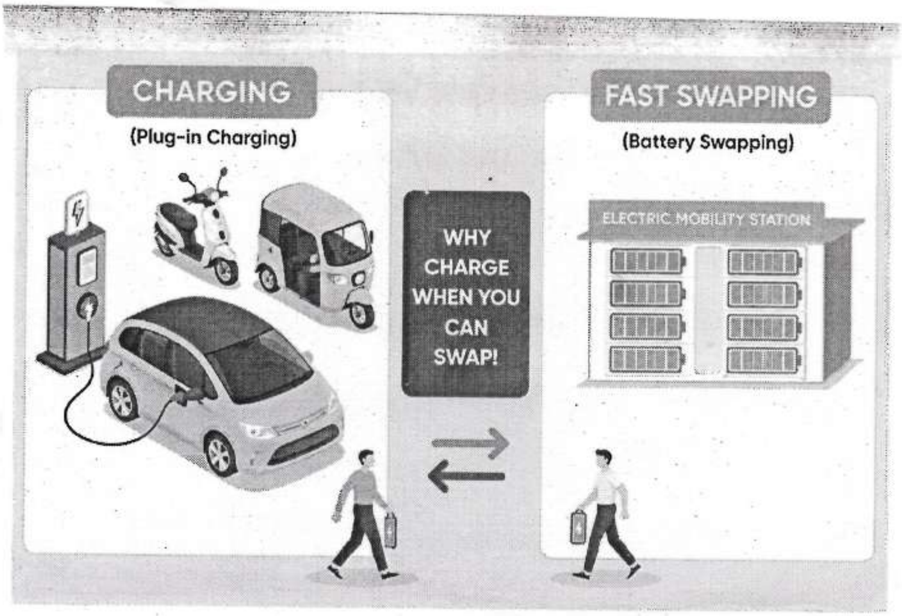


Fig. 4.12 - Battery swapping.

* Three main advantages of battery swapping :-
1) Faster than traditional charging methods (charging time reduced)
2) Battery swapping occupies less space (space reduced)
3) efficient use of swapable batteries can decrease the need for extensive charging infrastructure (cost reduced)

→ overall battery swapping is a promising solution for overcoming some of the limitations of conventional EV charging.

* Precautions Observed while Charging *

* Important safety precautions to be followed during EV are as follows :-
1) Use certified & compatible charging equipment.
2) Regularly inspect charging & connectors
3) Ensure a dry and well-ventilated environment.

4) Avoid Overcharging & Prolonged charging periods.
5) Refrain from Using extention Cords or Adapters.
6) Be mindful of Ambient temperature conditions.
7) monitor the charging process
8) Beprepared for emergencies.

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QUESTION BANK/ASSIGNMENT -01

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

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

Que. No.	Unit 4 Converters and EV Chargers (16 Marks)
1	Define a DC-DC converter and state its function in an electric vehicle.
2	Describe the role of filters in EV power electronics.
3	Draw and label the block diagram of a typical electric vehicle.)
4	Calculate the charging time for a 60 kWh battery using a 7.5 kW charger.
5	Compare trickle charging and DC fast charging in terms of time and energy efficiency.
6	State the difference between on-board and off-board charging systems in EVs.
7	Evaluate the benefits and challenges of using V2G (Vehicle-to-Grid) technology.
8	List the safety precautions required during the public charging of electric vehicles.
9	Design a basic layout of a public EV charging station.
10	List types of EV charging methods.