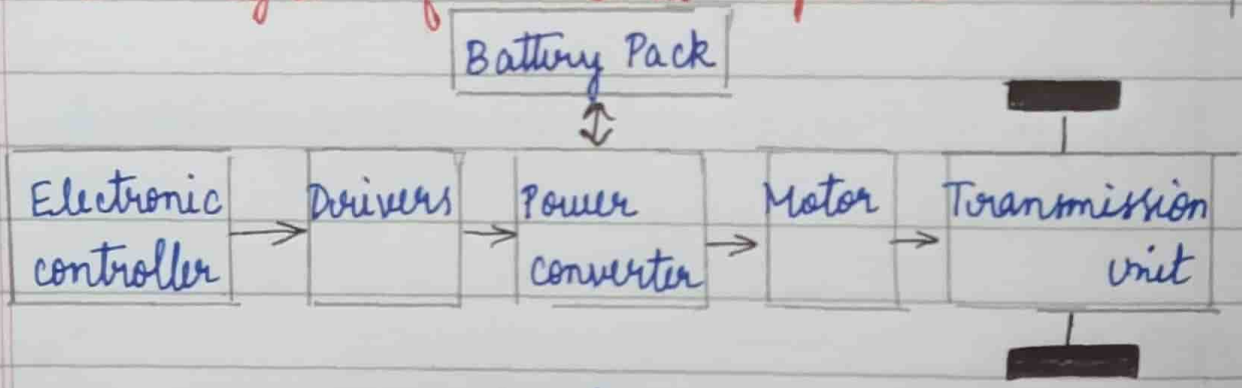
UNIT-III

- **Fundamentals:**
  - EVs → BEV (Battery electric vehicle)
    → PHEV (Plug in hybrid electric vehicle) → fuel (Gasoline)
  - Regenerative braking system - kinetic energy is not lost
  - More efficient than conventional vehicles
    ↳ As there is no tailpipe emissions
    ↳ Minimal maintenance

1. **Block diagram of EV and its components :- (6 M)** (Repeated)



- The major components of EV are :-
1. Battery
2. Electronic controllers
3. Drivers
4. Power converter
5. Motor
6. Transmission unit

1. **Battery:**
Batteries are the most important component of EV as it determines its weight, performance of EV, cost,

driving range
- The batteries are rechargable

2. Electronic controller:
- It moniters and controls all the functions of EV.
- It is a computer based system that has the main function ets of optimizing charge and energy output of the batteries.
- It increases the maximum operating range, improves the performance of EV.
- It can also predict the available range by the current state of the battery charge.

3. Drivers:
- A gate driver is a circuit accepts low-power input from electronic controller.
- Produces the appropriate current to drive the power converter.

4. Power Converters:
- Power converter modulates flow of power from battery pack to the motor in such a way that the motor is imparted with speed-torque characteristics which is required by the load.
- During certain operations like starting, braking.

speed reversal it restricts the current within some values.

- These converters allow bidirectional flow of energy.

5. Motor:

- The electric motor is used as a prime mover in EV.
- Its function is to convert the energy stored in battery to mechanical motion.
- This motor should have high starting torque to ensure quick acceleration.
- The output power of motor is delivered to the wheels through a transmission unit.
- Brushless DC Motor, Permanent Magnete synchronous motor, Three phase induction motor, Switched Reluctance motors are some examples of the motors used in EV

6. Transmission Unit:

- Transmission unit also called as gear box is a mechanical device that uses gears to change the speed or direction of rotation in a EV.
- Many transmission use multiple gear ratios but some transmission use single fixed gear ratio.
- In a EV transmission could be manual, semi automatic or fully automatic.

2. Brushless DC motor

i) Features which make them ideal for EV (4 Marks)

ii) Working of BLDC (6 Marks)

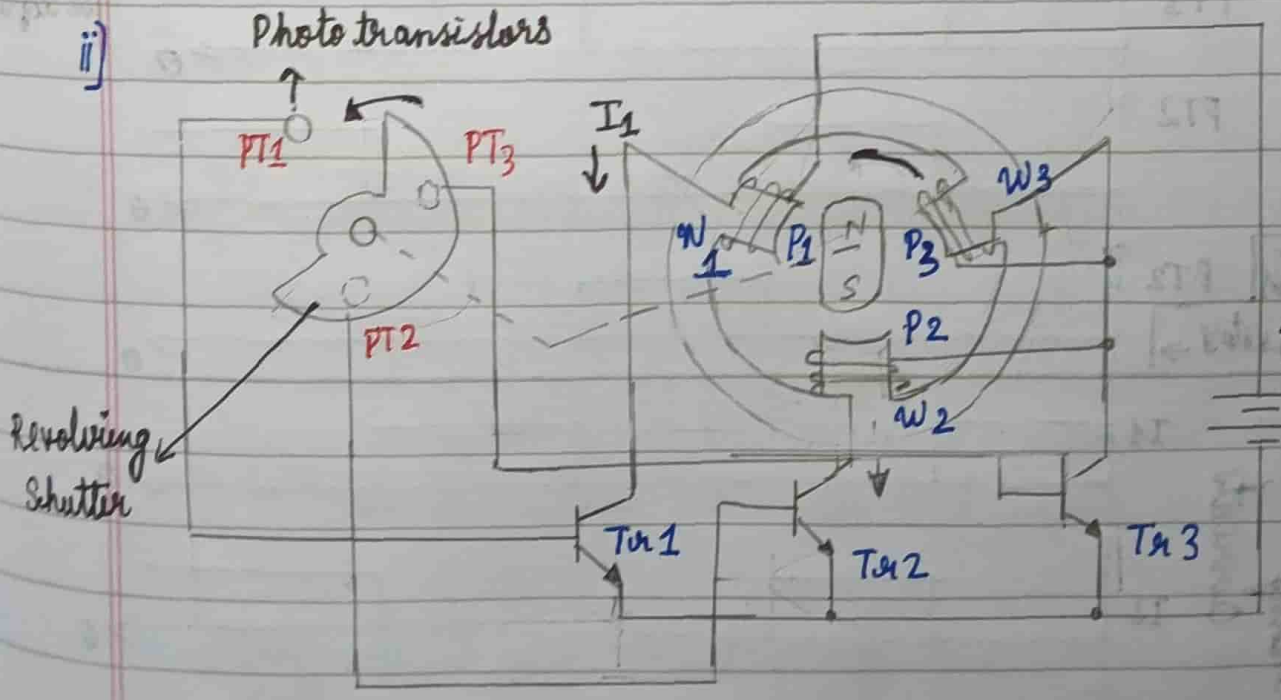
i] • BLDC motors posses high starting torque which is crucial for accelerating EV.

• The efficiency of BLDC is about (95-98%) (high efficiency) so it translates better energy utilization for longer driving ranges with reduced energy consumption.

• Due to absence of brushes and a commutator, BLDC motors require less maintenance.

• BLDC motors are well-suited for designs that demand high power output relative to their size and weight

ii]



→ A BLDC motor has a permanant magnet rotor and a stator with windings.

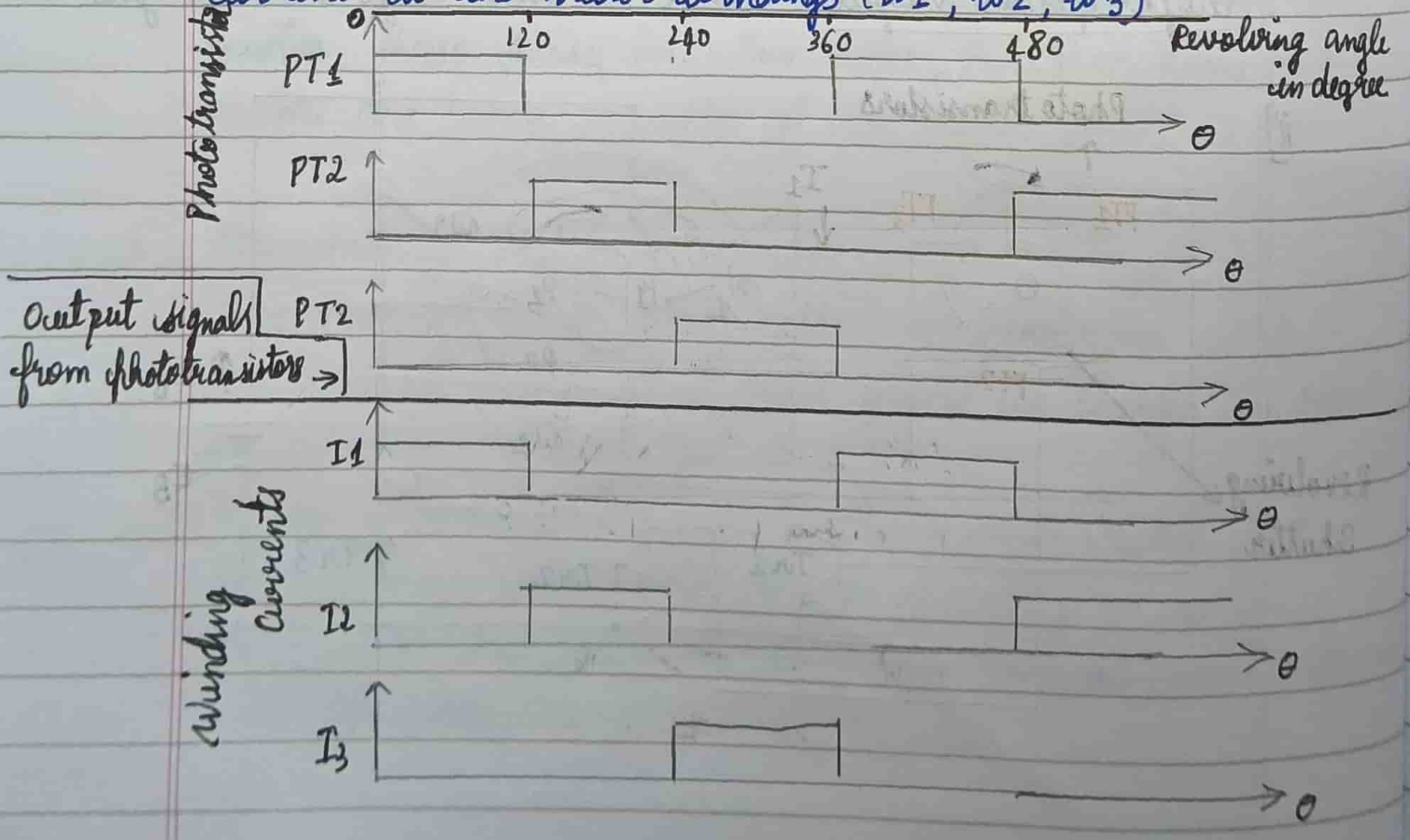
→ To determine the rotor's position a optical sensor is used.

→ This sensor consists of a light source, three phototransistor (PT1, PT2, PT3) mounted 120 degrees apart, and a revolving shutter attached to the motor shaft.

→ As the rotor rotates, the revolving shutter alternatively blocks and exposes the phototransistors to light source.

→ This generates a sequence of high and low signals from the phototransistor.

→ These signals from the phototransistor control the switching of transistors (Tr1, Tr2, Tr3), which in turn direct current to the stator windings (W1, W2, W3)



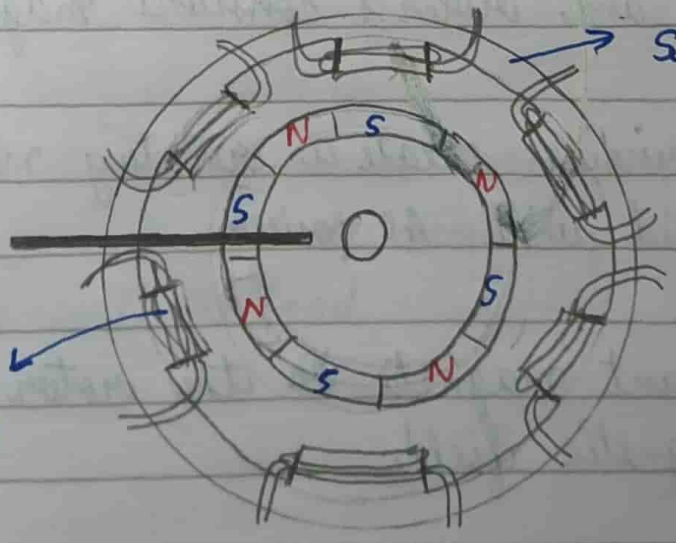
1. Rotor's south pole faces stator pole P2. PT1 detects light, turning Tr1 ON and current flows through W1, (creating a south pole at P1) The rotor moves clockwise

2. Shutter shades PT1, PT2 detects light turning Tr2 ON. Current flows through W2, (creating a south pole at P2) Rotor moves towards P2, W1 is de-energized.

3. Shutter shades PT2, PT3 detects light, turning Tr3 ON. Current flows through W3, (creating a south pole at P3) Rotor moves towards P3, and W2 is de energized.

→ This sequential switching creates a rotating magnetic field, causing the rotor to continously in a clockwise direction.

3. Explain the construction and working of PMSM (6M)



→ Construction of PMSM:

A permanant magnet Synchronous Motor has two main parts.

1. Stator: Similar to an induction motor, it has a laminated steel core with three-phase windings that create a rotating magnetic field when supplied with AC power

2. Rotor: The rotating part with permanant magnets that generate a constant magnetic field.
The magnets can be:
- Surface mounted (SPMSM) Magnets are on the rotor surface
- Interior mounted (IPMSM) Magnets are embedded inside the rotor core

→ Working of PMSM
The PMSM works on the interaction between the stator's rotating field and rotor's constant magnetic field.

1. The stator windings create a rotating magnetic field when supplied with AC power.

2. The permanant magnets on the rotor produce a constant magnetic field.

3. The interaction between the two magnetic fields produce torque, causing the rotor to rotate.

4. The rotor rotates at the same speed as the stator's rotating magnetic field; known as synchronous speed.

4) Switched Mode Power supply

- SMPS uses a switching regulator for efficient electrical power conversion.
- It transfers power from source to load, converting voltage and current.
- SMPS distributes power from DC or AC source to DC loads.
- They are smaller, lighter and more efficient than linear supplies.
- DC - DC converters ~~change~~ are a critical SMPS circuit in power management systems.
- DC - DC converters change DC voltage levels and maintain a constant output voltage.
- Step up and step down converter are common topologies.
- Key components include switches, diodes, inductors, capacitors and the load.

Boost Converter → Step up converter (8M) (Asked once)
Buck Converter → Step down converter
(Refer Notes for explaination)

ii) Applications of SMPS (4M)

i) Personal computers, servers, power stations.
ii) Mobile chargers
iii) Electric vehicle battery chargers
iv) Manufacturing units and factories to provide adjustable power and voltages
v) Security systems, railway systems, airports, etc

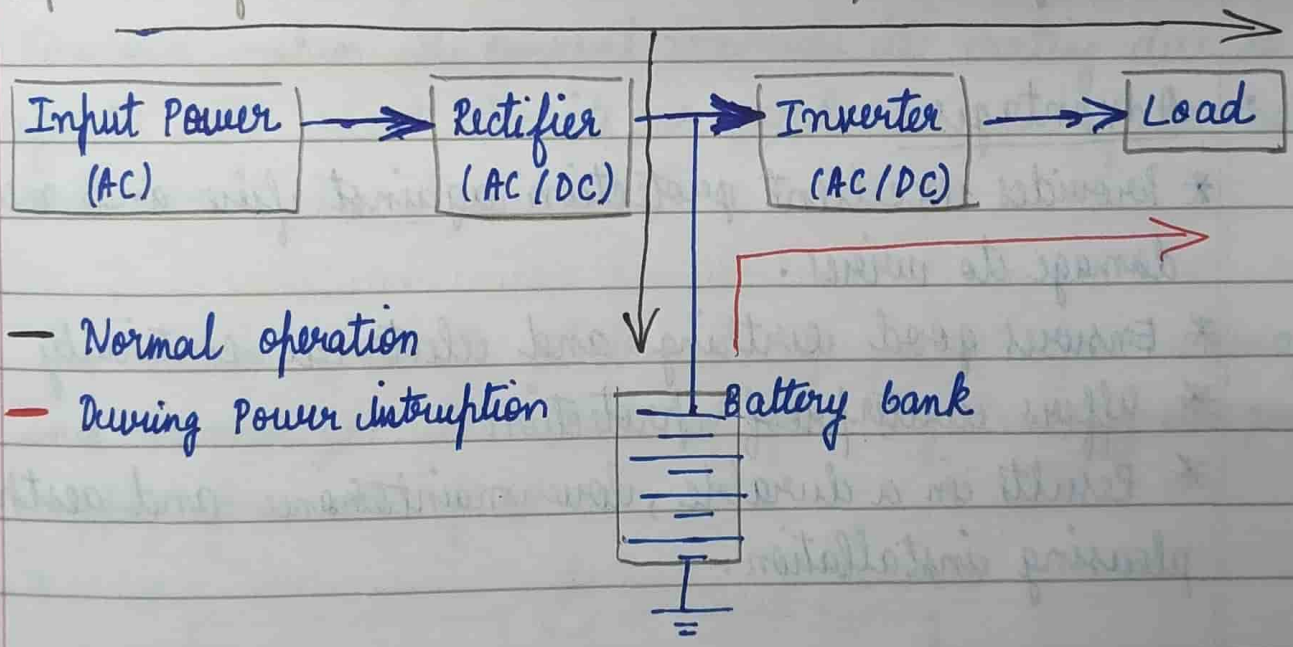
5. i) Discuss the principle operation of UPS (6M)

The principle operation of Uninterrupted Power supply is as follows:

- AC mains power is converted to DC by the rectifier, charging the battery bank and powering the inverter.
- The inverter converts DC power to AC, supplying it to the connected load.
- When AC Mains fails, the battery bank takes over, supplying DC power to the inverter.

- The inverter continues to convert DC to AC, maintaining power supply to the load.
- The UPS ensures a seamless transition between AC mains and battery power.
- This provides continous power to connected devices, protecting them from outages.

(If asked for 8 Marks draw block diagram as well)



ii) Applications of UPS (4M)

i) Computer data centers
ii) Industrial control and monitering systems
iii) Telecommunication systems
iv) Hospitals, banks, insurance offices etc for backup power

6. Domestic wiring (1 or 2M) (never asked so far)

- A network of wires distributing power from the meter board to energy-consuming devices
- Provides efficient power supply for lights, fans, appliances and other domestic uses in residential buildings.

7. What is conduit wiring? Mention its advantages and disadvantages. (4M)

Conduit wiring is a system using metal or PVC tubes to carry insulated conductors, installed on walls or ceilings

- Advantages:

* Provides excellent protection against fire and mechanical damage to wires.
* Ensures good earthing and electrical continuity
* Offers waterproof protection
* Results in a durable, low maintainance and aesthetically pleasing installation.

- Disadvantages:

* Requires skilled labor for proper installation.
* Erection can be time-consuming.
* Risk of short circuits in wet conditions due to condensation inside the conduits.

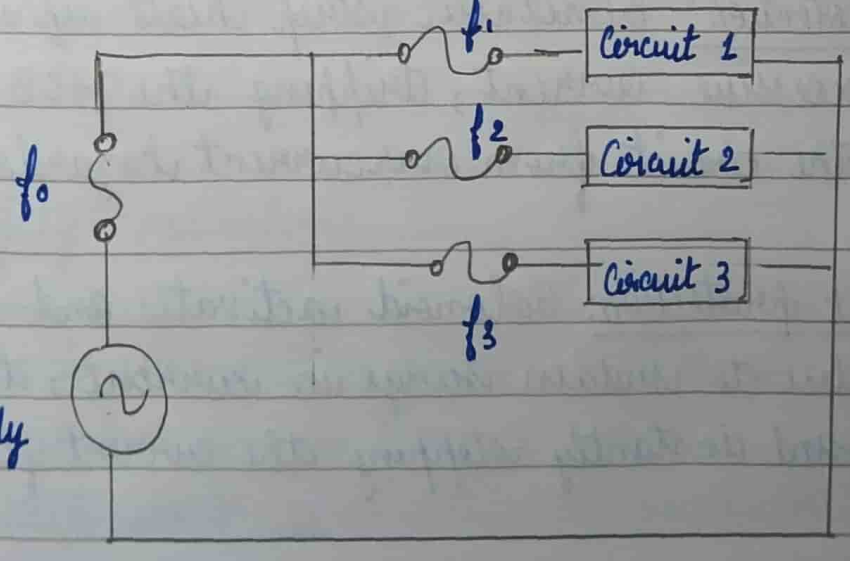
8. i) Note on fuse

- A fuse is a safety device in electrical installations, acting as the weakest link between the power supply and the load.

- It's a short wire made of materials like lead, tin, or their alloys selected for their low melting point and low ohmic losses.

- Under normal operation, it carries the expected current. However, when the current exceeds its rating due to faults like short circuits or overloads, the fuse melts and breaks the circuit.

- This action protects electrical equipment from damage and minimizes the risk of fire by isolating the power supply from the fault.



ii) List the characteristics of materials used as fuse wires (4M)

1. Low melting point - Melts quickly under excessive current, protecting equipment.
2. Low ohmic loses - Minimizes power loss and heat during normal operation.
3. High Conductivity - Allows current to flow easily without excessive heat
4. Low deterioation rate - Resists degradation and oxidation, ensuring reliability

9. Brief note on MCB (4M)

An MCB (Miniature circuit Breaker) is a compact device protecting electrical circuits from overloads and short circuits. It trips when excessive current flows and must be manually reset to restore power.

- Overload Protection: Bimetallic strip heats up and bends due to excessive current, tripping the MCB and protecting the circuit from overcurrent hazards.
- Short circuit protection: Solonoid activates ~~and instantly~~ rapidly due to sudden surge in current, tripping the MCB and instantly stopping the current flow.

MCBs offer advantages over traditional fuses, including manual reset capability and no need to re-wire after fault.

10. i) What is a Electric shock?
ii) Factors affecting its severity
iii) Safety Precautions while working with Electricity.

i) A sudden agitation to the nervous system of body, due to the passage of electric current through human body to ground is called as 'Electric shock'

ii) Factors effecting its severity are:
1. Magnitude of current passed through the body.
2. Path of the current passed through the body.
3. Time for which current is passed through the body
4. Frequency of the current.
5. Physical and Psychological condition of the affected person.

iii) Safety precautions:

1. Check wires for damage and good insulation
2. Test new wiring before use
3. Keep earth connections in good condition.

4. Turn off power before starting work
5. Use rubber gloves and insulated tools
6. Wear rubber soled shoes
7. Use a tester to check for live currents.
8. Don't touch multiple wires at once.

II i) What is earthing? Necessity of Earthing (4M)
ii) Explain Plate earthing (never asked)
iii) Explain Pipe earthing (6M or 8M) Repeated many times

i) Earthing is a wire coming from the ground 2.5 to 3 meters deep from an electrode.

- Necessity of Earthing :

- Provides a safe path for leakage current to flow to ground.
- Protects people from electric shock by minimizing risk
- Triggers fuses or circuit breakers in faulty equipment.
- Safely channels lightning surges to the ground, preventing damage.

ii) Plate earthing :

1. Used in electric substations for good earthing.
2. Earth plate made of copper (60 X 60 X 0.318 cm) or GI plate (60 X 60 X 6.35 mm)
3. Plate is embedded 3 meters in ground, often with coke and salt layers.
4. Copper plates are effective but GI plates are preffered due to low cost.
5. Plate area and depth of embedding affect earthing efficiency
6. Bolts and nuts are chosen based on plate material.

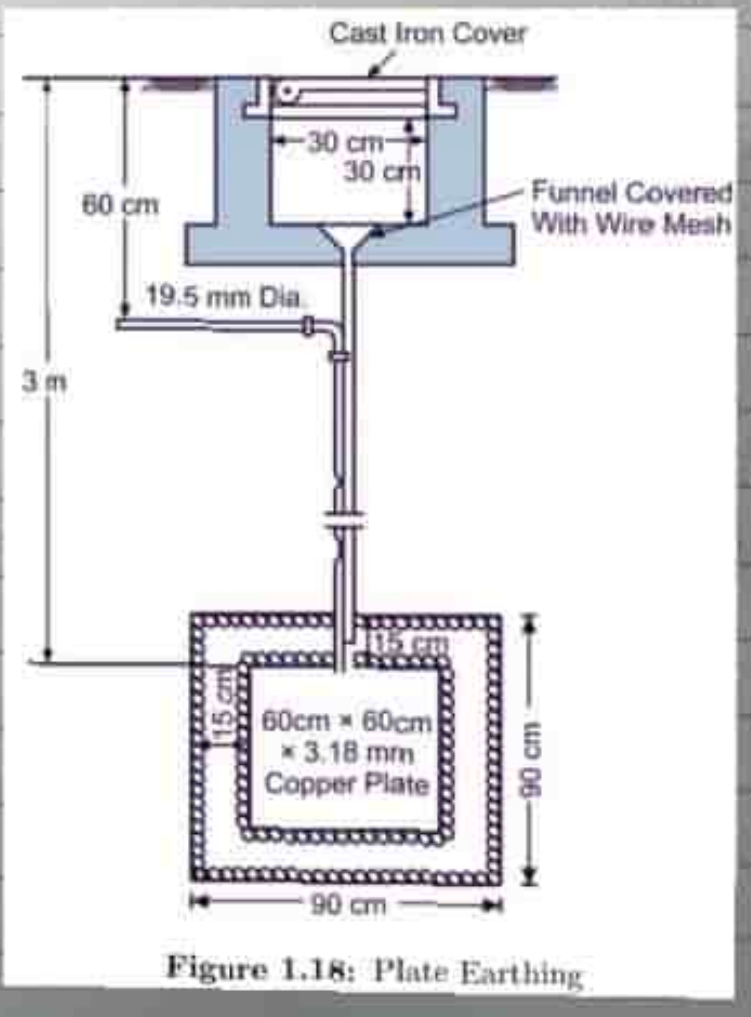


Figure 1.18: Plate Earthing

iii) Pipe Earthing (Very important)

1. A GI pipe (38 mm diameter, 2m - typically, ideally 4.75m) is vertically embedded in the ground as the earth electrode.

2. The soil around the pipe is treated with salt and Coal / coke mixture to enhance conductivity and earthing efficiency.

3. A provision for watering (using a funnel and connected pipe) is included to maintain soil mixture, especially in dry seasons.

4. Earth wires are connected to the top of the pipe above ground, allowing for easy inspection and continuity testing.

5. The earth lead must be GI wire of sufficient cross-sectional area ($\approx 12.97\ mm^2$ copper)

6. While effective for heavier leakage currents, pipe earthing may require deeper pipes in high resistivity soil, increasing cost.
ordinary soil resistance should be 2-5 ohms.

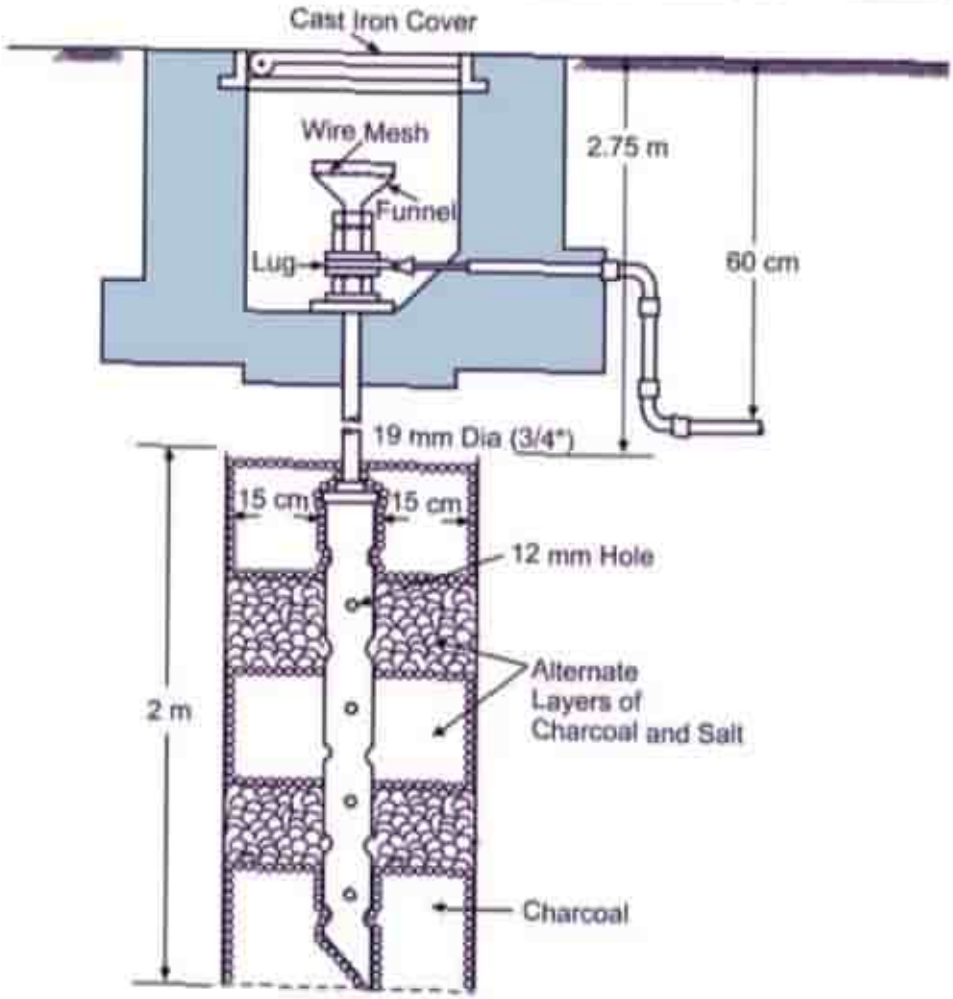


Figure 1.19: Pipe Earthing

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