Basic Electrical and Electronics Engineering

Part A: Electrical **Faculty: S.Imran khan**

Unit-3

Energy Resources, Electricity bill & Safety Measures

CONVENTIONAL SOURCES OF ENERGY:

Conventional sources of energy can be described as non-renewable sources of energy are being accumulated in nature for a very long time and cannot be replaced if exhausted.

Example: Coal, petroleum, natural gas and nuclear power etc.

NON CONVENTIONAL SOURCES OF ENERGY:

Non-conventional sources of energy are mostly renewable or available in abundance on earth. They are ecologically safe to use as well.

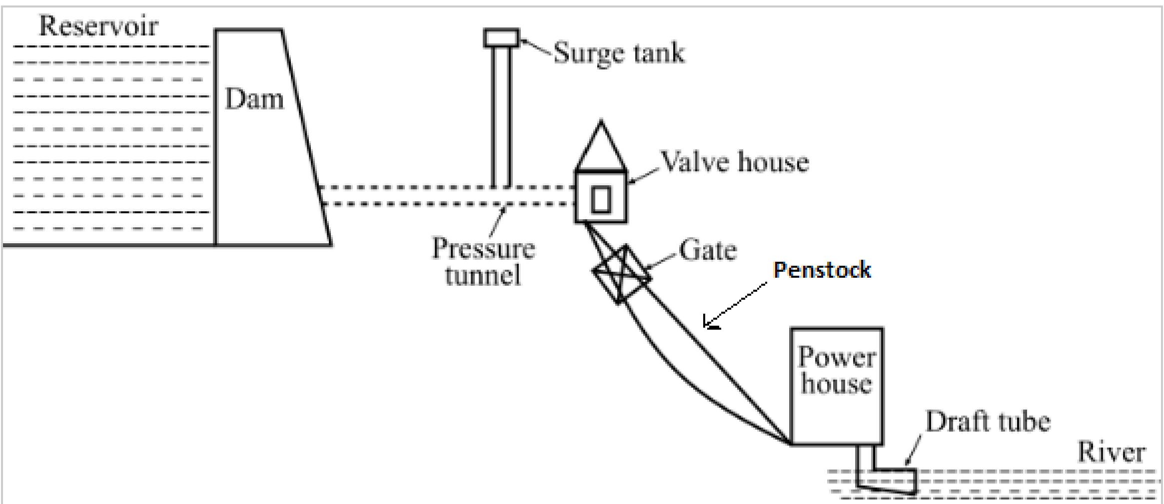
Example: wind, solar, hydro, geothermal energy etc

LAYOUT AND OPERATION OF HYDRO ELECTRIC POWER PLANT:

A *hydroelectric power plant* is a generating station which converts the potential energy of water at high level into electrical energy.

Generally, the hydroelectric power plants are installed in hilly areas where dams can be built and large water reservoirs can be obtained.

A schematic diagram of a typical hydroelectric power plant is shown in the figure.



Constructional details:

- Dam: In a hydroelectric power plant, the dam is constructed across a river or lake.
- Pressure tunnel : A pressure tunnel is formed between the reservoir and the valve house and water is brought to the valve house at the start of the penstock
- Penstock: a *penstock* is huge steel pipe which carries water from valve house to the turbine.
- Surge Tank: The surge tank protects the penstock from bursting in case the turbine gates suddenly close due to electrical load being thrown off
- valve house :The valve house contains *main sluice valves* which control the water flow to the power house and *automatic isolating* valves which cut off supply of water when the penstock bursts.

  Operation :
- Water from the valve house is taken to the water turbine through the penstock.
- Now, the water turbine converts the hydraulic energy of falling water into mechanical energy. The turbine drives an alternator which converts the mechanical energy of the turbine into electrical energy.

LAYOUT AND OPERATION OF A NUCLEAR POWER PLANT:

Constructional details:

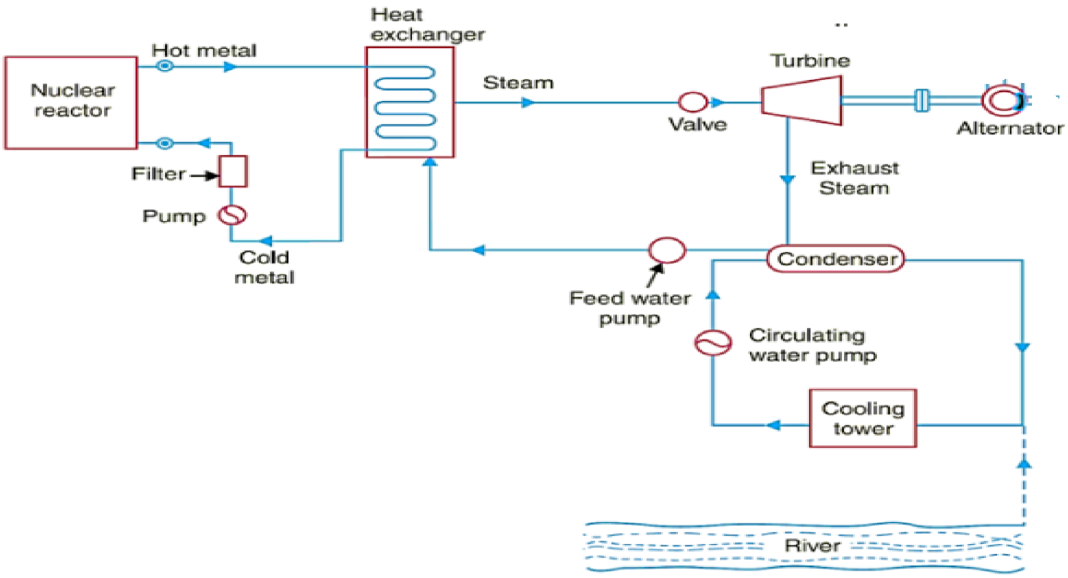


Fig1 Schematic diagram of Nuclear power plant

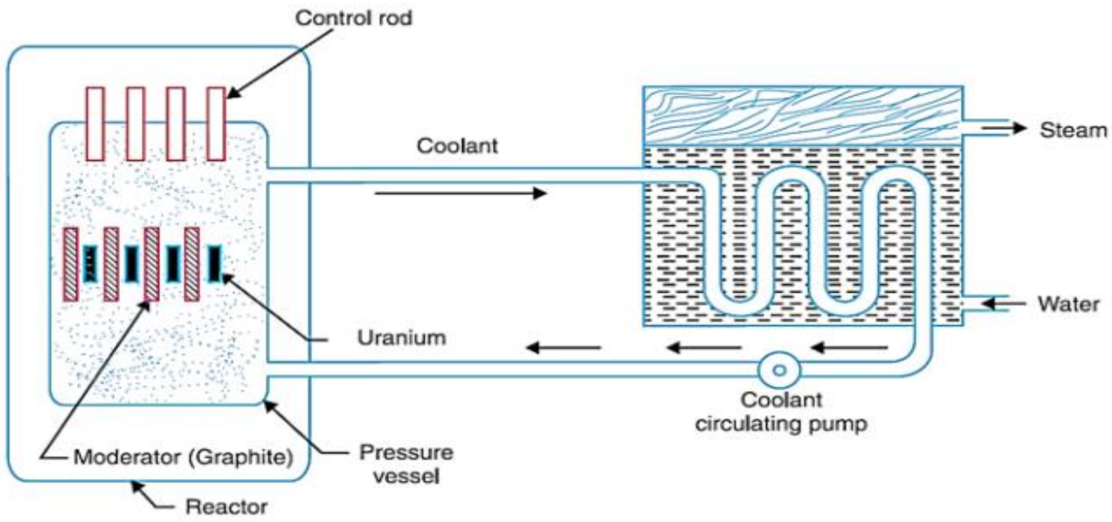


Fig. 2: Nuclear Reactor

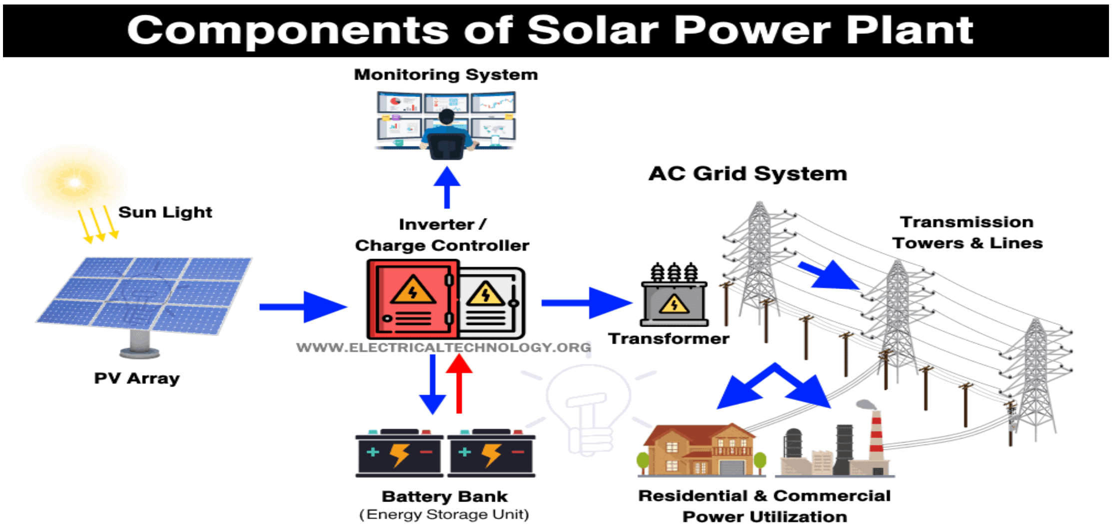
1. **Nuclear Reactor Core:**
    - The reactor core is where nuclear fission reactions take place.
    - It contains fuel rods made of enriched uranium or plutonium.
2. **Control Rods:**
    - Control rods made of materials like boron or cadmium are inserted into the reactor core to control the rate of fission reactions.
    - Adjusting the position of control rods helps regulate the power output.
3. **Coolant System:**
    - The reactor core generates a significant amount of heat during fission.
    - A coolant usually water, circulates around the reactor core to absorb and transport heat away.
4. **Moderator:**
    - Some reactors use a moderator such as graphite or heavy water to slow down neutrons, increasing the probability of nuclear fission reactions.

5. **Steam Generator:**
    - The heat absorbed by the coolant is transferred to a secondary system containing water.
    - The water in the secondary system is converted into steam.
6. **Turbine:**
    - The steam produced in the steam generator is directed to a turbine.
    - The turbine converts the thermal energy of the steam into mechanical energy by causing the turbine blades to rotate.
7. **Generator:**
    - The rotating turbine is connected to a generator.
    - The generator converts the mechanical energy into electrical energy.

Operation of a Nuclear Power Plant:

- Nuclear fission reactions occur in the reactor core when uranium or plutonium nuclei split into smaller fragments, releasing energy.
- The position of control rods is adjusted to control the rate of fission reactions and maintain a stable power output.
- The fission reactions generate intense heat, which is absorbed by the coolant circulating around the reactor core.
- The coolant transfers the absorbed heat to a secondary system, producing steam in the process.
- The steam is directed to a turbine, causing it to rotate.
- The rotating turbine is connected to a generator, converting the mechanical energy into electrical energy.

LAYOUT AND OPERATION OF SOLAR POWER PLANT:



Constructional details:

1. Solar Panels (Photovoltaic Cells):

- Solar panels, also known as photovoltaic (PV) cells, are the primary components that convert sunlight into electricity.
- These panels are typically arranged in arrays and mounted on structures like solar trackers or fixed-tilt structures to maximize exposure to sunlight.

2. Inverters:

- The direct current (DC) generated by solar panels is converted into alternating current (AC) by inverters.

3. Mounting Structures:

- Solar panels are mounted on various structures, including fixed-tilt racks or solar trackers.

4. Tracking Systems:

- Solar trackers adjust the orientation of solar panels to follow the sun's path, maximizing exposure and increasing energy output.

5. Monitoring System:

- A monitoring system is installed to track the performance of the solar power plant in real-time. It helps identify issues, optimize efficiency, and ensure proper functioning.

6. Energy Storage (Optional):

- Some solar power plants incorporate energy storage systems (such as batteries) to store excess energy generated during peak sunlight hours for use during periods of low sunlight.

7. Power Conditioning Equipment:

- Power conditioning equipment includes transformers and other devices to ensure that the electricity generated meets the required voltage and frequency standards.

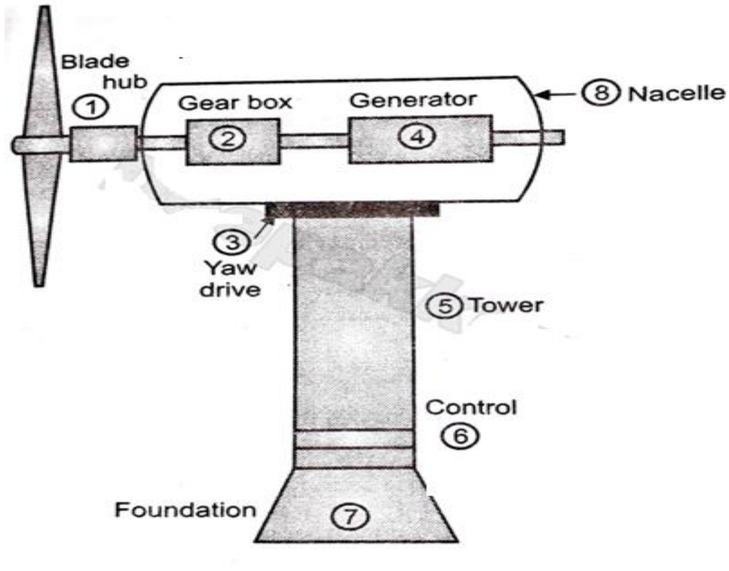
8. Electrical Grid Connection:

- Solar power plants are connected to the electrical grid, allowing them to supply electricity to the grid and draw power when needed.

Operation:

- Solar panels capture sunlight and convert it into DC electricity.
- Inverters convert DC electricity into AC electricity.
- The generated AC electricity is either used on-site or fed into the electrical grid.
- The solar power plant interacts with the grid, supplying electricity or drawing power as needed.
- Excess energy can be stored in batteries for later use.
- Continuous monitoring ensures the system's optimal performance, and regular maintenance is conducted to address any issues and prevent downtime.

LAYOUT AND OPERATION OF WIND POWER PLANT:



Wind Power Plant

Constructional details:

Blades: Blades are usually made of fiberglass or balsa wood. Most turbines have either two or three blades.

Rotor: It includes the blades and the hub together. The blades spin the rotor, which is attached to a shaft that transfers the torque it creates into the gearbox.

Main Shaft: The main shaft is the shaft attached to the rotor. It is made of steel or aluminum and connected to the gearbox.

Gear box: Gear box connect the low-speed shaft to the high-speed shaft and increases the rotational speeds from about 15 to 30 rotations per minute (rpm) to about 1000 to 1800 rpm.

Generator: A device that converts mechanical energy into electrical energy. It is located in the nacelle and is connected to the main shaft.

Nacelle: Nacelle sits at the top of the tower and contains the gear box, low- and high-speed shafts generator, controller, and brake. It is essentially the cover for the machinery that translates wind power into electrical power.

Brake: Brake is a disc that can be applied aerodynamically, electrically, or hydraulically to stop the rotor in emergencies.

Tower :Tower is usually made from tubular steel, concrete, or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.

Operation:

Wind turbines capture kinetic energy from the wind, causing the blades to rotate.

The rotation of the blades turns a generator in the nacelle, converting mechanical energy into electricity.

POWER RATING OF HOUSE HOLD APPLIANCES:

The power rating of household appliances is typically measured in watts (W) or kilowatts (kW). The power rating indicates the rate at which the appliance consumes electrical energy. Here are some common household appliances and their approximate power ratings:

Appliance	**Power ratings**
Incandescent Light Bulb	60W to 100W per bulb.
Compact Fluorescent Lamp (CFL) or LED Bulb	5W to 20W per bulb
Refrigerator	100W to 800W
Air Conditioner	Window units: 500W to 1.5kW.
	Central air: 2kW to 5kW.
Microwave Oven	700W to 1.5kW
Television	3 LED/LCD:0W to 200W
	Plasma: 100W to 500W
Washing Machine:	300W to 2kW
Electric Stove/Oven	1.5kW to 5kW per element.
Computer and Monitor	50W to 500
Ceiling Fan	10W to 100W
Printers	Inkjet Printers: 30W to 50W.
	Laser Printers: 300W to 800W.
Laptops	Standard Laptops: 30W to 90W.
	Ultrabooks and Energy Efficient Laptops: 15W to 45W.

DEFINITION OF UNIT used for consumption of electrical energy:

One unit of electricity is equal to one kilowatt-hour. It is the amount of power required to use an appliance of 1000 watt power rating for an hour.

Thus,

$$1\,kWh = 1\,kilowatt \times 1\,hour$$

$$= 10^3 watt \times 3600\,s$$

$$= 10^3\,J/s \times 3600\,s$$

$$= 3.6 \times 10^6\,J$$

Thus, $1\,kWh = 3.6 \times 10^6\,J$

TARIFF:

The tariff is the methods of charging a consumer for consuming electric power. The tariff covers the total cost of producing and supplying electric energy plus a reasonable cost.

TWO PART TARIFF:

When the rate of electrical energy consumption is charged on the basis of maximum demand of the consumer and the units consumed, is known as two part tariff.

In case of two-part tariff, the total charges are spilt into two components : fixed charges and running charges.

The fixed charges depend upon the maximum demand of the consumer whereas the running charges depend upon number of units consumed.

$$C = Ax + By$$

$$C = A(kW) + B(kWh)$$

where, C – total charge for a period (say one month)

x – maximum demand during the period (kW or kVA)

y – Total energy consumed during the period (kW or kVA)

A – cost per kW or kVa of maximum demand.

B – cost per kWh of energy consumed.

CALCULATION OF ELECTRICITY BILL FOR DOMESTIC CONSUMERS:

SL NO	Appliances	Watts	NO	Total no of watts	No of operational hours per day	Total Energy consumed = No of watts X No of operation hours	Energy consumed in kwh(unit) per day= energy consumed / 100
1	Tube light	60W	10	600	5	3000	3.0
2	Fan	75W	4	300	8	2400	2.4
3	Refrigerator	200W	1	200	24	4800	4.8
4	AC	1000W	1	1000	5	5000	5
5	Laptop	50W	1	50	2	100	0.1
6	Television	50W	1	50	3	150	0.15
7	Grinders	1000W	1	1000	1/2	500	0.5
8	Printers	50W	1	50	1/2	25	0.025
9	Washing machine	2000W	1	2000	1	2000	2
10	Micro wave	1000W	1	1000	1	1000	1
						total no of units consumed per day	**18.9=19 Units**

Energy consumption = Wattage X operational hours.

Calculation of Power consumption of electrical home appliances.

Let us consider different home appliances to calculate approximate total energy consumption of house per month.

calculation of power consumption of electrical home appliances
Therefore per day 19 units of energy is consumed

For 1 month = 19 x 30 = **570 units per month**

<u>Equipment safety Measures</u>

<u>Working Principle of Fuse :</u>

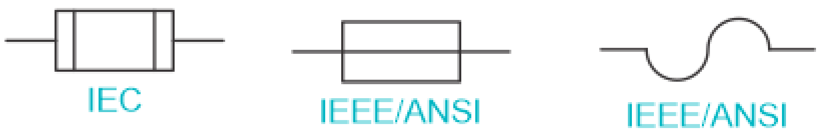
Fuse: An **Electrical Fuse** is a safety device that protects against the overflow of current in an electrical circuit

It protects electrical appliances from overloads and short circuits. It protects high voltage up to 400 kV and low voltage up to 66 kV.

The fuse comprises a highly selected metal conductor, and the cartridge holds the fuse. The fuse's primary purpose is to allow the normal current flow and break the circuit when there is a high-magnitude current.

Symbols of Electrical Fuse

The major symbols of Electrical Fuse are listed below



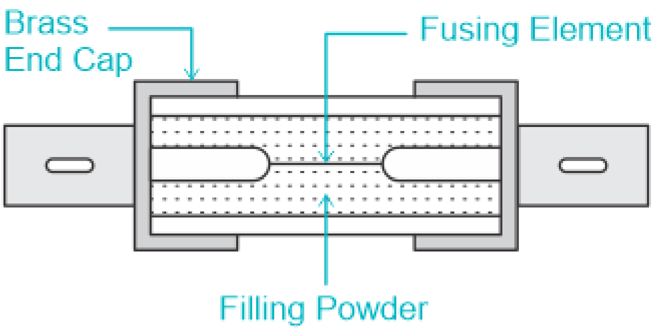
Construction of Electrical Fuse :

A fuse can be constructed using elements like copper, zinc, silver and Aluminium., The parts of the electrical fuse diagram are the brass end cap, the fusing element and the filling powder.

The fuse end cap provides the electrical connection between a fuse and an electric conductor.

The fuse element is made up of materials that have a low melting point and low ohmic losses like tin, lead, and zinc.

Filling powder fills the internal space of the fuse body. The filling powder materials used in fuse are quartz, Plaster of Paris, dust, marble, and chalk.



Electrical Fuse Working Principle

An electric fuse's working principle is based on the heating effect of the current. In normal conditions, the current passes through the fuse. The heat developed In the fuse gets dissipated, and the temperature becomes below the melting point.

The thickness of the fuse wire varies depending on the amount of current flowing through it. Electric fuse wire is made up of alloy of tin and lead. When an electric short circuit occurs, the current passes through the fuse. Hence, the fuse melts and breaks. Remember that in electrical wiring, fuse should be attached to the live wire.

Functions of Electric Fuse

Some of its main functions are as follows.

- The electric fuse acts as a protective barrier between the electrical circuit and the human body.
- It safeguards against device failure resulting from faulty circuit operation.
- The fuse prevents short circuits from occurring.
- It helps prevent overloads and blackouts.
- The fuse safeguards against damage caused by mismatched loads.

Advantages:

- Fuse is cheapest type of protection in an electrical circuit
- Fuse needs zero maintenance
- Operation of fuse is simple and no complexity is involved
- Fuse has the ability to interrupt enormous short circuit current without producing noise, flame, gas or smoke
- The operation time of fuse can be made much smaller than operation of circuit breaker. It is the primary protection device against short circuits
- It affords current limiting effect under short-circuit conditions
- Fuse inverse time current characteristic has the ability to use for over-load protection

Disadvantage:

During short circuit or overload once fuse blows off replacing of fuse takes time. During this period the circuit lost power

- When fuses are connected in series it is difficult to discriminate the fuse unless the fuse has significant size difference

Miniature Circuit breaker (MCB):

A miniature circuit breaker (MCB) is an Electrical Switch that automatically switches off the electrical circuit during an abnormal condition of the network means an overload condition as well as a faulty condition.

Nowadays we use an MCB in a low-voltage electrical network instead of a fuse. The fuse may not sense it but the miniature circuit breaker does it in a more reliable way. MCB is much more sensitive to overcurrent than a fuse.

Handling an MCB is electrically safer than a fuse. Quick restoration of supply is possible in case of a fuse because fuses must be rewirable or replaced for restoring the supply. Restoration is easily possible by just switching it ON.

A Miniature Circuit Breaker (MCB) typically consists of the following components:

Main contacts: These are the contacts that carry the load current and are connected to the incoming and outgoing wires of the circuit.

Trip Unit: This is the core component of an MCB, which monitors the current flowing through the circuit and trips the breaker in case of an over-current or short-circuit. The trip unit consists of a bimetallic strip, a magnetic element, and an operating mechanism.

Bimetallic Strip or Thermal Element: The thermal element is sensitive to the heat generated by overcurrents. When the current exceeds a predetermined threshold for a specific duration, the bimetallic strip heats up and causes the contacts to open, disconnecting the circuit.

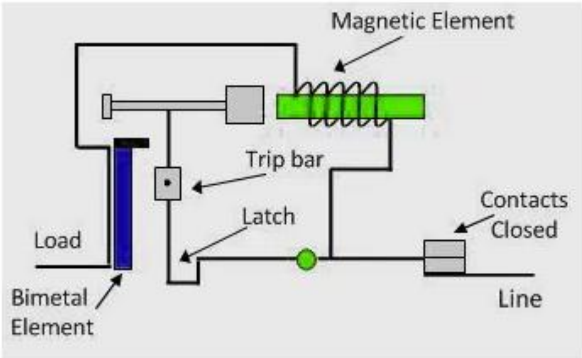
Operating Mechanism: The operating mechanism is responsible for opening and closing the contacts inside the MCB.

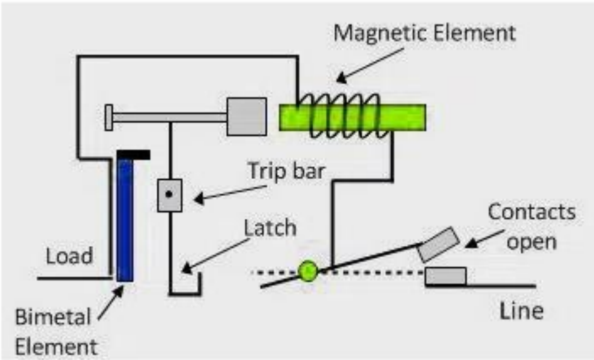
Magnetic Element: The magnetic element is designed to respond to short-circuit currents. It operates quickly to open the contacts when a high current surge is detected

Terminal: These are the connections for the incoming and outgoing wires.

Housing: The housing is the protective casing that houses the MCB components and provides insulation between live parts and other electrical components.

Working Principle of MCB





1. **Normal Operation (No Fault):**
    - In the normal operating condition, the MCB's contacts are closed, and current flows through the circuit without any issues.
    -
2. **Overcurrent or Fault Condition:**
    - When an overcurrent or fault occurs, the MCB responds in one of two ways:
        - Thermal Trip: The bimetallic strip heats up due to prolonged overcurrent, causing it to bend and open the contacts.
        - Magnetic Trip: For short-circuit currents, the magnetic element rapidly forces the contacts open.
3. **Arc Extinction:**
    - The arc chute helps in extinguishing the arc that forms when the contacts open, ensuring a safe interruption of the current.

Advantages of MCBs:

- MCBs have more sensitive to current then fuse.
- It has quick work against short circuits.

- It works quickly on overloading and under voltage.
- It is reusable hence less maintenance cost and less replacement cost.
- It is very simple to resume the supply.
- It can be easily used circuit control switch when needed.
- Handling MCB is electricity safer than handling fuse, in case of MCB.
- It has reliable.
- MCB provides a better interface.
- MCB performance immediate indication of faculty circuit.
- The performance of MCB is good in case of earth leakage.
- In the case of surge current, The MCB has time delay characteristics, therefore, it works properly.
- Shorter tripping time under moderate over current than with fuses.
- When the use of MCB, the faulty zone of the electrical circuit can be easily identified.

Disadvantages of MCBs:

- The cost of the MCB is greater than the fuse.
- The cost of the MCB distribution board is greater than the rewireable fuse board.
- The risk of overloading of the circuit due to unqualified of the person operating than completing removed.

ELECTRIC SHOCK:

Our bodies conduct electricity. If any part of your body meets live electricity an electric current flows through the tissues, which causes an electric shock. People sometimes call it electrocution.

Human body has a electrical conducting property. Without sweating the resistance of human body is approximately 80000Ω (ohm) and during sweating, resistance of the human body is approximately 1000Ω (ohm).

If we touch any current carrying conductor, the current is conducted through our body to earth and we get electric shock more over nervous structure, heart, lungs, and brain can also be affected. If the current is heavy, even death may occur.

Causes of electric shock:

Some causes of electric shock include:

- faulty appliances
- damaged or frayed cords or extension leads
- electrical appliances in contact with water
- incorrect, damaged or deteriorated household wiring
- downed powerlines
- lightning strike.

To prevent such electrical shocks, we must know about the preventive measures and protective measures for safety precautions.

SAFETY PRECAUTIONS TO AVOID ELECTRIC SHOCK :

Some of the methods employed to avoid electric shock are listed below:

- The operation of electrical equipment must be clearly known.
- Damaged wire should not be used for wiring or electrical connection.
- The electrical instruments used for connection (i.e switch, plug, pushing etc). It should not have any scratch or break.
- The hand tools should be properly insulated.
- Proper earthing should be provided.
- Wear rubber or plastic soled shoes when using electrical appliances, especially in wet areas, on concrete or outdoors.
- Insert safety plugs into unused power points to stop children from inserting objects into them.
- When buying electrical appliances, check they meet safety standards.
- If you have children, turn off and unplug electric appliances and keep them out of reach
- For any reason, do not operate by overcoming the safety rules.

Earthing:

The process of transferring an unintended electrical energy directly to the earth through a low resistance wire is called electrical earthing.

It refers to the connection of a noncurrent-carrying part of the equipment or neutral of supply system to the ground, which represents the zero potential.

The leakage current chooses the simple low resistance path to flow. Thus, the electrical system and equipment are protected from damage.

Need of Earthing

Earthing is needed for the following reasons −

- To protect the user from electrical shock.
- Earthing system shows the easiest path to the fault current even after the insulation failure.
- It protects the electrical apparatus used in the circuit from short circuit current, high voltage surges and lightning discharges.
- Protect the electrode lead from mechanical stress and corrosion.

Types of Electrical Earthing

The electrical equipment has two non-current carrying parts such as neutral of the system and frame of the equipment.

Earthing system is also classified into two types.

Equipment Earthing

When the metallic frame of the equipment is connected to the earth by the help of a conducting wire then it is called Equipment earthing.

In fault condition in the apparatus, the fault current flows to the earth and the system is protected.

Neutral Earthing

The process of connecting neutral of the system to the earth through a GI wire is known as Neutral earthing or System earthing.

It is used in star winding systems including generator, transformer, etc.

The three primary types of neutral grounding are:

1. **Solid Grounding:**
    - The neutral of the power system is directly connected to the earth.
    - Provides a low-impedance path for fault currents to flow during ground faults.
    - Commonly used in low-voltage systems.

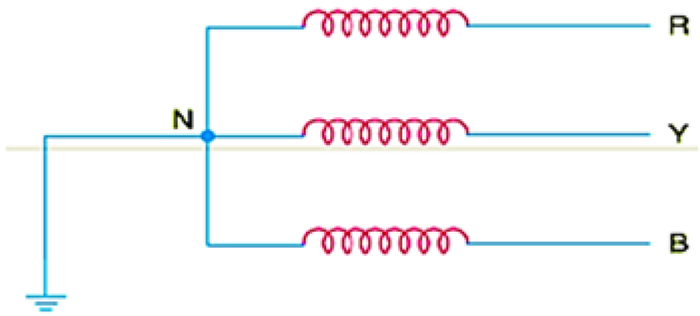


Fig 1 : Solid Nuetral Grouning

2. **Resistance Grounding:**
    - The neutral is grounded through a resistor, which limits the fault current.
    - Often used in medium-voltage systems.

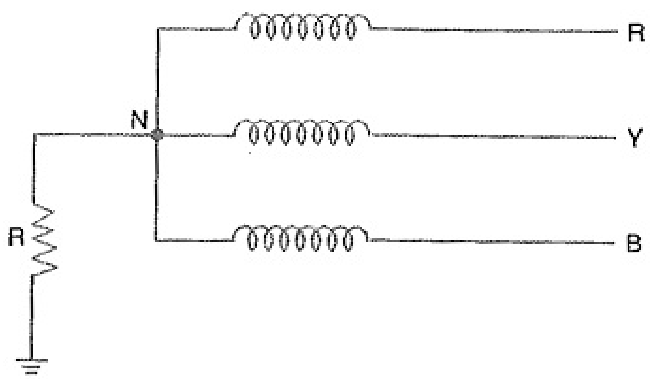


Fig 2 : Resistance Neutral Grounding

3. **Reactance Grounding:**

- The neutral is connected through an inductor (reactor), which limits the fault current.
- Suitable for both medium and high-voltage systems.

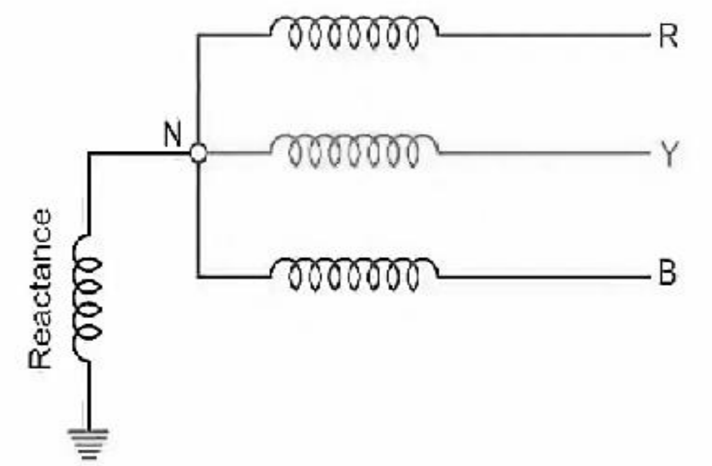


Fig 3 :Reactance Neutral Grounding