UNIT-V

Electrical Installations

Necessity of Protection System

The operating voltage of an electrical power ranges from 230V to 400KV or even higher. In the electrical power System we are using rotating machines, transformers, transmission lines, insulators, cables and so on, which are necessary and costly equipments. Due to abnormal or faulty conditions like over-voltage, lightning surges, insulation failure, resonance, improper earthing, short-circuit or open-circuit conditions, and balanced and unbalanced faults causes the damage of electrical system, electrical equipments, and causes electrical shocks to human's life.

Hence, it becomes neeessary to protect equipment from faulty conditions and also important to safeguard the human personnel life. This protection scheme is classified as

1. Primary protection
2. Back-up protection.

→ In this protection schemes different protective equipment or devices are using like Circuit breakers, fuses and protective relays.

Switchgear :- Switchgear refers to the device used for switching, controlling and protecting the electrical circuits and components.

Essential features of Switch Gear

→ complete reliability
→ quick operation
→ Absolutely discrimination
→ Provision for manual control.

Components of Switch Gear

The basis components of switchgear are

① Switches
② Fuses
③ Circuit breakers
④ Relays

① Switch :- The device which is used to open or close an electrical circuit in a most conventional way is called, switch. It can be operated at any condition of the circuit. But disadvatage of the switch is it cannot interrupt the current under faulty condition.

Fuse :- A simple protective device used to protect the cables and electrical equipment under overload and short circuit conditions is called fuse. It is a small piece or thin strip of wire which melts when fault current flows through it for a sufficient time.

Protective relay :- It is a device which continuously detects the faults in a circuit and send the information to the circuit breaker.

Circuit Breaker :- It is a switching device, which can used to make or break a circuit manually, automatically or with the help of remote control, under different normal or fault conditions.

Fuse :- A fuse is a short piece of wire or metal or thin strip, which is inserted in series to the circuit. When the fault current flows through the fuse for a sufficient time, it melts and thus isolates the circuit.

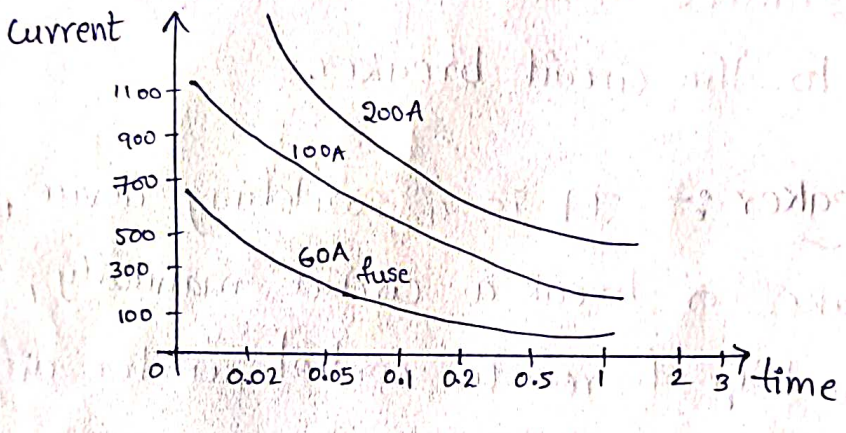
→ Under normal operation, the fuse helps in carrying the normal current, but when fault occurs due to short circuit or overload condition, then high current

which is higher than normal current flows through the fuse.

→ This fault current increases the temperature above the melting point of the material used in fuse.

→ Hence the material melts or blows thereby isolating the healthy part and protects the circuit.

→ The fuse having inverse time-current characteristics as shown below.



Desirable characterstics of Fuse element materials

→ low melting point ... example tin, lead

→ high conductivity ... e.g silver, copper.

→ least effect to oxidation e.g silver

→ affordable ... e.g lead, tin, copper.

→ Silver is used as fuse element ~~for~~ in many electrical circuits because it have all above maximum characterstics and faster operation is possible.

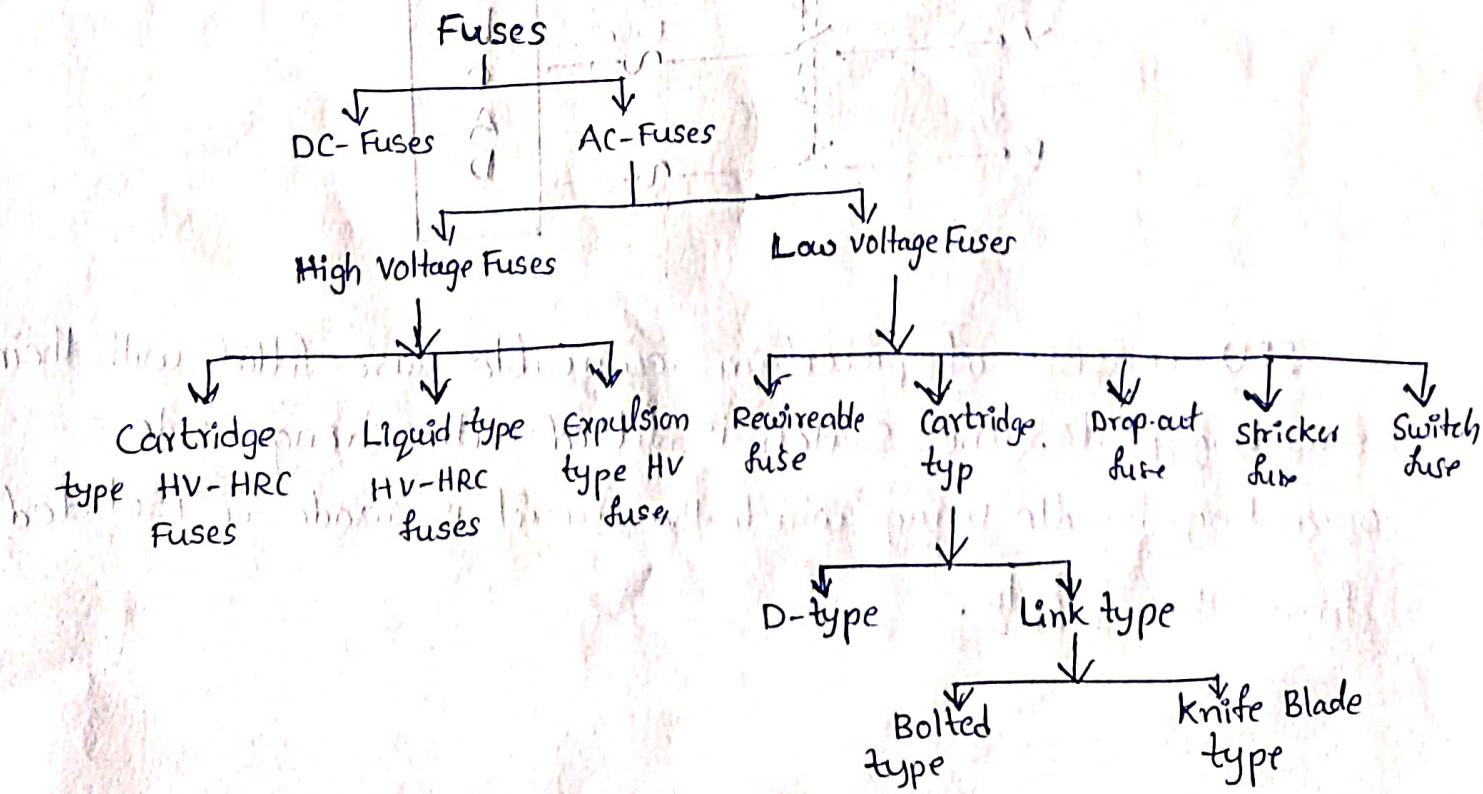
Advatages of fuse

→ cheapest form of protection device
→ Requires no-maintenance
→ operation of fuse is completely automatic
→ Easily breaks the large amount of fault current.
→ Pollution free protection device
→ Suitable for over-current conditions
→ Require less time in isolating the faulty part of circuit.

Disadvatages of fuse

→ Replacing or rewiring a fuse takes a considerable time
→ Discrimination between fuses connected in series is not possible
→ Co-relation characterstics of fuse always not possible.

Classification of fuses



Switch Fuse Unit :- (SFU)

The switch fuse unit (SFU) is a low voltage AC-fuse unit which is used to protect the electrical device or equipment from different fault conditions.

→ This fuse is most commonly used for low and medium voltage applications.

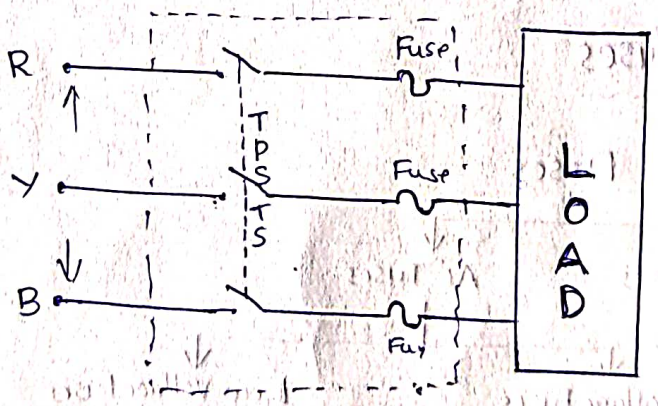
→ Rating of SFU varies from 30 to 800 Amperes.

→ But the making capacity of SFU goes high till 46kA.

→ In general SFU is available 3 pole and 4-pole unit.

→ SFU has the capability of withstanding till the fault current reaches 3-times the full load current.

→ The Schematic Diagram of SFU is shown in below.



SFU consists of porcelain rewireable fuse fitted with their conducting parts. The switch is fitted with strong side operating handle using which the circuit is made or isolated from the supply.

→ In this SFU, the different contacts are made up of electrolytic copper and other components are made up of with steel material.

→ In SFU a enclosure is provided for interlock to prevent the opening of the unit when the switch is ON-condition.

Miniature Circuit Breaker (MCB):

An electromagnetic device that is used in the protection of electrical circuit from an over-current is called "miniature circuit breaker (MCB).

→ When MCB compared with fuse, it has a better alternative in protecting the circuit and no-replacement is required.

→ In addition, MCB offers operational safety and easier operation when compared to fuse.

→ The rating of the MCB is nearly 100 A

→ The MCB can protect the circuit till the overload current reaches 5 to 15% of the rated current.

→ The operating time of the MCB is less than 2.5ms for short-circuit faults and 2sec to 2 minutes for over load condition.

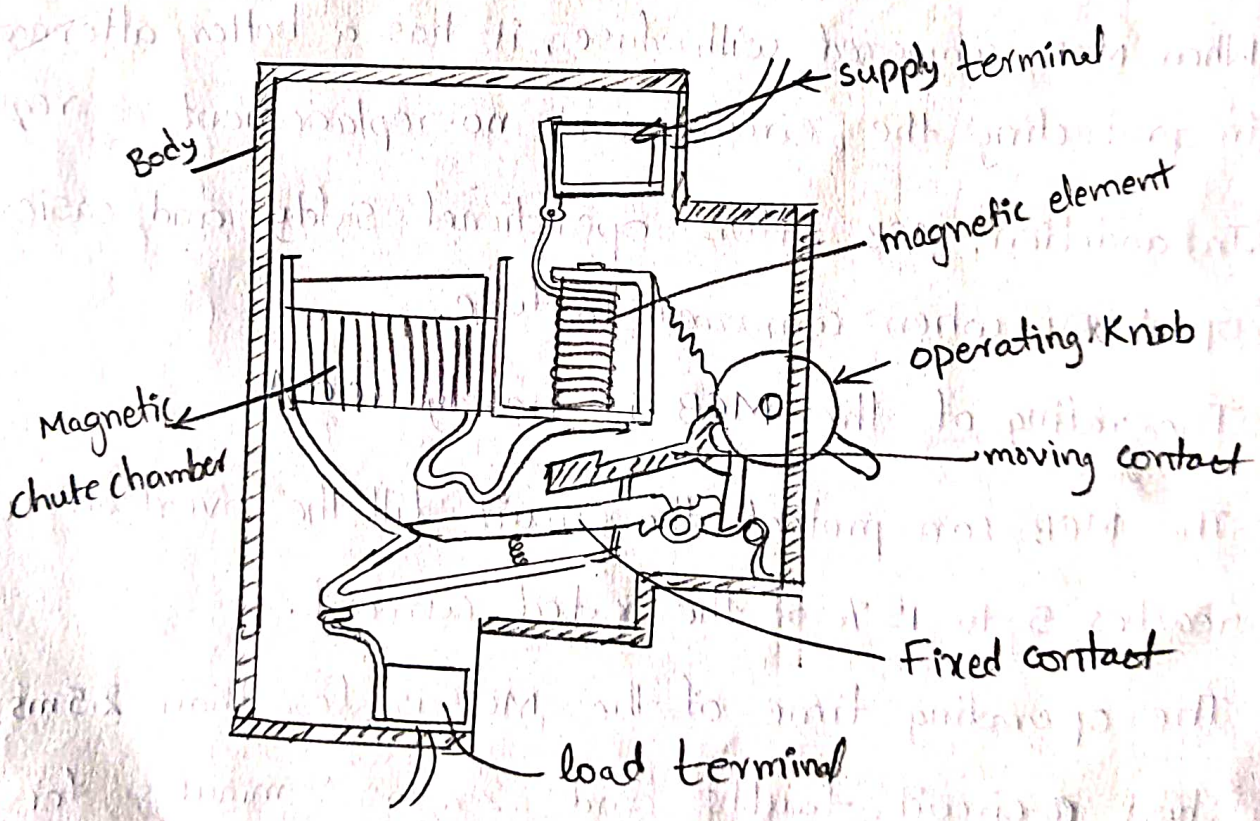
→ It is used in local control switches.

Construction of MCB

→ For single-phase circuits, single pole construction is used in the MCB design. Flame retadant plastic moulding is used in the MCB design to protect the different parts present in it.

→ Hence, MCB will have high melting point and dielectric strength, low water absorption and linear thermal expansion co-efficient.

→ It schematic diagram shown as below.



The MCB uses a thermal and magnetic trip units to open the contacts during any fault conditions.

In MCB, these units get mechanically operated independently along with the trip mechanism to open the contacts and the protect the circuit. A thermal-magnetic arrangement is provided in the thermal tripping unit to open the contact in MCB. In this mechanism is provided by bimetallic strip, which is having low and high resistance.

→ For a very low current MCB, a heater is placed around the bimetallic strip to generate the required heat.

→ During fault situation, magnetic effect is developed on the trip latch which moves and opens the contacts, a Solenoid is used to produce the required magnetic field in MCB.

Working of MCB :-

The working of MCB under normal, overload and short circuit conditions shown in below figures.

→ Under normal conditions, the operation of MCB is similar to the normal switch and helps to make the circuit ON or OFF.

→ Under different fault conditions, the MCB gets operated automatically to trip (or) open the circuit, so that fault current does not pass through the loads connected to the circuit.

→ The automatic operation of MCB can be obtained in two ways of fault conditions

(2)

① Magnetic tripping (ii) thermal tripping.

→ The magnetic tripping is used in the short circuit condition and thermal tripping is used in the overload condition.

→ When overload condition exists in the circuit, then bimetallic strip causes the deflection due to excess current. The deflection of bimetallic strip, the trip latch gets realeased which makes the contact to separate of circuit. from the loads. Shown in fig (3)

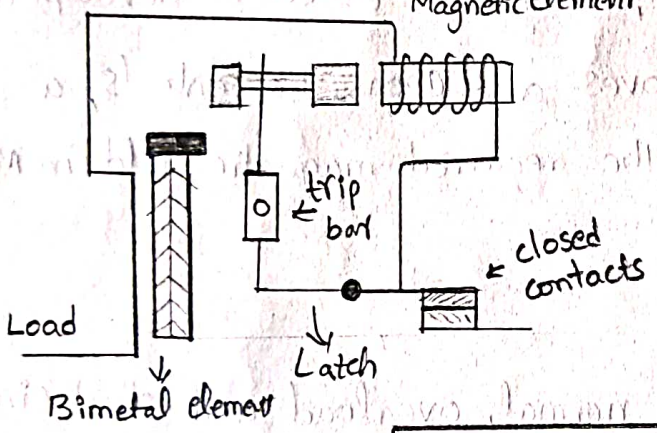
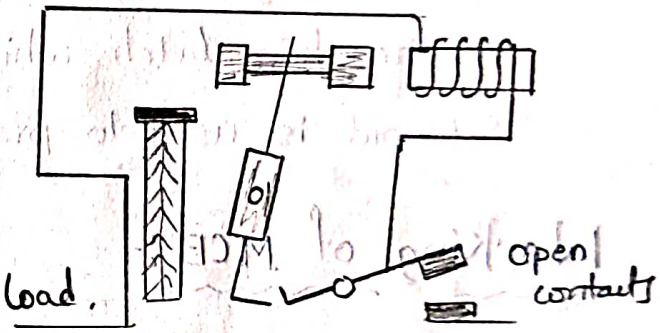


fig (2)



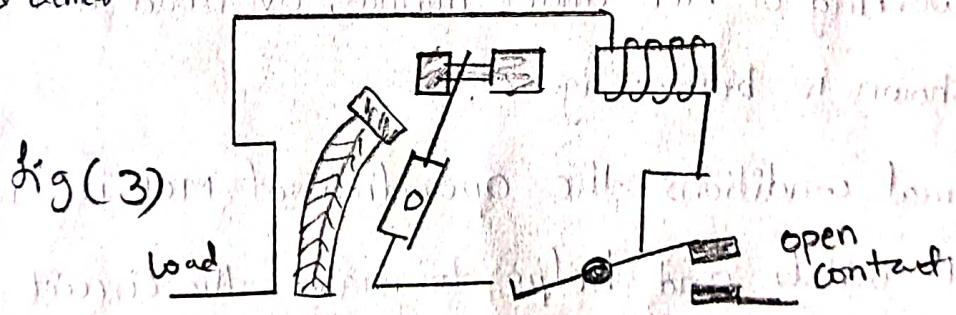


fig (3)

→ when a short circuit condition exists in the circuit, a large amount of fault current flows through the circuit. The high current energizes the magnetic circuit i.e solenoid. Due to this magnetic field, the plunger gets attracted which helps to releases the contacts of circuit from the loads.
as shown in fig (2).

Advatages of MCB

→ Response time of MCB is fast against short circuit condition.
→ It works faster in overloading and under voltage conditions.
→ Posses good performance against earth leakage
→ Reliability of MCB is high.
→ Less maintenance and replacement cost.
→ Easier and safer to operate MCB.

Disadvatages :-

→ cost of MCB is high when compared to fuse.
→ Highly vulnerable to heat.
→ Aging and wear problem exist in MCB.

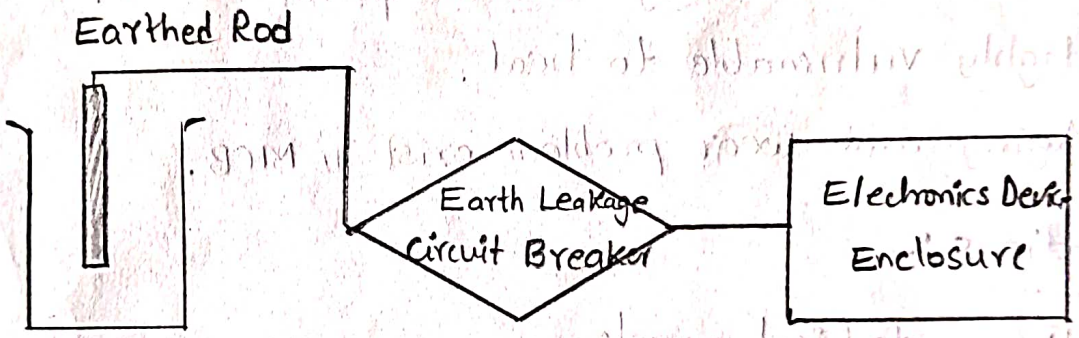
Applications :-

→ Home electrical panels
→ Ground fault trip mechanism
→ Lighting system
→ Small scale industrial applications
→ Heaters.

Earth Leakage Circuit Breaker (ELCB)

The safety device which detects the leakage current flowing to the earth directly and interrupts the power supply is called an "Earth leakage Circuit Breaker" (ELCB).

When there exists a leakage current, the voltage difference between the metallic part of the installation and earth is high and dangerous. ELCB detects the earth leakage current and helps in protecting the system by tripping the supply.



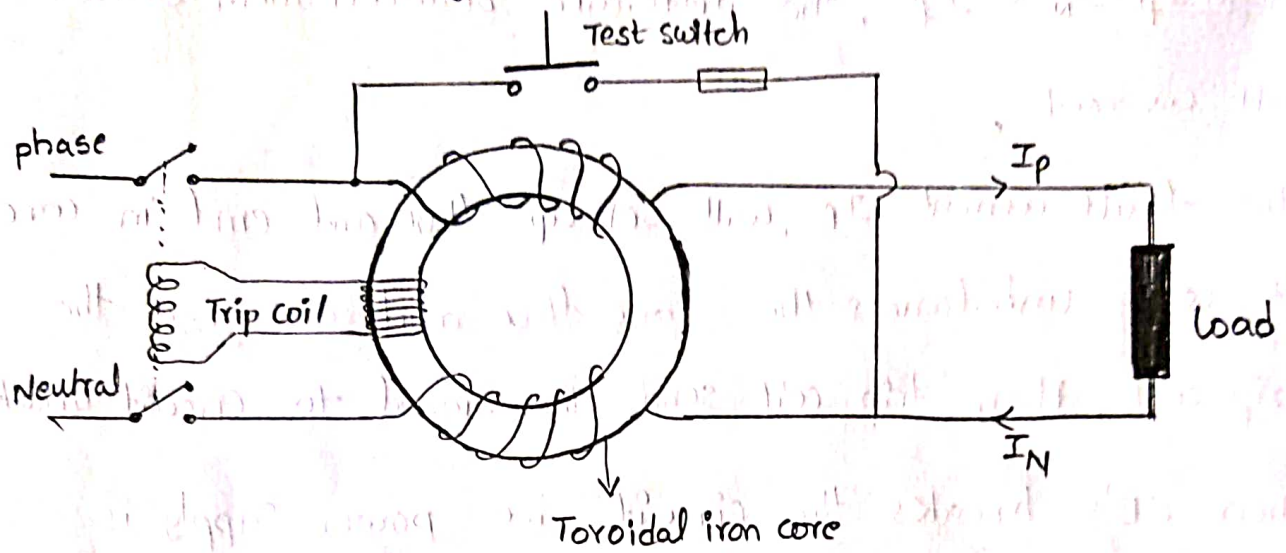
There are two different types of ELCB viz

(i) Voltage operated ELCB (ii) Current operated ELCB.

Current Operated ELCB or Residual Current Circuit Breaker (RCCB)

The current operated ELCB's is a device which operates based on the residual current to detect the earth leakage in the device connected to it.

The circuit diagram of a single phase current operated ELCB shown in below figure.



The elements that are present in the ELCB are

- → A toroidal iron core
- → Phase and Neutral windings
- → Search coil
- → Trip coil
- → Test switch.

→ Under normal conditions, the current in phase and neutral windings is same, so that net current $(I_{ph} - I_N)$ flowing iron core is zero i.e $(I_p - I_N = 0)$. So their is no leakage current, so no flux produced in Iron core and no emf induced, so that breaker does not trip the contacts.

→ If any fault occurs, then leakage current exists in

If the device (or) equipment i.e I_p and I_N are not equal then $I_p - I_N = I_f$, the difference between them causes fault current,

→ This fault current I_f, will set up flux and emf in core, it unbalances the core flux and energizes the trip coil, then trip coil sends the signal to Circuit Breaker.

→ Then CB's breaks the circuit i.e power supply is disconnected to the device.

→ Thus ELCB provides protection against electric shock when a person comes in contact with live parts, resulting in flow of current from body to earth.

→ Similarly there is risk of fire due to such earth leakage currents, it can be cleared by using ELCB

Importance of ELCB

→ Provides protection to a human against the electric shock.

→ Detects very small leakage currents (in mAmps)

→ Reduces the risk of fire due to hot spots.

→ Saves electrical energy due to leakage

→ Energy conservation can be achived.

→ For increasing of lifespan of devices it is preferable.

Moulded Case Circuit Breaker (MCCB)

→ An electromechanical device that is used in the protection of electrical circuit & components from over-current and short circuit conditions is called "Moulded Case Circuit Breaker"

→ The main objective of MCCB is to open a circuit either manually or automatically when fault current exists.

→ It can be used as a moulded case to accommodate and support different current carrying components in addition to as insulation system.

→ The rating of the MCCB is 10A to 3000A.

→ The selection of MCCB depends on
- → current rating
- → current setting range
- → short circuit rating
- → operating characteristics.

Classification of MCCB:- Based on operating mechanism classified as
(a) Thermal magnetic release
(b) Electronic release
(c) Microprocessor release.

In thermal magnetic release, MCCB operates as a MCB which has bimetallic strip and electromagnetic assemblies to

to provide protection to the devices.

→ In Electronic release, the circuit based on power electronic device is used to protect the from over-current situations

→ In microprocessor release, the constantly monitors the current value and if it exceeds predetermined value, circuit breaker is activated and isolate the device from faulty conditions.

The MCCB does not require any replacement it can be considered as an alternative fuse, and it can be reset the fault with short period. It's operation is safely with reasonable cost.

→ The basic difference between MCB and MCCB is only in current rating capacity, operation & construction is nearly same.

→ MCCB are used for high current protection devices as

- → Generator protection
- → Main feeder protection
- → Motor protection
- → Capacitor bank protection
- → Welding applications
- → Current trip setting devices.

Comparison between MCB and MCCB

MCB	MCCB
1. It protects the circuit from overloaded current	1. It protects the equipment from over-current and short circuit curre
2. It posses a fixed tripping circuit	2. It posses a movable tripping circuit
3. 1 or 3-pole configuration is possible	3). 1 or 4-pole configuration is possible.
4.) The rated current of device is 100A	4). The rated current of device is 10 to 3000 A
5. the circuit can be interrupted is current is 1800 A	5. it's interrupted current is 10K – 200KA
6. It can be installed in domestic applications	6. It can be installed in commercial and industrial applications.
7. Remote operation is not possible	7. Remote operation is possible.
8. It protects the circuit only	8). It protects the circuit and provides insulation to equipments.

Wires and Cables

Wires :- Wire is a single electrical conductor (or) a group of thin conductor strands covered by an insulation material. These are used to carry electrical and telecommunication signals.

Factors Affecting the choice of Wires

There are different factors based on which an electrical wire is selected for a particular application.

- → Wire size
- → Wire lettering
- → Colour codes
- → Ampacity and Wattage

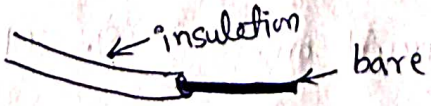
Types of Wires

We have two types of wires

① Solid wire ② Stranded wire

① Solid wire :-

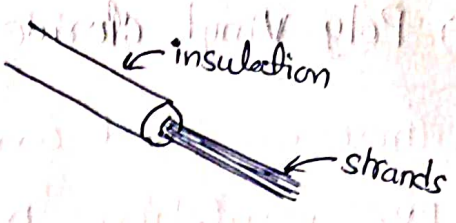
A single conductor that is either bare or covered by protective coloured insulation is called "Solid wire". It is most commonly used in high frequency application since it offers a low resistance.



② Stranded wire :-

When many thin strands of wire of equal size are twisted and covered by a insulation sheath is

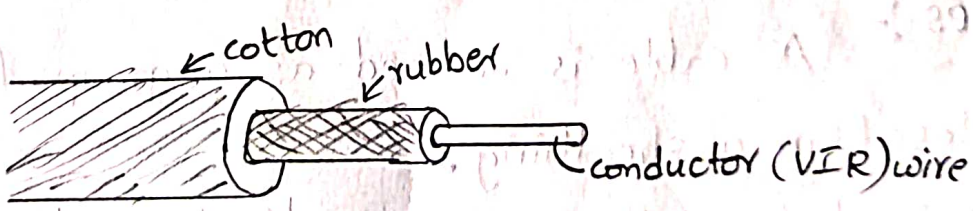
called "Stranded wire". These are flexible wires & used for longer period. These are having large-cross-sectional area when compared with solid wire



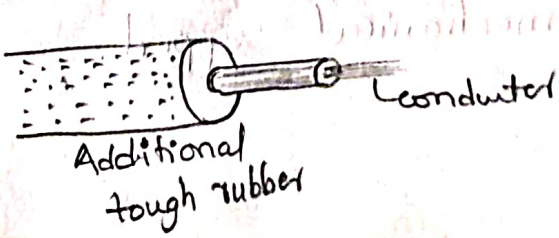
→ Based on insulation of wires, thus classified into 4-types

1. Vulcanised India Rubber wires (V.I.R)
2. Cab-tyre sheathed wires (C.T.S)
3. Poly-Vinyl chloride wires (PVC)
4. Flexible wires.

① Vulcanised India Rubber wires (V.I.R) :- This type of wire consists tinned conductor coated with rubber insulation. This is further covered with protective cotton and bitumen. This makes it moisture and heat resistance.



② Cab-Tyre sheathed wire (C.T.S) :- In this type, ordinary rubber insulated conductors are provided with a additional tough rubber sheath. It provides moisture, heat resistance and chemical fumes and, wear and tear.



(3) Poly-Vinyl chloride wires (P.V.C)

→ These are most commonly used wires, because it has PVC-insulation. Due to PVC insulation it has

→ It is non-hygroscopic and moisture proof.
→ It is tough and hence durable
→ Resistant to corrosion.
→ It is chemically inert.

(4) Flexible wires :-

→ These are mostly used in domestic wiring i.e home applications
→ It consist of two separately insulated stranded conductors, which are parallel twisted twins.

Cables :- A cable is defined as a group of wires enclosed in a sheathing.

→ It is two (or) more wires combined (or) bonded together, twisted, braided and sheathed together, it forms the cables.
→ Cables are mostly used in power transmission as underground cables and also used telecommunication signal systems.
→ It is finally provided with different layers which are gives proper mechanical support.

Types of Cables :-

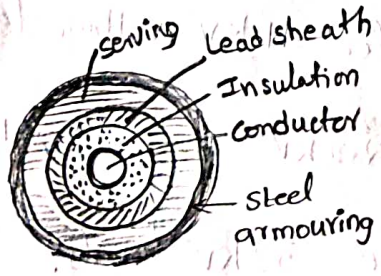
The different cables used for wiring domestic, commercial and industrial applications can be classified based on following categories

(a) **Type of Conductor :-** Based on the conductor material used in the cables, the cables are classified into two types as

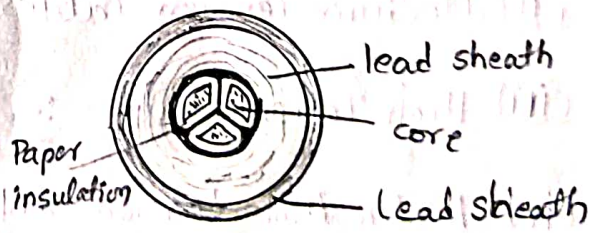
(i) copper conductor cables
(ii) Aluminium Conductor Cables

(b) **Number of cores:-** Based on the number of cores existing in the cables, it is classified into

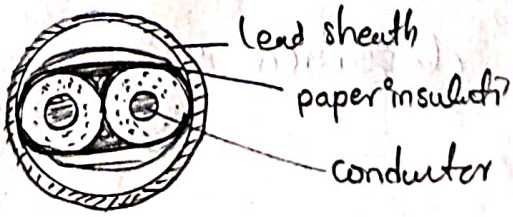
(i) Single core cables
(ii) two core cables
(iii) Three core and half core cable
(iv) Four core cables.



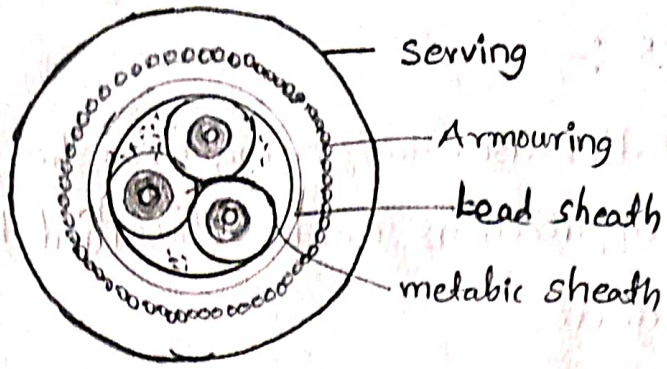
(i) Single - core cable



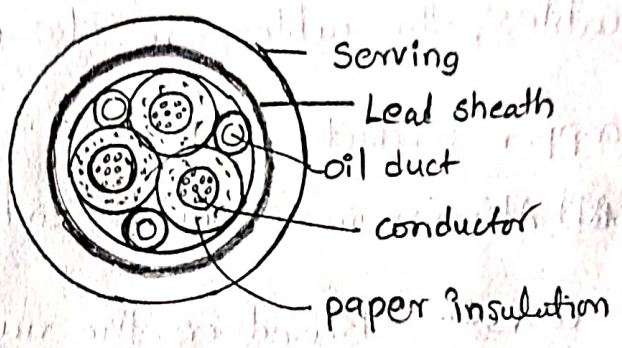
(iii) 3 - core cable



(ii) 2- core Cable



H-Type 3-core Cable



Oil filled three core cable

(c) Voltage grading :- Based on voltage leves classified as

(i) Low Tension (L.T) Cables :- These are used upto 6.6Kv

(ii) Medium Tension Cables :- used for 11 KV voltage levels.

(iii) High Tension cables :- used for 2.2 KV to 33 Kv levels

(iv) Extra High tension cables :- above 33 Kv levels.

(d) Type of insulation :- Based on type of insulation

Cables are classified as

(i) Vulcanized Indian Rubber (VIR) insulated cables
(ii) Cab type sheathed (CTS) cables
(iii) Polyvinyl chloride (PVC) cables
(iv) Lead sheath cables
(v) Weather proof cables
(vi) Cross linked polyethylen (XLPE) cables
(vii) Flexible cables

(e) Based on the application :- Cables are classified based application as aerospace cable, automotive cable, battery cable, switchboard cable, mining cable, power cable, solar cable etc.

In general the cable is classified into 4-categories

→ Twisted pair cables
→ Co-axial cables
→ Multi Conductor Cables
→ Fiber opic cables

Advatages of Cables :-

→ Require less maintenance
→ Voltage drop is less than overhead line
→ Possibility of accidents and faults are less
→ Beauty of towns and cities get's maintained.

Earthing :-

The connection of electrically conductive part of an electrical equipment to the ground with a conducting material (i.e earth plate (or) electrode) of very low resistance, is called "Earthing (or) Grounding".

→ In general glvanized iron is used for earthing purpose.

→ It helps in protecting the equipment and provides a return path for the leakage (or) fault current to pass to the ground.

Need (or) Importance of Earthing :-

(i) Protect the human lives and electrical equipment from fault currents.

(ii) Maintain the voltage at a constant level even when fault occurs in any system.

(iii) Protect the electrical equipment and buildings from over voltages occurring due to lightning.

(iv) Provide a return path for the fault current occurring in the system.

(v) Prevent fire in electrical systems.

(vi) It provides the low resistance path for fault current.

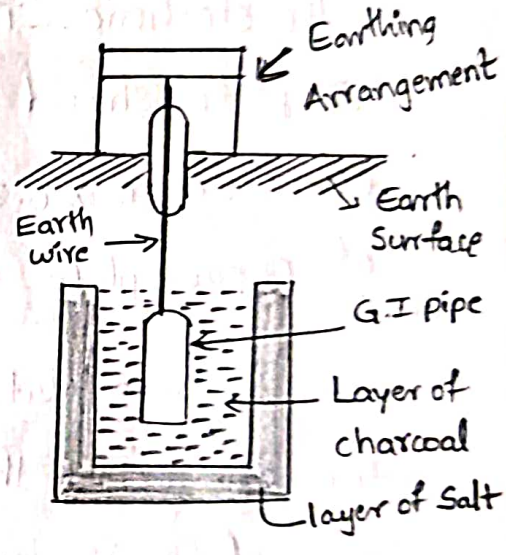
Methods of Earthing

We have 5-types of earthings

1. Pipe earthing
2. Plate earthing
3. Rod earthing
4. Earthing through water main
5. Horizontal strip earthing.

(1) Pipe earthing :-

In this method a galvanised iron (GI) pipe is used as an earth electrode. The length and diameter of pipe depends upon the current to be carried and soil type to which earth electrode is buried.

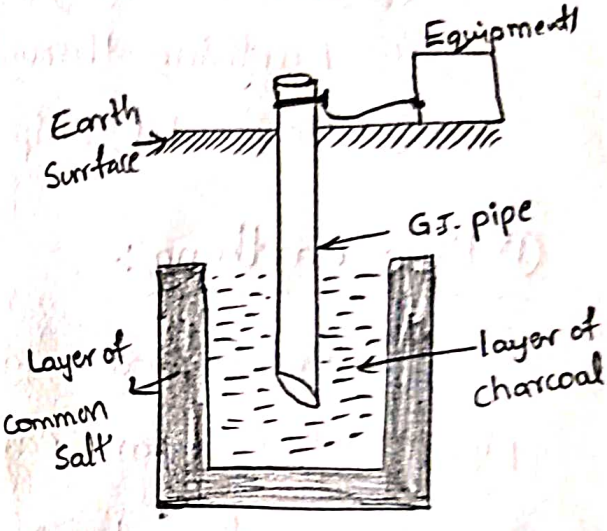


According to ISI-standard, the diameter of the pipe used to earthing should be greater the 3.81 cm and length of the pipe used should be 2m, 2.75 m and 1.75 m for ordinary, dry and rocky soils respt'ly.

In the underground, broken coke or charcoal piece is used to surround of GI pipe for a distance of 15cm. It is necessary since coke along with salt helps in decreasing the earth resistance.

Generally, alternate layers of coke and salt is used. In Summer to prevent the increase in earth resistance due to decrease in moisture level, bucket of water is poured to the funnel connected to GI pipe.

Plate Earthing :-



In this type of earthing GI or copper plate is used as an earth electrode. The size of this GI plate should be greater than 60 cm X 60 cm X 6.35 mm and the size of copper plate should be 60 cm X 60 cm X 3.18 mm

These plates with its face vertical is buried inside the ground so that the distance between the ground level and plate is greater than 2m. This plate shall be completely covered by 15 cm of coke and salt.

The earthing efficiency increases with the increases of the plate area and depth of embedding. If the resistivity of soil is high, it is necessary to embed the plate vertically at a greater depth into the ground.

Batteries :-

→ A device that converts the stored chemical energy into electrical energy using chemical action is called "Battery".

→ The chemical action that takes place in the battery is the movement of electrons from one terminal to another.

→ A Cell is a device that consists of two electrodes as Anode (+) & Cathode (-) and an electrolyte.

→ But battery is a single unit which comprises of two or more cell which are connected together electrically.

Types of Batteries

The two main categories of batteries are

① Primary batteries

② Secondary batteries

① Primary batteries :-

The batteries which used only single time and it cannot be recharge again, thus batteries are called Primary batteries. It's internal electrolytes of primary battery is utilized completely.

Examples :- Alkaline batteries, Mercury batteries
Silver-oxide batteries, Zinc Carbon batteries.

(ii) Secondary Batteries :-

The batteries that can be electrically recharged again are called "secondary batteries. By allowing the current in opposite direction, these batteries can be recharged.

Example :- Nickel cadmium battery
Lead-Acid battery
Lithium-ion battery.

Comparision between primary and Secondary batteries

primary battery	Secondary battery
→ Initial cost is less	→ Initial cost is high
→ cost per kWh is high	→ cost per kwh is less
→ these are disposable, their is no-requirement of maintenance	→ these are rechargeable, regular maintenance is require.
→ has good charge maintenance	→ has poor charge maintenance.
→ Not suitable for heavy load applications	→ It is suitable for heavy load applications.
→ These are mostly suited for portable application	→ Less suited for portable applications
→ these are limited to specific applications	→ these are mostly used in application
Ex :- Alkaline batteries Mercury batteries Silver oxide batteries	Ex :- Nickel cadmium battery Lead-Acid battery Lithium-ion battery

Applications of Primary batteries :-

The primary batteries are not suitable for heavy load application So these are generally use for limited applications.

→ Alkaline primary batteries are used in
  → remote controllers
  → clocks and radios
  → Digital Cameras
  → Hand held games
  → MP3 players.

→ Zinc - carbon batteries used in
  → flash lights, remote controls, toys, table clocks

→ Mercury batteries used in
  → Photographic light cameras
  → real-time clock of CPU.

→ Silver - oxide batteries used in
  → Calculators, ipods, digital diaries
  → wrist watches and stop watches
  → toys and artificial face makers
  → These used in military and submarines.

Applications of secondary batteries

→ Lead Acid batteries are used in
  → Automobile applications
  → lighting and security alarm systems
  → trains, lift, truck etc
  → as energy source in submarines

→ Nickel Cadmium batteries used in
  → flash lights, photo flash units
  → emergency lighting and alaram systems
  → air crafts, space satellite systems
  → starting of large diesel engines & turbines.

→ Lithium ion-batteries are used in
  → laptop computers and advanced cellular phones
  → used in military equipments like
    mine detectors, satellites, military radios
    thermal weapon sights.

These secondary batteries are having heavy load applications and cost per Kwh is less

Important Characteristics for Batteries :-

The various characterstics for batteries are

① Type of battery :- The based on type of battery i.e primary and secondary it is will be selected.

② Nominal voltage :- It is indicated on a battery depending on the amount of cells connected in series. The nominal voltage of battery is always less than the theorical voltage

③ Battery Capacity :- It is specified in Amp-hours (Ah)

It indicates the amount of electricity which a battery can supply at the specified dishcharge rate till its voltage falls to a specified value

$$\therefore \text{Battery Capacity} = I_D \times T_D \text{ (Ah)}$$

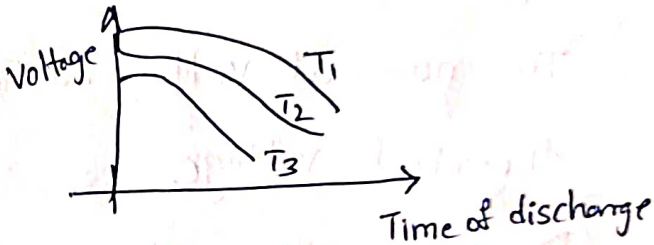
where $I_D \rightarrow$ dishcharge current

$T_D \rightarrow$ time for dishcharge.

④. Specific gravity of Electrolytic :- More the specific gravity of electrolyte, more is the battery capacity. It decides internal resistance of a battery.

(5) Specific Energy :- The battery capacity expressed in watt-hour per kg weight is called "Specific energy". It also called "gravimetric energy density of a battery".

(6) Electrical characteristics :- These characteristics includes, the charging and dishcharging curves for battery. It is the graph of termined voltage to charging (or) discharging time in hours.



(7) Power Density

The power obtained per unit weight of the cell is called "Power density" of battery it is measured in (W/kg).

(8) Service life :- The service life of a battery depends on two parameters as battery cycle life & battery shelf life.

(9) Cost :- Based on cost also we will prefer different batteries i.e their initial cost, cost of charging, maintenance cost etc.

(10) Battery efficiency :- It is defined as the ratio of the output dischcharging to the input required during charging to regain the original state of battery

$$\text{i.e } \eta_{Ah} = \left[\frac{\text{current} \times \text{time on discharge}}{\text{current} \times \text{time on charge}}\right] \times 100.$$

Elementary Calculations for Energy Consumption :-

→ The electrical energy consumption is calculated when electrical power is known, it means Energy and power are closely related.

→ We know that Electrical Power $(P) = \text{Voltage} \times \text{Current}$

→ The electrical energy is the product of electrical power and time i.e

$$\text{Energy} = \text{Power} \times \text{Time}$$

→ Units are "Watt-hour (or) Killowatthour (KWh).

* To calculate the consumption of an electrical appliances, following factors are required

i) Capacity of electrical appliance in watts
ii) Numbers of hours for which appliances is use in one day.
iii) Number of days per month (or) years as per the required energy calculation

⇒ Then Mathematically energy consumption of an appliance is given by

$$\text{KWh per month} = \frac{\left[\text{Capacity of appliance in Watts}\right] \times \left[\text{Number of hours/day}\right] \times \left[\text{Number of days/month}\right]}{1000}$$

→ in above equation 1000 division is to express energy consumption in KWh in units.

→ By calculation of energy consumption, the reasonable price is estimated.

Tariff : The reasonable price (or) rate at which the produced electrical energy is supplied to the consumer is defined as "tariff".

→ These tariff's rates are different for different factors as line

→ Nature of load
→ Maximum demand
→ Load requirement time
→ Load power factor.

* *

Problem :- Calculate total energy consumed per day by the use of following loads

(i) 10 number of 50w light operated 5 hours per day
(ii) 2 H.P motor is operated 4 hours per day
(iii) 5KW heater is operated 2 hours per day
(iv) 1 computer is used for 6 hours per day with printer 30 minutes.

Solu :- We have energy consumption equation is,

$$KWh = \frac{\left[\text{Capacity of appliance in watts}\right] \times \left[\text{No. of hour/day}\right] \times \left[\text{No. of days/month}\right]}{1000}$$

for load

(i) Lights

Energy consumption is $= \frac{[10 \times 50w] \times [5] \times [1/1]}{1000} = 2.5\ kWh$

(ii) 2 H.P motor

We have 1 H.P = 736 Watts

Energy consumption is $= \frac{(2 \times 736W)\ [4]\ [1]}{1000} = 5.888\ kWh$

(iii) Heater $E.C = \frac{[5\ kW] \times [2]\ [1]}{1000} = 10\ kWh$

(iv) Energy Consumption

Let [computer – 250w, printer – 400w]

for computer $= \frac{[250] \times 6 \times 1}{1000} = 1.5\ kWh$

for printer $= \frac{400 \times (\frac{1}{2}\ hour) \times 1}{1000} = 0.2\ kwh$

The

Total energy consumped per day $= 2.5 + 5.888 + 10 + 1.5 + 0.2$

$= 20.088\ Kwh$

If 1Kwh energy is 2/- then @ 1 units is 2 Ruppes.

Tariff is $\Rightarrow 2 \times 20.088 = Rs.40.176$ Total bill

Prob — The monthly electric consumption of a residential home is 123 units. Determine monthly bill for (i) Rs. 2.74 per unit for first 15 units (ii) Rs. 2.70 per unit for next 25 units and (iii) Rs.3 per unit for remaining. Also the surcharge is Rs.20 rupees per month.

(1)

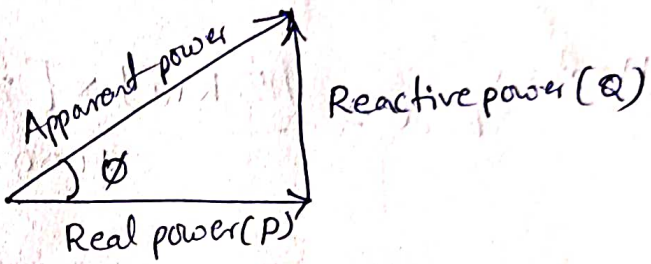
Power factor

The cosine of angle between voltage and current in an ac-circuit is known as "Power factor".

(or) It is fraction of active power to the apparent power

i.e $$\cos\phi = \frac{\text{Active power}}{\text{Apparent power}}$$

From power Triangle



→ The power factor value is varies between (0 to 1)

→ The most economical value of p.f is (0.9 and 0.95)

Causes of Low power factor :-

The different causes of low power factor are

(i) Single-phase and three-phase induction motors, these motors causes current lags the voltage by 90°, as it is purely inductive in nature.

(ii) Other inductive equipments, example transformer, generators, arc lamps, electric furnaces and so on

(iii) Load variation in the power system i.e if the power system is loaded lightly, the power factor becomes low.

(iv) Existence of harmonic current reduces the power factor.

(v) Imbalance in the power system due to improper wiring and electrical accident.

Effects of low power factors :-

→ current drawn by the circuit will be high

→ copper loss in the equipment will be high. so efficiency of the equipment decreases

→ Equipment gets overheated due to copper loss.

→ the size of the conducter has to be increased because high current drawing by circuit

→ voltage drop in the equipment will be increased

→ Leads to decrease in the active power.

Methods for improving power factors :-

Mainly we are using 3-types of methods for improving power factor as

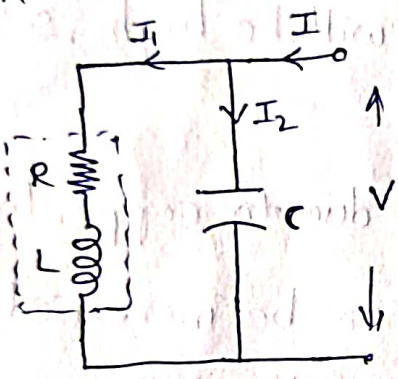
1. Static Capacitors
2. Synchronous condenser
3. Phase Advancer.

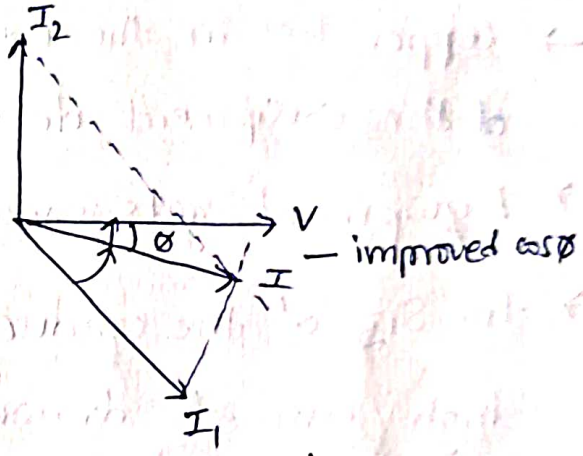
(P1)

① Static Capacitors :-

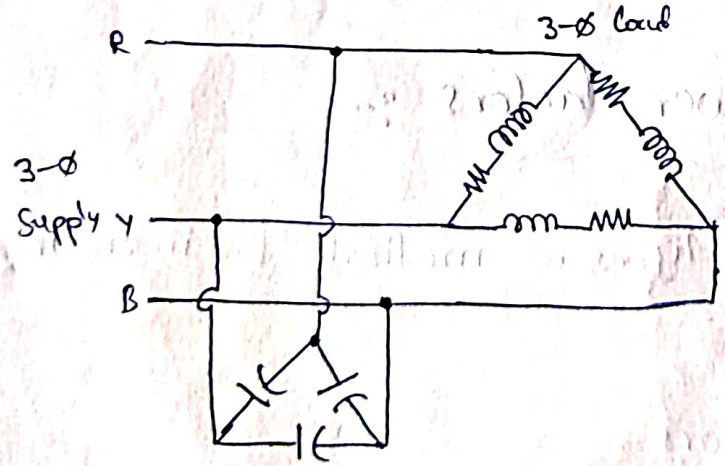
→ Static capacitors, are used as devices to improve or correct power factor of the system.

→ In single phase system, for improving the power factor, a capacitor is connected across the load as shown below.

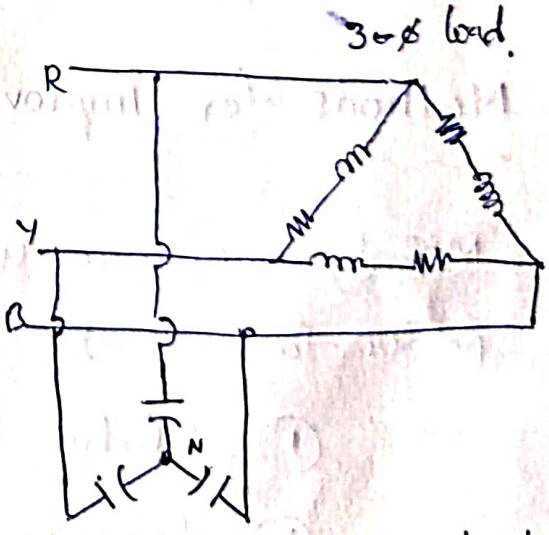




→ In a three-phase system, the capacitors bank arranged in delta (or) star connection for improve the power factor.



Delta connected capacitor Bank.



Star-connected capacitor bank

→ This is simplest method and easier installation, less weight.

(2) Synchronous Condensers:-

A synchronous motor takes a leading current when it is ~~excited~~ over-excited, then it behaves as a capacitor. At this time if it running no-load condition, it is called as synchronous condenser.

When such a machine is connected in parallel with the supply, it takes a leading current which partly neutralizes the lagging reactive component of the load, thus the power factor is improved.

(3) Phase Advancers:-

In an induction motor, the power factor is low because the stator winding draws lagging current from the supply.

→ Phase advancer, which can be used only in induction motors to improve power factor, is a simple AC-exciter.

→ It is mounted on the shaft of the induction motor and is connected to rotor circuit. Phase advancer supplies exciting ampere-turns to the rotor circuit of induction motor at slip frequency, which improves the power factor of induction motor.

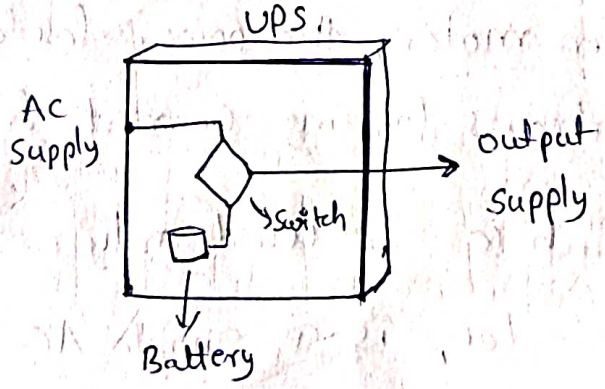
Battery Backup :-

Battery backup means to provide a continuous power supply to electrical (or) electronic equiments when the main grid fails (or) absence of main power.

→ It means it providing (or) supplies secondary power to the loads.

→ The main battery backup device is" UPS (Uninterruptable Power Supply) is commonly used in business and domestic applications.

→ The basic block diagram of battery backup device UPS, which is using two power sources as shown below.



Types of Battery backup devices:-

Based on operating of battery backup devices we have 3-types of device

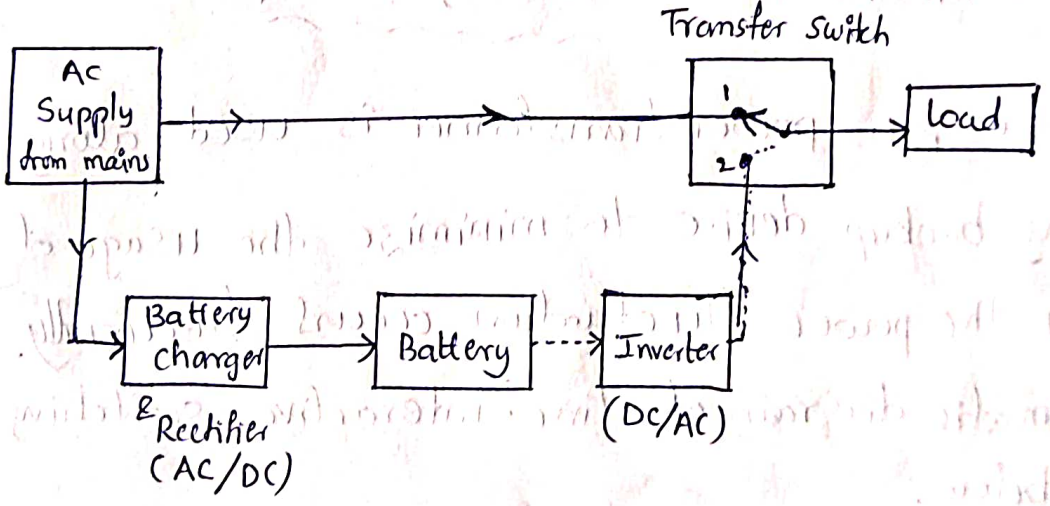
1. off-line device
2. line-interative device
3. On-line device.

→ Basically every battery backup system having four major blocks as

(i) Battery charger
(ii) Inverter
(iii) Switching control
(iv) Battery management system.

① Offline Switching of battery backup device (or) UPS

The schematic diagram of the offline switching in the battery backup device is shown in below figure.



In this device, the battery and inverter are normally not supplying power to the load, it means this inverter circuit is opened by transfer switch.

→ At this switching by battery charger which is having rectifier (i.e converts AC-to DC) circuit, it charge the

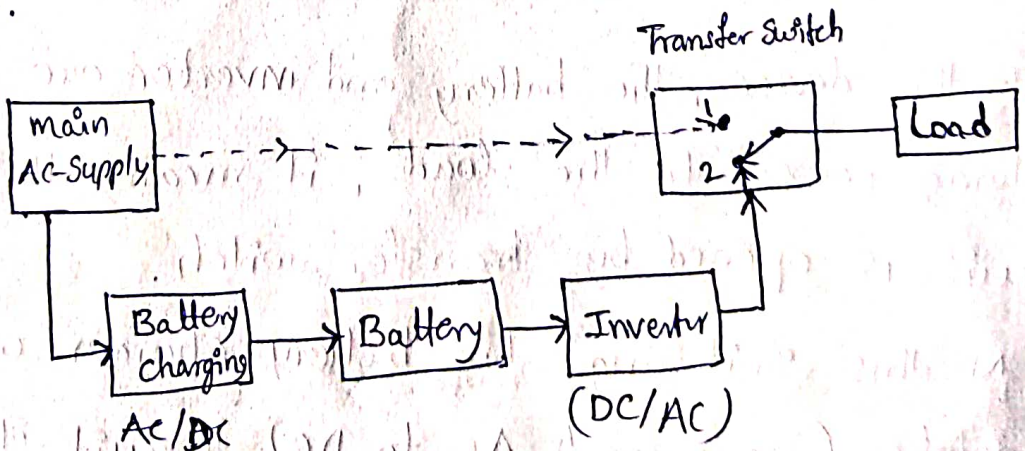
battery from supply mains. Here battery and ~~charger~~ inverter are waiting in stand by mode till they are needed. Hence the ups is called "Stand by UPS".

→ As main line is primary power source, it is also called "line preferred UPS.

→ When main supply is fails then by using switching mechanism we will connect battery & inverter to supply the power to the load.

(2) Line - interactive of battery backup device:-

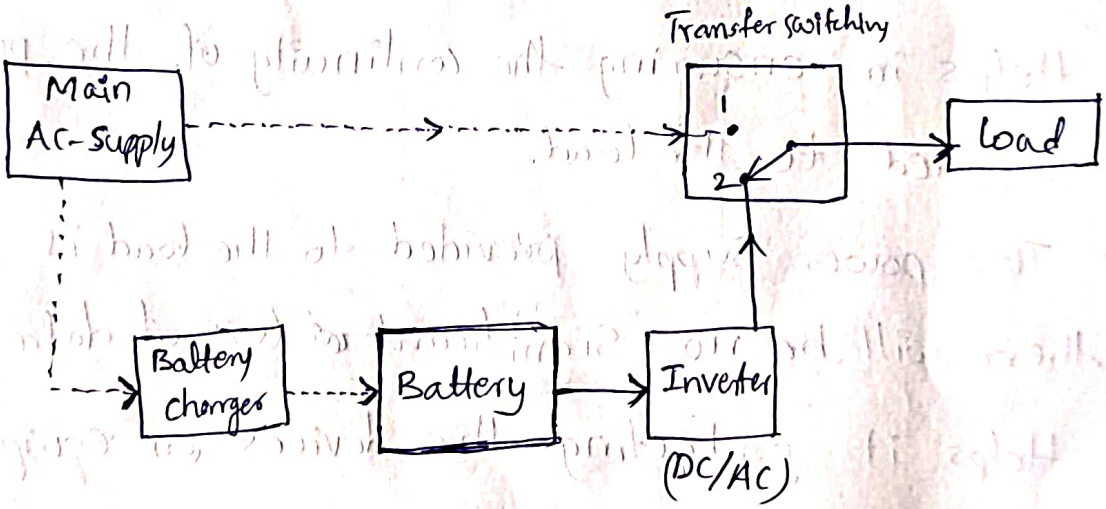
Here, a power transformer is used along with the battery backup device to minimize the usage of the UPS when the power fluctuation occurs frequently. The schematic diagram of line-interactive switching shown as below.



In this type of switching device, when the low voltage is recorded then battery backup device get activated. It is similar to the off-line device, this line-interactive device experiences a brief time delay.

③. ON-line switching of battery backup device :-

In this type switching device, the circuit is supplied with a constant power from the battery backup device as shown in below figure.



In this type, the battery backup device gets constantly charged while the battery is discharged based on the ongoing basis. When compared to the other two types, there exist no time lag since the battery backup device is constantly charged.

In this switching, the inverter gets the DC-supply from the battery which is continuously charged using the battery charge and the power obtained from the min supply.

Advatages of battery backup :-

→ Helps in maintaining the consistency in the power delivered to the load i.e it regulates the power during spikes, surges & other faults.

→ Helps in ensuring the continuity of the power supplied to the load.

→ The power supply provided to the load is continuous there will be no significant loss of data.

→ Helps it protecting the devices or equipment

→ There is no noise pollution.

X