MODULE-3

3a. Single Phase Transformers:

TRANSFORMER is a static device which transfers electric energy from one electric circuit to another at any desired voltage without any change in frequency.

PRINCIPLE:- A transformer works on the principle of mutual induction. "Whenever a change in current takes place in a coil there will be an induced emf in the other coil wound over the same magnetic core". This is the principle of mutual induction by which the two coils are said to be coupled with each other.

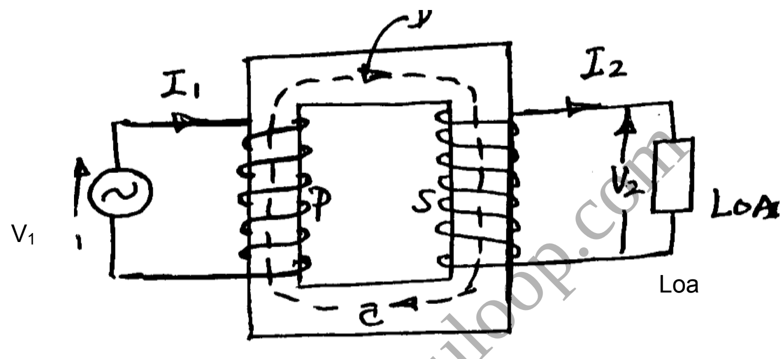

Fig.1

The fig1 shows the general arrangement of a transformer. C is the iron core made of laminated sheets of about 0.35mm thick insulated from one another by varnish or thin paper. The purpose of laminating the core is to reduce the power loss due to eddy currents induced by the alternating magnetic flux. The vertical portions of the core are called limbs and the top and bottom portions are called the yokes. Coils P and S are wound on the limbs. Coil P is connected to the supply and therefore called as the primary, coil S is connected to the load and is called as the secondary.

An alternating voltage applied to P drives an alternating current though P and this current produces an alternating flux in the iron core, the mean path of the flux is represented by the dotted line D. This flux links with the coil S and thereby induces an emf in S.

TYPES AND CONSTRUCTION OF TRANSFORMERS

There are two basic circuits in a transformer

1) **Magnetic circuit**
2) **Electric circuit**

The core forms the magnetic circuit and the electric circuit consists of two windings primary and secondary and is made of pure copper. There are two types of single phase transformers.

a) CORE TYPE

b) SHELL TYPE

Figs (a) and (b) shows the details of the elevation and plan of a core type transformer. The limbs are wound with half the L.V. and half the H.V. windings with proper insulation between them. The whole assembly taken inside a steel tank filled with oil for the purpose of insulation and cooling.

CORE TYPE TRANSFORMER.

In the core type the core is surrounded by the coils but in the shell type the core is on the either side of the coils. There are three limbs and the central limb is of large cross section than that of outer limbs, and both the LV and HV windings are wound on the central limb and the outer limb is only for providing the return path for the flux.

The windings are of concentric type (i.e. LV on which the HV windings) or Sandwich type.

The core is made of very thin laminations of high grade silicon steel material to reduce the eddy current loss and Hysteresis losses in the core.

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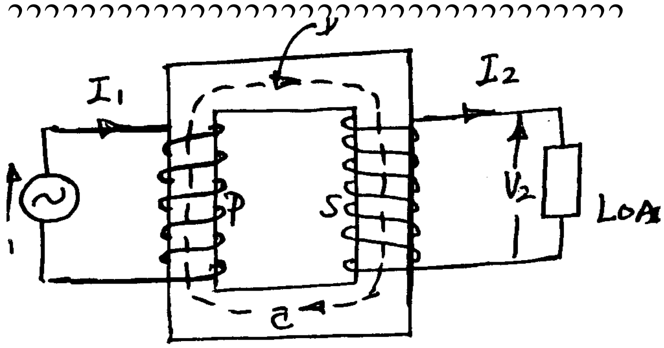


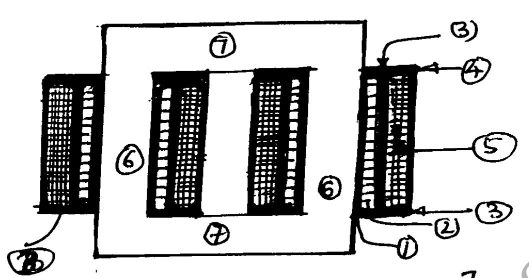
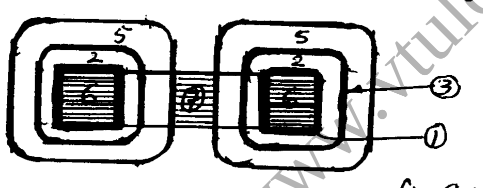


Fig (a)

nd



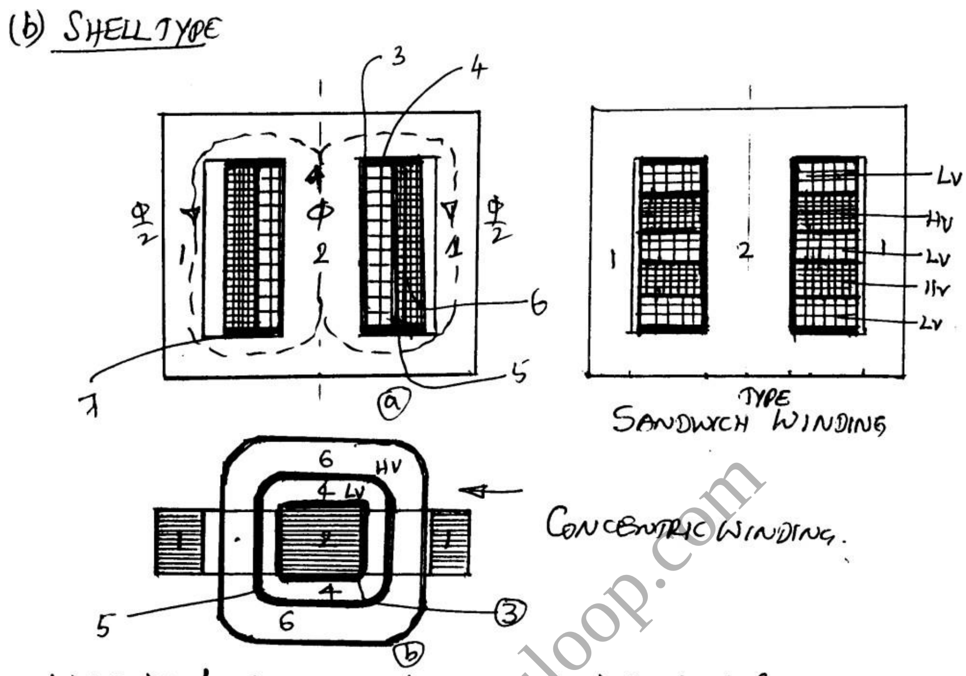
1- Insulation between L V

and the core.
2- L V winding.
3- Insulation between L V
winding.

the yoke.
5- H V winding.
6- Limbs.
7- Yoke.

FIG. (b)

SHELL TYPE TRANSFORMER.



1 – Outer limbs, 4 – L V winding

2 – Central limb, 5 – Insulation between L V and H V windings.

3 – Insulation between L V and Core. 6 – H V winding. 7 – End insulation

In the shell type transformers the core is of different type having three limbs with the central limb of larger cross section compared to the two outer limbs and carries both the L V and H V windings wound over each other with proper insulation between them. The entire assembly is immersed in a steel tank filled with oil for the cooling purpose.

EMF EQUATION:

Principle: - Whenever a coil is subjected to alternating flux, there will be an induced emf in it and is called the statically induced emf $e = \frac{Nd\phi}{dt}$

Let N_1, N_2 be the no. of turns of the primary and secondary windings, E_1, E_2 the induced emf in the primary and secondary coils. ϕ be the flux which is sinusoidal f be the frequency in Hz

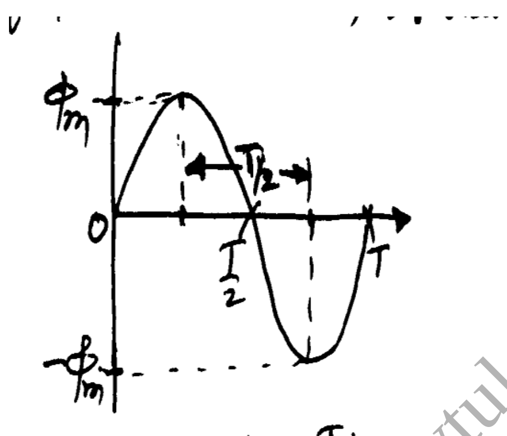


Figure showing the sinusoidally varying flux of peak value $\mathbf{\Phi_m}$ **.**

Whenever a coil of **N** no- of tunes are linked by a time varying flux ϕ, the average emf induced in this coil is

$$e = \frac{Nd\phi}{dt}$$

As the flux is sinusoidal the change in flux from + ϕ_m **to -** ϕ_m is d ϕ **= 2** ϕm, and this change takes place in a duration dt = T/2 seconds.

The average induced emf in these N number of turns is

$$\mathbf{E_{avg} = N.d\phi/dt = N.2\phi_m / (T/2) = 4\phi_m N/T = 4f\phi_m N \text{ volts (as } f = 1/T)}$$

We know that the Form factor of a pure sine wave **F.F. =** $\mathbf{E_{rms}/E_{avg} = 1.11}$

Therefore, $\mathbf{E_{rms} = 1.11\ E_{avg.}}$

$= \mathbf{(1.11)\ (4f\phi_m N) = 4.44\ f\phi_m N}$ **volts.**

In the primary coil, $\mathbf{N = N_1}$, $\mathbf{E1 = 4.44f\phi_m N_1}$ **volts**

In the secondary coil, $N = \mathbf{N_2}$, $\mathbf{E_2 = 4.44f\phi_m N_2}$ **volts**

TRANSFORMATION RATIO:

It is defined as the ratio of the secondary induced emf to the primary induced emf.

Therefore, $\mathbf{E_1 / E_2 = N_1 / N_2 = K}$

For an ideal (loss free) transformer, the input power is equal to the output power.

Therefore $\mathbf{E_1 I_1 = E_2 I_2}$, from which, $\mathbf{E_2/E_1 = I_1/I_2}$

Also the induced emf per turn is same for both the primary and secondary turns.

If the value of the transformation ratio **K>1,** then it is a **step up** case.

If the value of the transformation ratio **K<1**, then it is a **step down** case.

If the value of the transformation ratio **K=1**, then it is a **one:one** transformer.

LOSSES AND EFFICIENCY:

There a two types of power losses occur in a transformer

1) Iron loss

2) Copper loss

1) Iron Loss: This is the power loss that occurs in the iron part. This loss is due to the alternating frequency of the emf. Iron loss in further classified into two other losses.

a) Eddy current loss **b) Hysteresis loss**

a) **EDDY CURRENT LOSS:** This power loss is due to the alternating flux linking the core, which will induced an emf in the core called the eddy emf, due to which a current called the eddy current is being circulated in the core. As there is some resistance in the core with this eddy current circulation converts into heat called the eddy current power loss. Eddy current loss is proportional to the square of the supply frequency.

b) **HYSTERISIS LOSS**: This is the loss in the iron core, due to the magnetic reversal of the flux in the core, which results in the form of heat in the core. This loss is directly proportional to the supply frequency.

Eddy current loss can be minimized by using the core made of thin sheets of silicon steel material, and each lamination is coated with varnish insulation to suppress the path of the eddy currents.

Hysteresis loss can be minimized by using the core material having high permeability.

2) COPPER LOSS: This is the power loss that occurs in the primary and secondary coils when the transformer is on load. This power is wasted in the form of heat due to the resistance of the coils. This loss is proportional to the sequence of the load hence it is called the Variable loss whereas the Iron loss is called as the Constant loss as the supply voltage and frequency are constants

EFFICENCY: It is the ratio of the out put power to the input power of a transformer

Input = Output + Total losses

= Output + Iron loss + Copper loss

$$\eta = \frac{outputpower}{outputpower + Ironloss + copperloss}$$

$$= \frac{V_2 I_2 \cos\phi}{V_2 I_2 \cos\phi + W_{eron} + W_{copper}}$$

Where, V_2 is the secondary (out put) voltage, I_2 is the secondary (out put) current and cos**Φ** is the power factor of the load.

The transformers are normally specified with their ratings as KVA,

Therefore,

$$\text{Efficiency} = \frac{(KVA)(10^3)\cos\Phi}{(KVA)(10^3)\cos\Phi + W_{iron} + W_{copper}}$$

Since the copper loss varies as the square of the load the efficiency of the transformer at any desired load x is given by

$$\text{Efficiency} = \frac{x.\ (KVA)(10^3)\cos\Phi}{x.\ (KVA)(10^3)\cos\Phi + W_{iron} + (x)^2\, W_{copper}}$$

Where W_{copper} is the copper loss at full load

$W_{copper} = I^2R$ watts

CONDITION FOR MAXIMUM EFFICIENCY:

In general for the efficiency to be maximum for any device the losses must be minimum. Between the iron and copper losses the iron loss is the fixed loss and the copper loss is the variable loss. When these two losses are equal and also minimum the efficiency will be maximum.

Therefore the condition for maximum efficiency in a transformer is

Iron loss = Copper loss (whichever is minimum)

VOLTAGE REGULATION:

The voltage regulation of a transformer is defined as the change in the secondary terminal voltage between no load and full load at a specified power factor expressed as a percentage of the full load terminal voltage.

$$\text{(Percentage Voltage Regulation)} = \frac{\text{(No load secondary voltage)-(Full load secondary voltage)}}{\text{(Full load secondary voltage)}} \times 100$$

Voltage regulation is a measure of the change in the terminal voltage of a transformer between No load and Full load. A good transformer has least value of the regulation of the order of ±5%

1. A 600 KVA transformer has an efficiency of 92% at full load, uni8ty p.f. and at half load, 0.9 p.f. determine its efficiency of 75% of full load and 0.9 p.f.

Sol. : S = 600 KVA, % η = 92% on full load and half load both

$$\text{On full load, } \%\,\eta = \frac{(\textbf{VA rating})\cos\emptyset_2}{(\textbf{VA rating})\cos\emptyset_2 + \mathbf{P_i} + (\mathbf{P_{cu}})\mathbf{F.L.}} \times 100$$

$$0.92 = \frac{600 \times 10^3 \times 1}{600 \times 10^3 \times \mathbf{P_i} + (\mathbf{P_{cu}})\mathbf{F.L.}}$$

$$\mathbf{P_i} + (\mathbf{P_{cu}})\mathbf{F.L.} = 52173.91 \quad \ldots\ldots\ldots (1)$$

On half load, $\mathbf{n} = \frac{1}{2}$ and

$$(\mathbf{P_{cu}})\mathbf{H.L.} = \mathbf{n}^2(\mathbf{P_{cu}})\mathbf{F.L.} = \frac{1}{4}(\mathbf{P_{cu}})\mathbf{F.L.}$$

$$0.92 = \frac{\frac{1}{2} \times 600 \times 10^3 \times 0.9}{\frac{1}{2} \times 600 \times 10^3 \times 0.9 + \mathbf{P_i} + \frac{1}{4}(\mathbf{P_{cu}})\mathbf{F.L.}}$$

$$\mathbf{P_i} + 0.25(\mathbf{P_{cu}})\mathbf{F.L.} = 23478.261 \quad \ldots\ldots\ldots\ldots (2)$$

Subtracting (2) from (1),

$0.75(P_{cu})F.L. = 28695.64$

$(P_{cu})F.L = 38260.86$ watts

and $P_i = 13913.04$ watts

Now $n = 0.75$ i.e., 75% of full load and $\cos\Phi_2 = 0.9$

(P_{cu}) new $= n^2 (P_{cu})$ F.L. $= (0.75)^2 \times (P_{cu})$ F.L. .

$$\% \eta = \frac{n(\text{VA rating})\cos\emptyset_2}{n(\text{VA rating})\cos\emptyset_2 + P_i + (P_{cu})\text{new}} \times 100$$

$$= \frac{0.75 \times 600 \times 10^3 \times 0.9}{0.75 \times 600 \times 10^3 \times 0.9 + 13913.04 + (0.75)^2 \times 38260.86} \times 100$$

$= 91.95\%$

2.Transformer has 80 turns on the secondary.

Calculate:

i) The rated primary and secondary currents
ii) The number of primary turns
iii) The maximum value of flux
iv) Voltage induced per turn.

Sol: KVA rating = 250

$V_1 = 11000$ volts

$V_2 = 415$ volts

$N_2 = 80$

$$\frac{N_2}{N_1} = \frac{V_2}{V_1}$$

$$N_1 = \frac{N_2}{\left(\frac{V_2}{V_1}\right)} = N2\left(\frac{V_1}{V_2}\right) = 80\left(\frac{11000}{415}\right) = 2120$$

$N_1 = 2120$

$KVA = V_1 I_1 = V_2 I_2$

$I_1 = \frac{KVA}{V_1} = \frac{250 \times 10^3}{11000} = 22.72A$

$I2 = \frac{KVA}{V_2} = \frac{250 \times 10^3}{415} = 602.40A$

Neglecting drops in primary,

$V1 = E1 = 11000$

$E1 = 4.44f \phi_m \times N1$

$\therefore \quad \frac{11000}{4.44 \times 50 \times 2120} = \phi_m$

$\therefore \quad \phi_m = 0.023 \text{ Wb} = 23 \text{ mWb}$

Voltage induced per turn = $\frac{E_1}{N_1} = \frac{11000}{2120} = 5.1886$ volts.

3. In a 25 kVA, 2000/200 V Transformer, the iron and copper losses are 350 watts and 400 watts respectively, calculate the efficiency at U.P.F. at half and 3/4th full load.

Sol.: $S = 25 \text{ k V A}$

$P_i = 350$ W, $(P_{cu})FL = 400$ W

i) At half load, $\cos \emptyset = 1$

$$\frac{(P_{cu})H.L.}{(P_{cu})F.L.} = \left[\frac{I_{HL}}{I_{FL}}\right]^2 = \left[\frac{\frac{1}{2} I_{FL}}{I_{FL}}\right]^2 = \frac{1}{4}$$

$$(P_{cu})_{HL} = \frac{1}{4} \times 400 = 100 \text{ W}$$

$$\% \text{ Efficiency} = \frac{\textbf{kVA rating} \times \cos\emptyset}{\textbf{kVA rating} \times \cos\emptyset + \mathbf{P_i} + \mathbf{P_{cu}}} \times 100$$

$$= \frac{\frac{1}{2} \times 25 \times 1 \times 10^3}{\frac{1}{2} \times 25 \times 1 \times 10^3 + 350 + 100} \times 100$$

$$= \frac{12.5 \times 10^3}{12.5 \times \mathbf{IC}^3 + 450} \times 100$$

$\therefore$ % Efficiency = 96.525

ii) At $\frac{3}{4}$ th load, $\cos\emptyset = 1$

$$\frac{(\mathbf{P_{cu}})\frac{3}{4}\textbf{load}}{(\mathbf{P_{cu}})\textbf{F. L.}} = \left(\frac{\mathbf{I}_{\frac{3}{4}}}{\mathbf{I_{FL}}}\right)^2$$

$$(\mathbf{P_{cu}})\frac{3}{4}\textbf{load} = \left(\frac{3}{4}\right)^2 \times \mathbf{P_{cu\,FL}} = \frac{9}{16} \times 400 = 225\ \mathbf{W}$$

$$\% \text{ Efficiency} = \frac{\textbf{kVA rating} \times \cos\emptyset}{\textbf{kVA rating} \times \cos\emptyset + \mathbf{P_i} + \mathbf{P_{cu}}} \times 100$$

$$= \frac{\frac{3}{4} \times 25 \times 10^3 \times 1}{\frac{3}{4} \times 25 \times 10^3 + 350 + 225} \times 100$$

$\therefore$ % Efficiency = 97.02%

4. A 600 KVA transformer has an efficiency of 92% at full load, uni8ty p.f. and at half load, 0.9 p.f. determine its efficiency of 75% of full load and 0.9 p.f.

Sol. : S = 600 KVA, % η = 92% on full load and half load both

On full load, % η = $\frac{(\text{VA rating})\cos\emptyset_2}{(\text{VA rating})\cos\emptyset_2 + P_i + (P_{cu})F.L.} \times 100$

$$0.92 = \frac{600 \times 10^3 \times 1}{600 \times 10^3 \times P_i + (P_{cu})F.L.}$$

$P_i + (P_{cu})F.L. = 52173.91$ ………… (1)

On half load, $n = \frac{1}{2}$ and

$(P_{cu})H.L. = n^2 (P_{cu})F.L. = \frac{1}{4}(P_{cu})F.L.$

$$0.92 = \frac{\frac{1}{2} \times 600 \times 10^3 \times 0.9}{\frac{1}{2} \times 600 \times 10^3 \times 0.9 + P_i + \frac{1}{4}(P_{cu})F.L.}$$

$P_i + 0.25(P_{cu})F.L. = 23478.261$ ………….. (2)

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Now n = 0.75 i.e., 75% of full load and $\cos \Phi_2 = 0.9$

(P_{cu}) new = $n^2 (P_{cu})$ F.L. = $(0.75)^2 \times (P_{cu})F.L$.

$$\% \eta = \frac{n(\text{VA rating})\cos\emptyset_2}{n(\text{VA rating})\cos\emptyset_2 + P_i + (P_{cu})\text{new}} \times 100$$

$$= \frac{0.75 \times 600 \times 10^3 \times 0.9}{0.75 \times 600 \times 10^3 \times 0.9 + 13913.04 + (0.75)^2 \times 38260.86} \times 100$$

= 91.95%

3b. Domestic Wiring:

Introduction

A network of wires drawn connecting the meter board to the various energy consuming loads (lamps, fans, motors etc) through control and protective devices for efficient distribution of power is known as electrical wiring.

Electrical wiring done in residential and commercial buildings to provide power for lights, fans, pumps and other domestic appliances is known as domestic wiring. There are several wiring systems in practice. They can be classified into:

Types of wiring: Depending upon the above factors various types of wiring used in practice are:

1. Cleat wiring
2. Casing wiring
3. Surface wiring
4. Conduit wiring

i) Clear wiring:

In this type V.I.R or P.V.C wires are clamped between porcelain cleats.

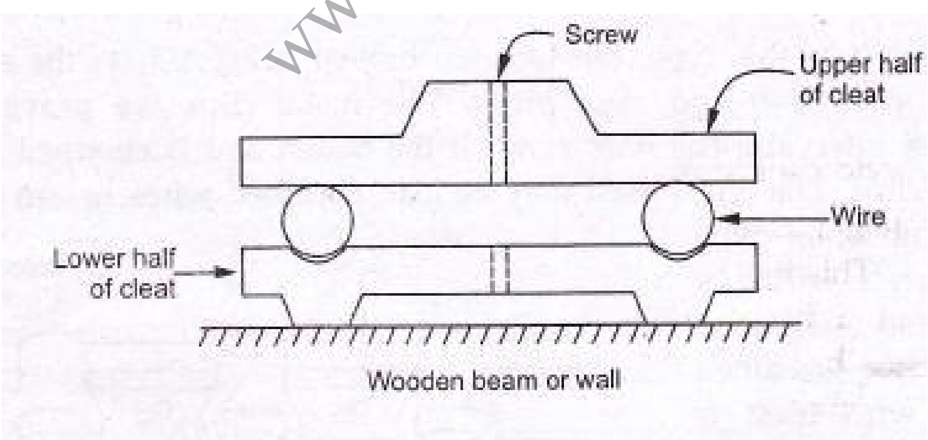


Fig. 16 Cleat wiring

The cleats are made up of two halves. One half is grooved through which wire passes while the other fits over the first. The whole assembly is then mounted on the wall or wooden beam with the help of screws.

This method is one of the cheapest method and most suitable for temporary work. It can be very quickly installed and can be recovered without any damage of material. Inspection and changes can be made very easily.

This method does not give attractive appearance. After some time due to sagging at some places, it looks shabby. Dust and dirt collects on the cleats. The wires are directly exposed to atmospheric conditions like moisture, chemical fumes etc. maintenance cost is very high.

Due to these disadvantages this type is not suitable for permanent jobs.

ii) Casing capping: This is very popularly used for residential buildings. In this method, casing is a rectangular strip made from teak wood or new a day"s made up of P.V.C. It has two grooves into which the wires are laid. Then casing is covered with a rectangular strip of wood or P.V.C. of the same width, called capping. The capping is screwed into casing is fixed to the walls the help or porcelain discs or cleats.

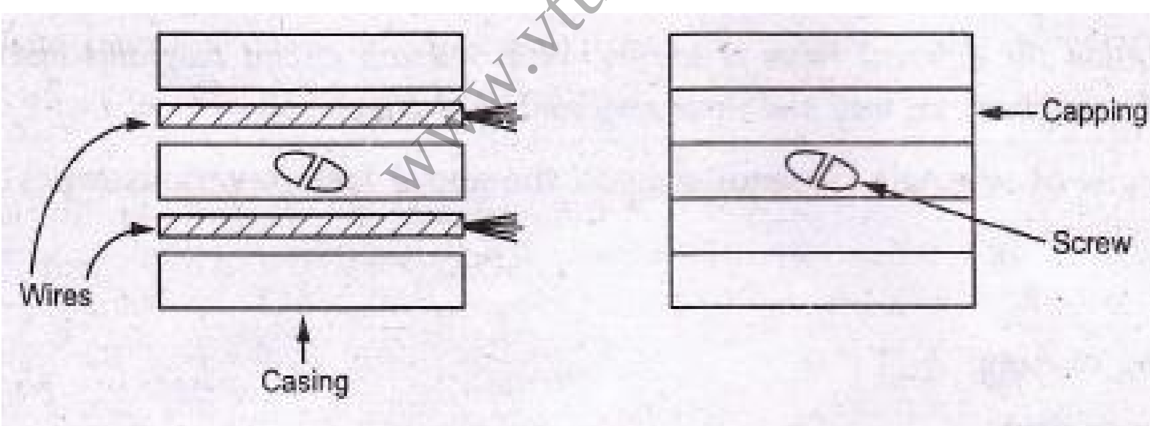


Fig. 17 Casing capping

Good protection to the conductors from dangerous atmospheric conditions, neat and clean appearance are the advantages of this type.

In case of wooden casing capping, there is high risk of fire along with the requirement of skilled labour. The method is costly.

Surface wiring: in this type, the wooden battens are fixed on the surface of the wall, by means of screws and rawl plugs. The metal clips are provided with the battens at regular intervals. The wire runs on the batten and is clamped on the batten using the metal clips. The wires used may lead sheathed wires or can tyre sheathed wires. Depending upon type of wire used surface wiring is also called lead sheathed wiring or cab tyre sheathed wiring. If the wire used is though rubber Sheathed then it is called T.R.S. wiring while if the wire used is cab tyre Sheathed Then it is called C.T.S wiring.

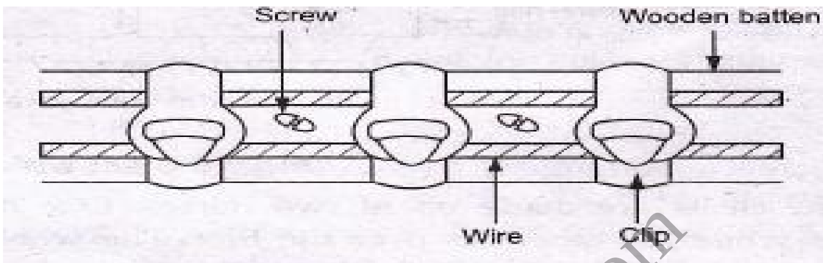


Fig. 18 Wooden batten wiring

Conduit wiring: In this method, metallic tubes called as conduits are used to run the wires. This is the best system of wiring as it gives full mechanical protection to the wires. This is most desirable for workshops and public Buildings. Depending on whether the conduits are laid inside the walls or supported on the walls, there are two types of conduit wiring which are :

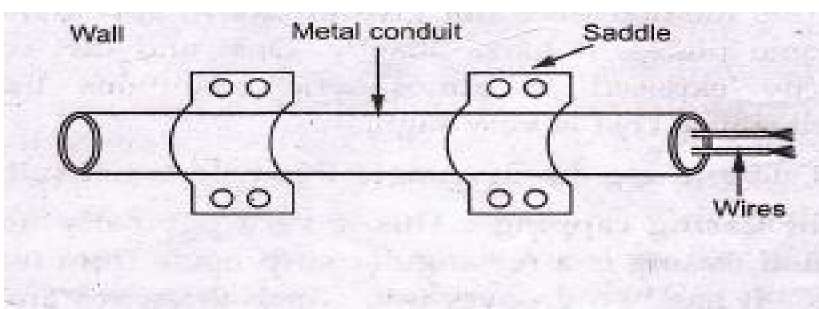


Fig. 19 Surface conduit wiring

i) Surface conduit wiring: in this method conduits are mounted or supported on the walls with the help of pipe books or saddles. In damp situations, the conduits are spaced apart from the wall by means of wooden blocks.

ii) Concealed conduit wiring: In this method, the conduit are buried under the wall at the some of plastering. This is also called recessed conduit wiring.

The beauty of the premises is maintained due to conduit wiring. It is durable and has long life. It protects the wires from mechanical shocks and fire hazards. Proper earthing of conduits makes the method electrical shock proof. It requires very less maintenance.

The repairs are very difficult in case of concealed conduit wiring. This method is most costly and erection requires highly skilled labour. These are few disadvantages of the conduit type of wiring. In concealed conduit wiring, keeping conduit at earth potential is must.

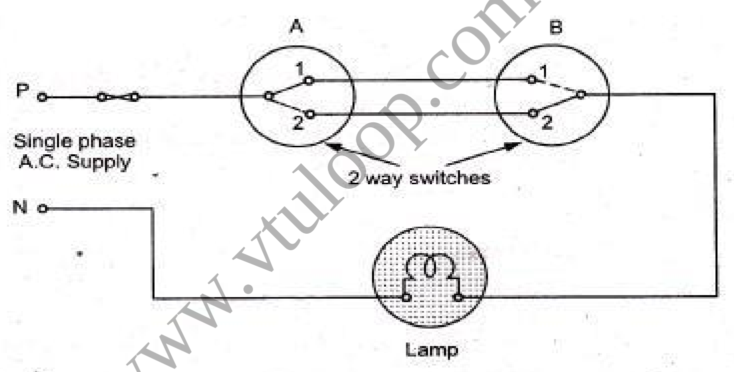


Fig. 20 Control of one from two points

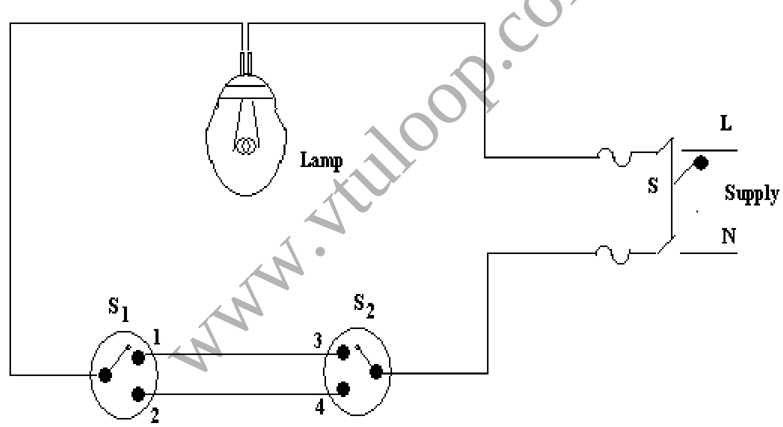
Two- way and Three- way Control of Lamps:

The domestic lighting circuits are quite simple and they are usually controlled from one point. But in certain cases it might be necessary to control a single lamp from more than one point (Two or Three different points).

For example: staircases, long corridors, large halls etc.

Two-way Control of lamp:

Two-way control is usually used for staircase lighting. The lamp can be controlled from two different points: one at the top and the other at the bottom - using two- way switches which strap wires interconnect. They are also used in bedrooms, big halls and large corridors. The circuit is shown in the following figure.



Two -way control of lamp

Switches **S_1** and **S_2** are two-way switches with a pair of terminals 1&2, and 3&4 respectively. When the switch **S_1** is in position**1** and switch **S_2** is in position **4**, the circuit does not form a closed loop and there is no path for the current to flow and hence the lamp will be **OFF.** When **S_1** is changed to position **2** the circuit gets completed and hence the lamp glows or is **ON**. Now if **S_2** is changed to position **3** with **S_1** at position **2** the circuit continuity is broken and the lamp is off. Thus the lamp can be controlled from two different points.

Position of S1	Position of S2	Condition of lamp
1	3	ON
1	4	OFF
2	3	OFF
2	4	ON

Three- way Control of lamp:

In case of very long corridors it may be necessary to control the lamp from 3 different points. In such cases, the circuit connection requires two; two-way switches **S_1**and **S_2** and an intermediate switch **S_3**. An intermediate switch is a combination of two, two way switches coupled together. It has 4 terminals ABCD. It can be connected in two ways

a) Straight connection

b) Cross connection

In case of straight connection, the terminals or points AB and CD are connected as shown in figure 1(a) while in case of cross connection, the terminals AB and

C D is connected as shown in figure 1(b). As explained in two –way control the lamp is ON if the circuit is complete and is OFF if the circuit does not form a closed loop.

Three -way control of lamp

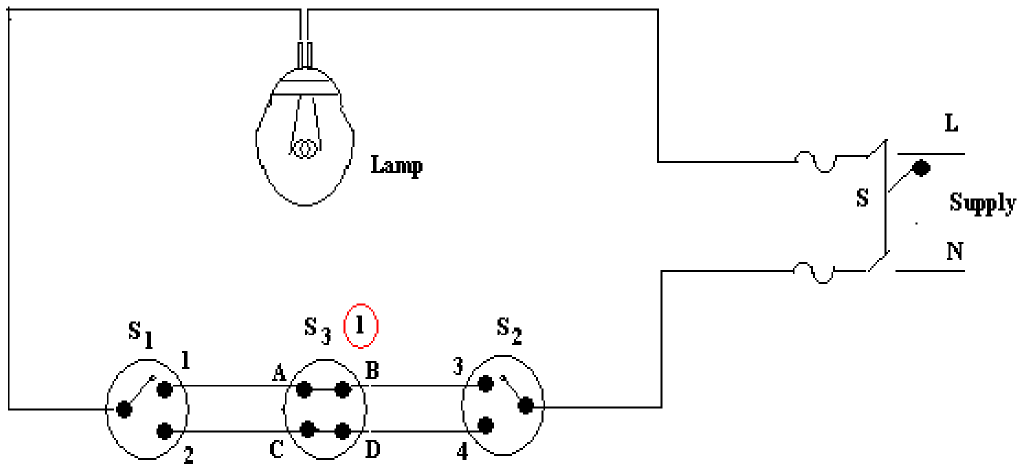


Figure 1 (a) Straight connection

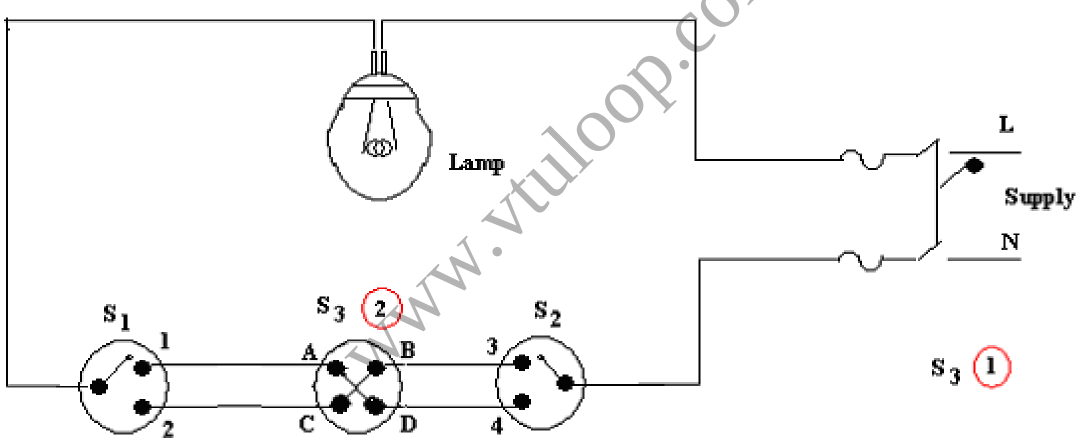


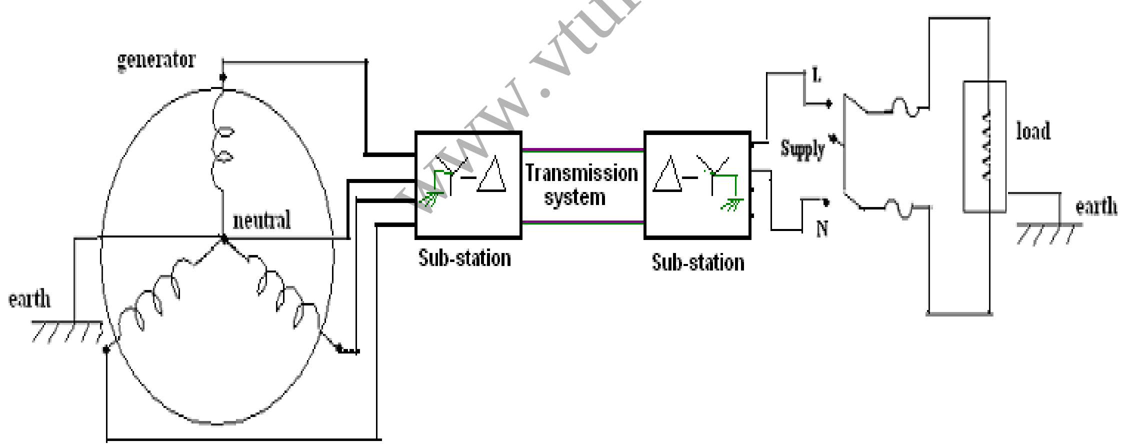
Figure 1 (b) Cross connection

The condition of the lamp is given in the table depending on the positions of the switches **S_1**, **S_2** and **S_3**.

EARTHING:

The potential of the earth is considered to be at zero for all practical purposes as the generator (supply) neutral is always earthed. The body of any electrical equipment is connected to the earth by means of a wire of negligible resistance to safely discharge electric energy, which may be due to failure of the insulation, line coming in contact with the casing etc. Earthing brings the potential of the body of the equipment to ZERO i.e. to the earth‟s potential, thus protecting the operating personnel against electrical shock. The body of the electrical equipment is not connected to the supply neutral because due to long transmission lines and intermediate substations, the same neutral wire of the generator will not be available at the load end. Even if the same neutral wire is running it will have a self-resistance, which is higher than the human body resistance. Hence, the body of the electrical equipment is connected to earth only.

Thus earthing is to connect any electrical equipment to earth with a very low resistance wire, making it to attain earth‟s potential. The wire is usually connected to a copper plate placed at a depth of 2.5 to 3meters from the ground level.



BLOCK DIAGRAM

The earth resistance is affected by the following factors:

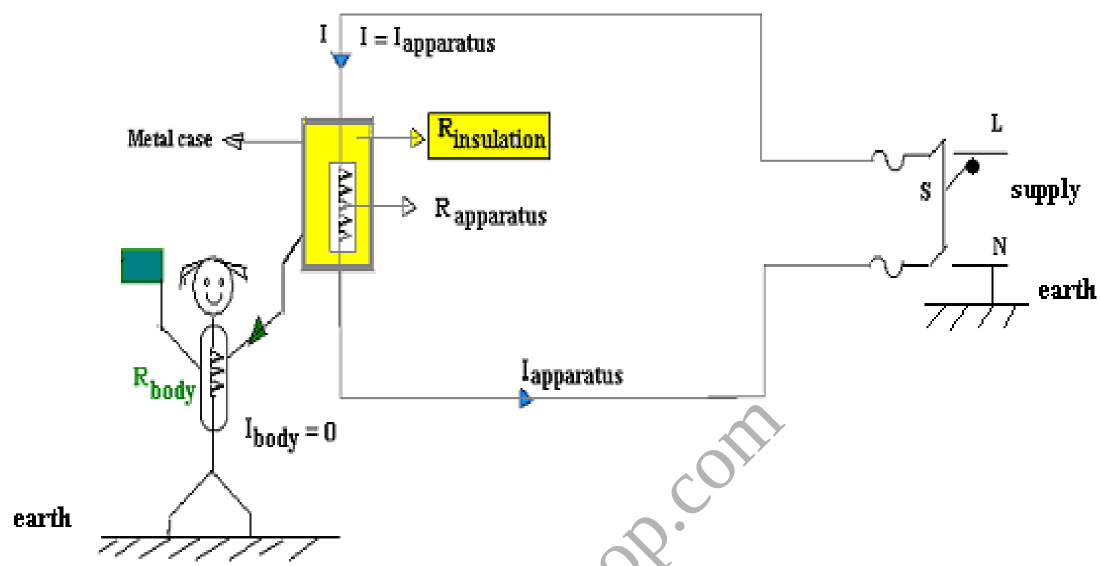
1. Material properties of the earth wire and the electrode
2. Temperature and moisture content of the soil
3. Depth of the pit
4. Quantity of the charcoal used

The importance of earthing is illustrated in the following figures

Case I

Healthy insulation

Apparatus not earthed

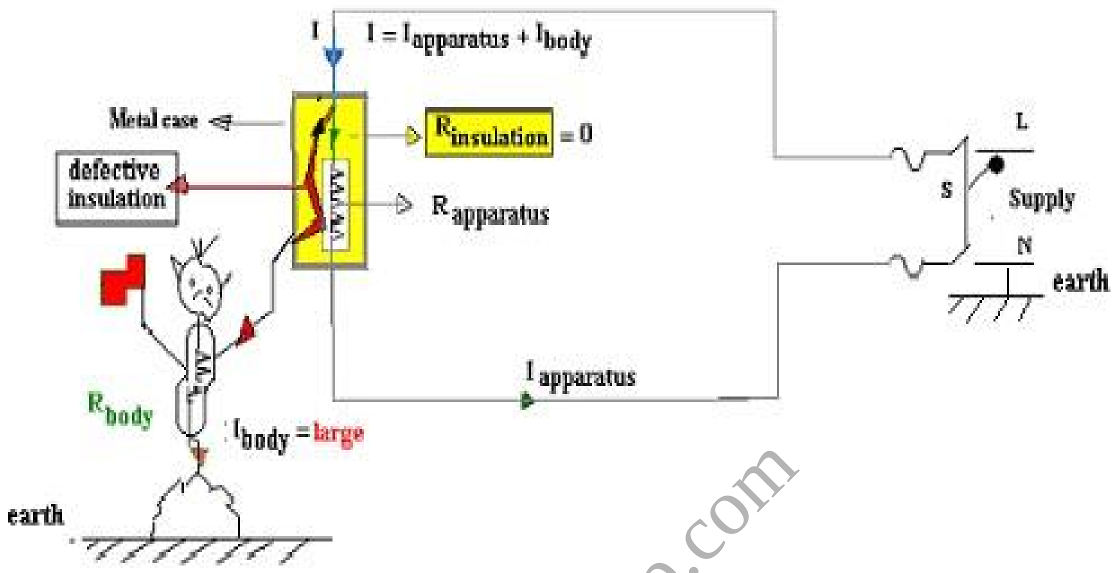


1. Insulation is healthy (R insulation $= \infty$)
2. Supply current flows through the resistence of the apparatus only ($R_{apparatus}$)
3. No current flows through the body resistance ($I_{body} = 0$)
4. The person is safe even if the apparatus is not earthed

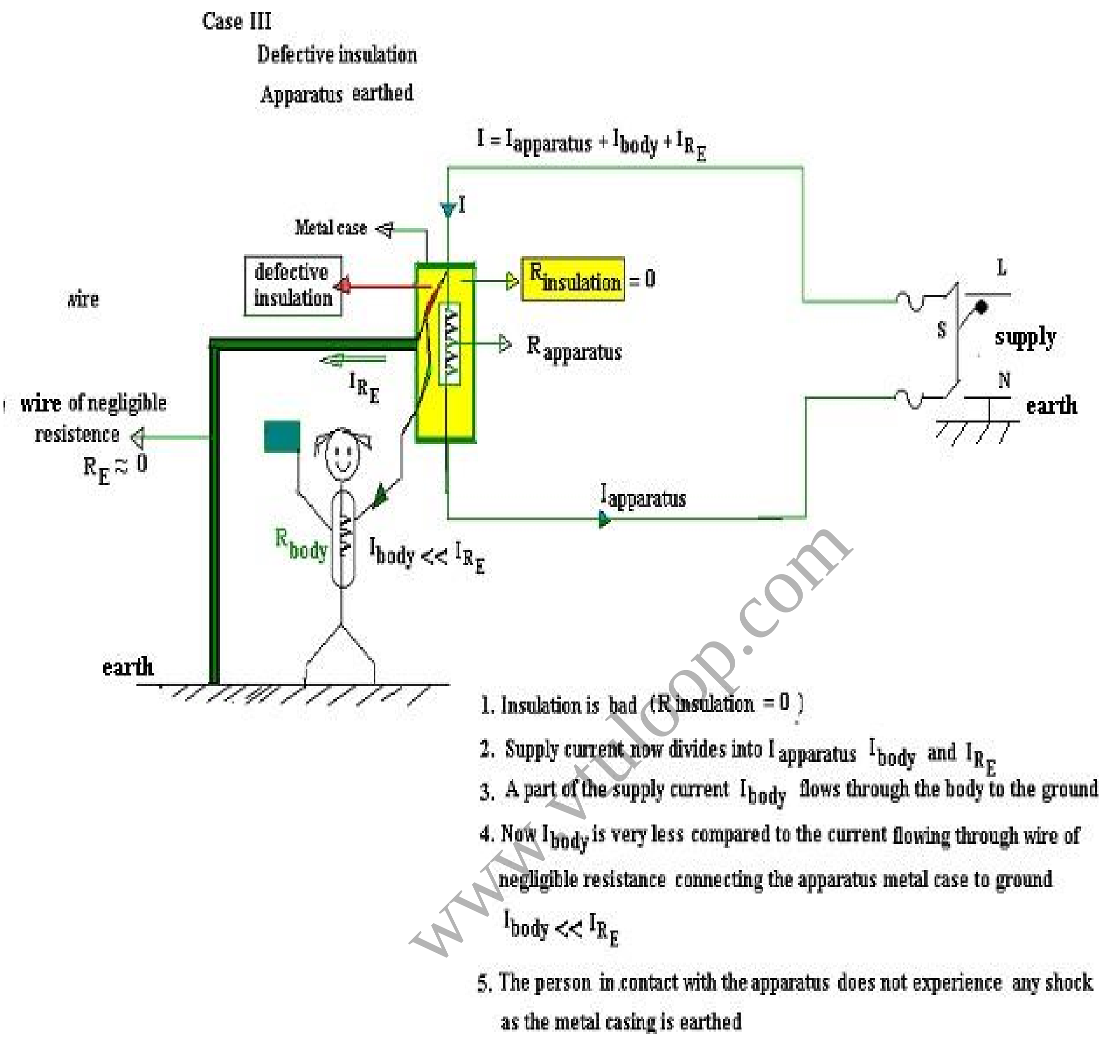
Case II

Defective insulation

Apparatus not earthed



1. Insulation is bad (R insulation $= 0$)
2. Supply current now divides into $I_{apparatus}$ and I_{body}
3. A part of the supply current flows through the body to the ground I_{body}
4. The person experiences shock as the apparatus is not earthed



❖ **Necessity of Earthing**:

1. To protect the operating personnel from danger of shock in case they come in contact with the charged frame due to defective insulation.
2. To maintain the line voltage constant under unbalanced load condition.
3. Protection of the equipments
4. Protection of large buildings and all machines fed from overhead lines against lightning.

❖ **Methods of Earthing**:

The important methods of earthing are the plate earthing and the pipe earthing. The earth resistance for copper wire is 1 ohm and that of G I wire less than 3 ohms. The earth resistance should be kept as low as possible so that the neutral of any electrical system, which is earthed, is maintained almost at the earth potential. The typical value of the earth resistance at powerhouse is 0. 5 ohm and that at substation is 1 ohm.

Plate earthing 2. Pipe earthing Plate Earthing

In this method a copper plate of 60cm x 60cm x 3.18cm or a GI plate of the size 60cm x 60cm x 6.35cm is used for earthing. The plate is placed vertically down inside the ground at a depth of 3m and is embedded in alternate layers of coal and salt for a thickness of 15 cm. In addition, water is poured for keeping the earth electrode resistance value well below a maximum of 5 ohms. The earth wire is securely bolted to the earth plate. A cement masonry chamber is built with a cast iron cover for easy regular maintenance.

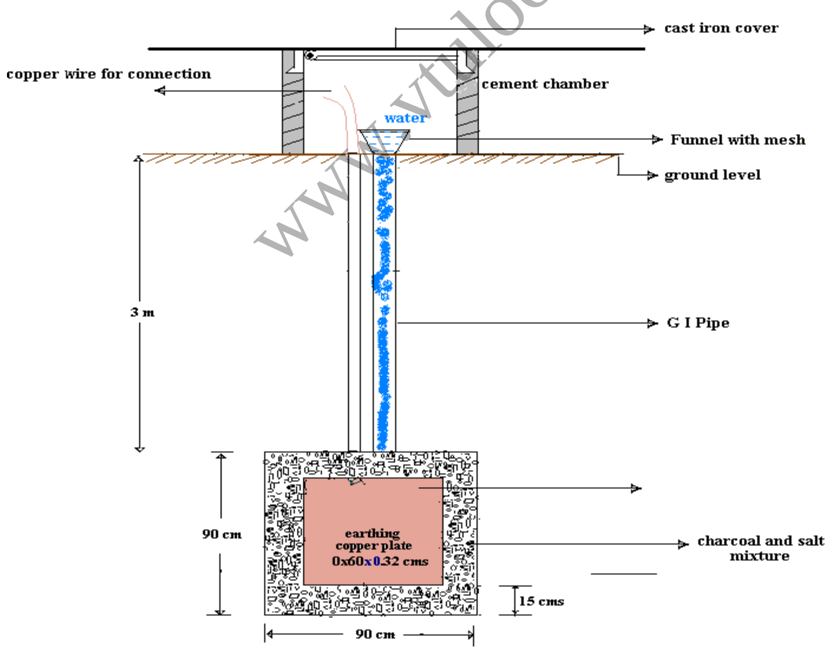
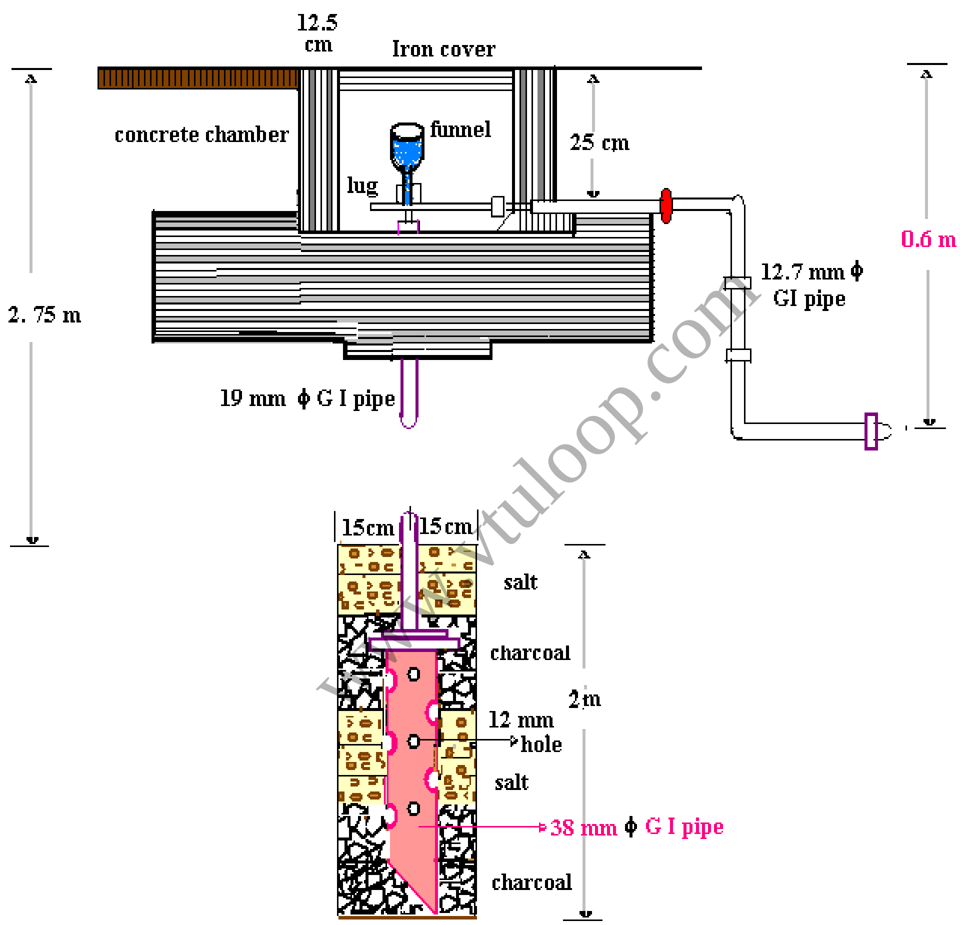


PLATE EARTHING

Pipe Earthing

Earth electrode made of a GI (galvanized) iron pipe of 38mm in diameter and length of 2m (depending on the current) with 12mm holes on the surface is placed upright at a depth of 4.75m in a permanently wet ground. To keep the value of the earth resistance at the desired level, the area (15 cms) surrounding the GI pipe is filled with a mixture of salt and coal.. The efficiency of the earthing system is improved by pouring water through the funnel periodically. The GI earth wires of sufficient cross- sectional area are run through a 12.7mm diameter pipe (at 60cms below) from the 19mm diameter pipe and secured tightly at the top as shown in the following figure.



PIPE EARTHING

When compared to the plate earth system the pipe earth system can carry larger leakage currents as a much larger surface area is in contact with the soil for a given electrode size. The system also enables easy maintenance as the earth wire connection is housed at the ground level.

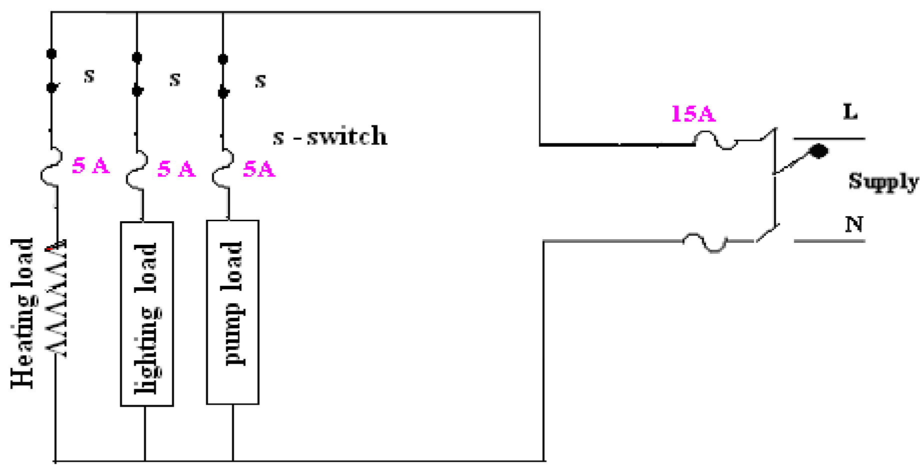
PROTECTIVE DEVICES

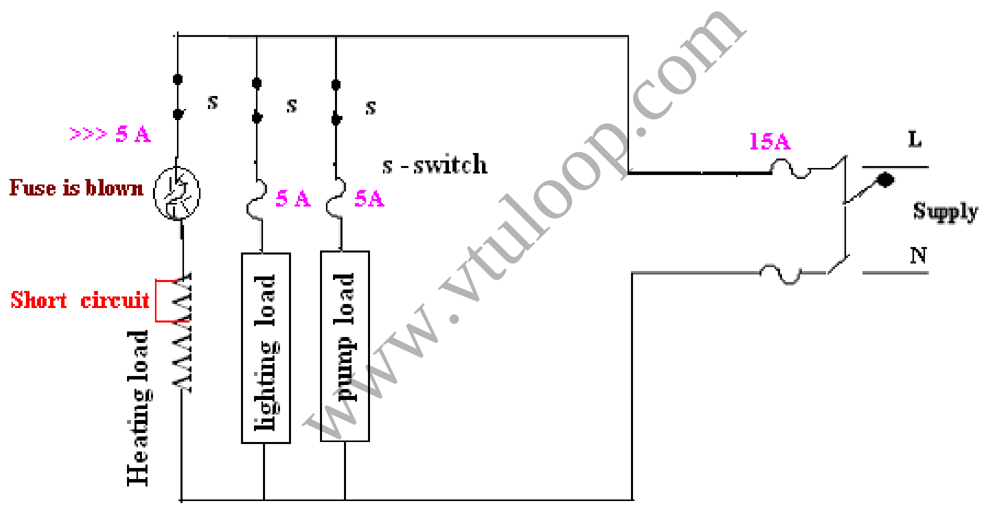
Protection for electrical installation must be provided in the event of faults such as short circuit, overload and earth faults. The protective circuit or device must be fast acting and isolate the faulty part of the circuit immediately. It also helps in isolating only required part of the circuit without affecting the remaining circuit during maintenance. The following devices are usually used to provide the necessary protection:

- Fuses
- Relays
- Miniature circuit breakers (MCB)
- Earth leakage circuit breakers (ELCB)

FUSE

The electrical equipment"s are designed to carry a particular rated value of current under normal circumstances. Under abnormal conditions such as short circuit, overload or any fault the current raises above this value, damaging the equipment and sometimes resulting in fire hazard. Fuses are pressed into operation under such situations. Fuse is a safety device used in any electrical installation, which forms the weakest link between the supply and the load. It is a short length of wire made of lead / tin /alloy of lead and tin/ zinc having a low melting point and low ohmic losses. Under normal operating conditions it is designed to carry the full load current. If the current increases beyond this designed value due any of the reasons mentioned above, the fuse melts (said to be blown) isolating the power supply from the load as shown in the following figures.





CHARACTERISTICS OF FUSE MATERIAL

The material used for fuse wires must have the following characteristics

1. Low melting point
2. Low ohmic losses
3. High conductivity
4. Lower rate of deterioration

Different types of fuses:

- **Re-wirable or kit -kat fuses:** These fuses are simple in construction, cheap and available up-to a current rating of 200A. They are erratic in operation and their performance deteriorates with time.

- **Plug fuse**: The fuse carrier is provided with a glass window for visual inspection of the fuse wire.

- **Cartridge fuse**: Fuse wire usually an alloy of lead is enclosed in a strong fiber casing. The fuse element is fastened to copper caps at the ends of the casing. They are available up-to a voltage rating of 25kV. They are used for protection in lighting installations and power lines.

- **Miniature Cartridge fuses**: These are the miniature version of the higher rating cartridge fuses, which are extensively used in automobiles, TV sets, and other electronic equipment‟s.

- **Transformer fuse blocks:** These porcelain housed fuses are placed on secondary of the distribution transformers for protection against short circuits and overloads.

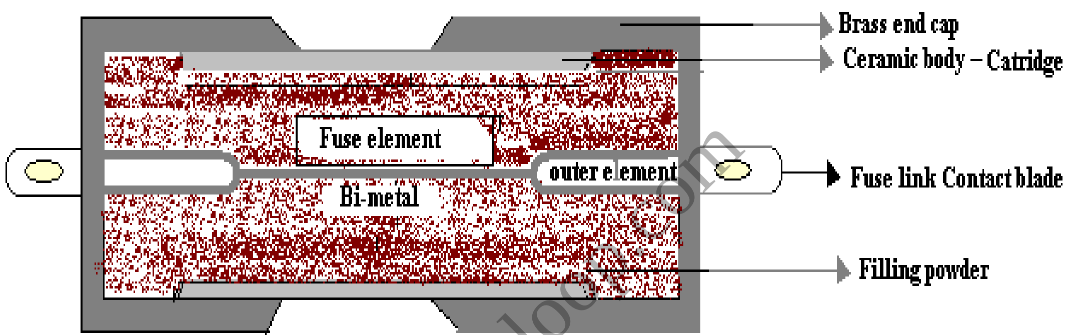
- **Expulsion fuses:** These consist of fuse wire placed in hollow tube of fiber lined with asbestos. These are suited only for out door use for example, protection of high voltage circuits.

- **Semi-enclosed re-wirable fuses:** These have limited use because of low breaking capacity.

- **Time-delay fuse:** These are specially designed to withstand a current overload for a limited time and find application in motor circuits.

HRC CARTRIDGE FUSE:

The high rupturing capacity or (HRC) fuse consists of a heat resistant ceramic body. Then silver or bimetallic fuse element is welded to the end brass caps. The space surrounding the fuse element is filled with quartz powder. This filler material absorbs the arc energy and extinguishes it. When the current exceeds the rated value the element melts and vaporizes. The vaporized silver fuses with the quartz and offers a high resistance and the arc is extinguished.



H R C Catridge fuse

Advantages:

1. Fast acting
2. Highly reliable
3. Relatively cheaper in comparison to other high current interrupting device

Disadvantages:

1. Requires replacement
2. The associated high temperature rise will affect the performance of other devices

TERMS RELATED WITH FUSES:

Rated current: It is the maximum current, which a fuse can carry without undue heating or melting. It depends on the following factors:

1.Permissible temperature rise of the contacts of the fuse holder and the fuse

material

2.Degree of deterioration due to oxidation.

Fusing current: The minimum current at which the fuse melts is known as the fusing current. It depends on the material characteristics, length, diameter, cross-sectional area of the fuse element and the type of enclosure used.

Fusing Factor: It is the ratio of the minimum fusing current to the rated current. It is always greater than unity.