CMR INSTITUTE OF TECHNOLOGY	USN										

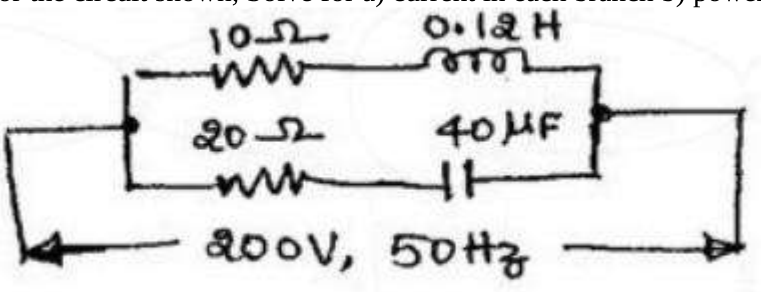
Internal Assesment Test II – May 2019

Sub:	BASIC ELECTRICAL ENGINEERING						Code:	18ELE23
Date:	15.05.2019	Duration:	90 mins	Max Marks:	50	Sem: 2	Section:	I,J,K,L,M,N,O

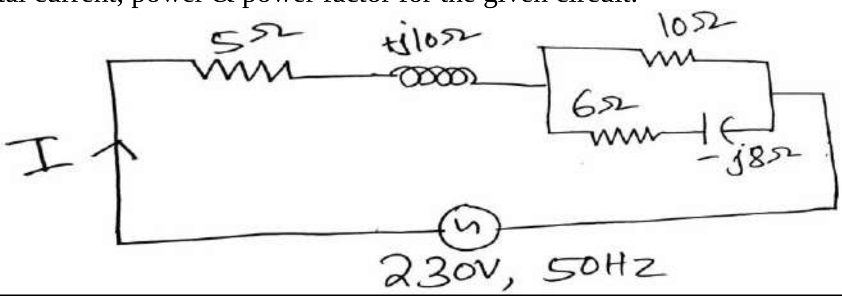
Note: Answer any **FIVE FULL** Questions

Sketch neat figures wherever necessary. Answer to the point. **Good luck!**

		Marks	OBE CO	OBE RBT
1 (a)	For the circuit shown, Solve for a) current in each branch b) power factor of the circuit	[5]	CO2	L3



		Marks	OBE CO	OBE RBT
(b)	What is Phase Sequence? List the advantages of three phase system over single phase system.	[5]	CO3	L1
2 (a)	In a three phase star connection, find the relation between line and phase values of voltages and currents. Also derive the equation for three phase power	[5]	CO3	L2
(b)	Three coils each having a resistance of 10 Ω and inductance of 0.02H are connected in star across 440V, 50 Hz three phase supply. Calculate phase voltage, phase current, line current and Power.	[5]	CO3	L3
3 (a)	In a three phase delta connection, find the relation between line and phase values of voltages and currents. Also derive the equation for three phase power	[5]	CO3	L2
(b)	A 3 phase delta connected balanced load consumes a power of 60 KW taking up a lagging current of 200 A, at a line voltage of 400 V, 50 Hz. Find the parameters of each phase.	[5]	CO3	L3
4	Show that two wattmeters are sufficient to measure three phase power. Also with phasor diagram, derive an expression for the power factor in terms of wattmeter readings	[10]	CO3	L2
5 (a)	What is the necessity of earthing? Explain any one type of earthing with a neat diagram	[5]	CO5	L2
(b)	Write a short note on a)MCB b) Precautions against Electric Shock	[5]	CO5	L1
6	With a neat sketch and truth table, explain two way and three way control of a lamp	[10]	CO5	L2
7 a)	Find total current, power & power factor for the given circuit.	[5]	CO4	L3



		Marks	OBE CO	OBE RBT
b)	The input power to a three phase induction motor running on 400V, 50 Hz supply was measured by two wattmeter method and the readings were 3000 W and 1000 W. Calculate a) Total Power input b) Power factor c) Line current	[5]	CO3	L3
8 a)	Briefly explain conduit wiring with neat sketches. Also mention its advantages and disadvantages.	[5]	CO4	L2
b)	Two wattmeter method is used to measure power consumed by a delta connected load. Each branch of load having an impedance of (10+17.32j) Ω. Supply voltage is 400V. Calculate the total Power and readings on individual wattmeters.	[5]	CO3	L3

1b)

Advantages of 3ϕ system

→ Output of a 3ϕ machine is higher than a 1ϕ machine.

→ For transmission + distribution, 3ϕ s/m needs less conductor material ~~for the~~ than 1ϕ s/m for the given VA & voltage rating. So, Transmission becomes economical

→ 3ϕ supply produced rotating field, so 3ϕ IM are self-starting.

→ Power in a 1ϕ s/m develops pulsating torque whereas in a 3ϕ s/m - uniform torque.

→ can supply domestic as well as industrial load

→ Voltage regulation better in 3ϕ than 1ϕ.

2a)

Voltage & current relations in 3ϕ s/m

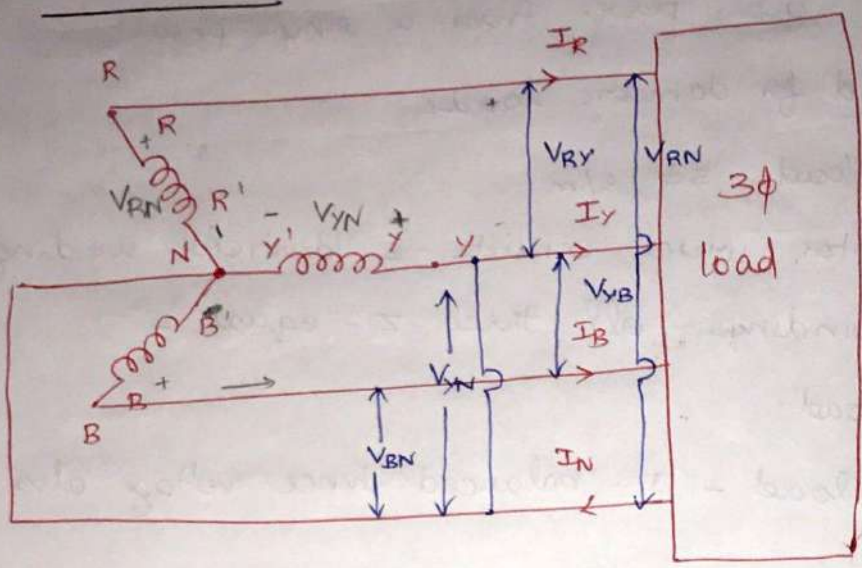
→ line voltage → line current

→ Phase voltage → Phase current

$V_{RY} = V_{RN} - V_{YN}$

Star connected s/m

$-V_{RY} - V_{YN} + V_{RN} = 0$



V_{RY}, V_{YB}, V_{BR} - Line voltage $\quad -V_{BN} + V_{YN} - V_{YB} = 0$

V_{RN}, V_{YN}, V_{BN} - Phase voltage $\quad V_{YB} = V_{YN} - V_{BN}$

Applying KVL, $-V_{RY} - V_{YN} + V_{RN} = 0$

$$V_{RY} = V_{RN} - V_{YN}$$

V_{RN} - rms value of each phase voltage of R-line

$$V_{BR} = V_{BN} - V_{RN} \qquad V_{YB} = V_{YN} - V_{BN}.$$

Balanced s/m, each phase voltage same magnitude

Let $|V_{RN}| = |V_{YN}| = |V_{BN}| = V_{ph}$

$V_{RN} = V_{ph}\angle 0^\circ \quad V_{YN} = V_{ph}\angle -120^\circ \quad V_{BN} = V_{ph}\angle -240^\circ$

So, $V_{RY} = V_{RN} - V_{YN} = \sout{V_{ph}\angle 120^\circ}$

$= V_{ph}\angle 0^\circ - V_{ph}\angle -120^\circ$

$= V_{ph} - V_{ph}\left[\cos 120^\circ - j\sin 120^\circ\right]$

$= V_{ph}\left[(1-\cos 120^\circ) + j\sin 120^\circ\right]$

$= V_{ph}\left[1.5 + j0.866\right]$

$V_{RY} = 1.73\, V_{ph} = 1.73\angle 30^\circ\, V_{ph}$

$\Rightarrow \boxed{V_L = \sqrt{3}\, V_{ph}}$

$\theta = \tan^{-1}\dfrac{0.866}{1.5} = 30^\circ = V_{RY}$

$V_{RY} = \sqrt{3}\, V_{ph}\angle 30^\circ$

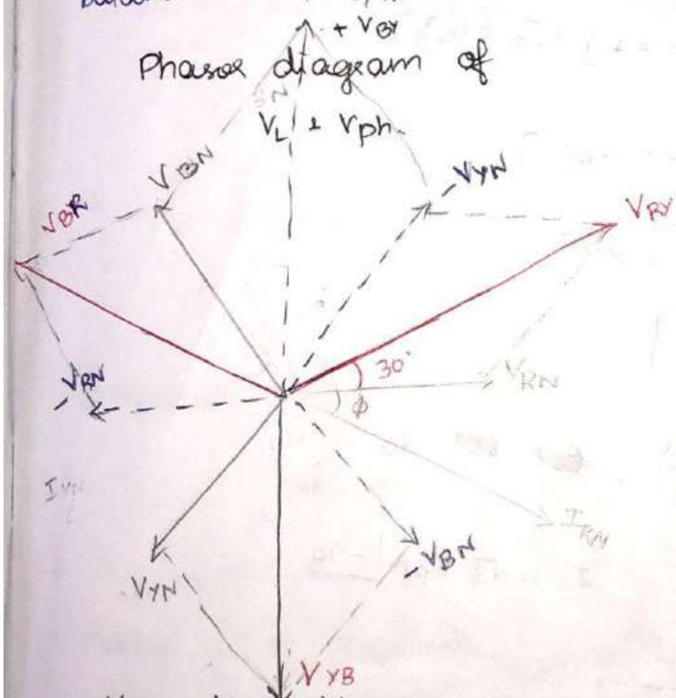
$V_{YB} = \sqrt{3}\, V_{ph}\angle -90^\circ$ $\quad V_{BR} = \sqrt{3}\, V_{ph}\angle -210^\circ$ (or)

$= \sqrt{3}\, V_{ph}\angle 150^\circ$

Star connection $I_L = I_{ph}$.

Line voltage – voltage between two line conductors in a balanced 3ϕ s/m

Phasor diagram of V_L & V_{ph}



$V_{RY} = V_{RN} - V_{YN}$

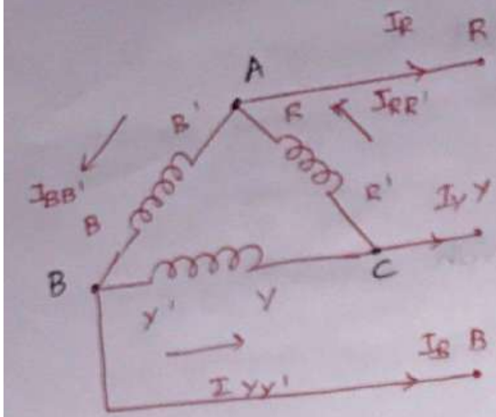
$V_{YB} = V_{YN} - V_{BN}$

$V_{BR} = V_{BN} - V_{RN}$

3a)

$I_{RR'}$ - phase I of R

Delta connected system.



~~$V_{RY} = V_{YB} = V_{BR}$~~

$V_{RY} + V_{YB} + V_{BR} = 0$

$V_{RY} = V_{ph}\angle 0^\circ$

$V_{YB} = V_{ph}\angle -120^\circ$ $\quad V_{BR} = V_{ph}\angle$ [illegible]

Applying KCL at A,

$I_{RR'} = I_R + I_{BB'} \Rightarrow I_R = I_{RR'} - I_{BB'}$

Let $|I_{RR'}| = |I_{BB'}| = |I_{YY'}| = I_{ph}$

$I_{RR'} = I_{ph}\angle 0^\circ \quad I_{YY'} = I_{ph}\angle -120^\circ \quad I_{BB'} = I_{ph}\angle -240^\circ$

$\Rightarrow I_R = I_{ph}\angle 0^\circ - I_{ph}\angle -240^\circ$

$= I_{ph} - I_{ph}[\cos(+240^\circ) - j\sin 240^\circ]$

$= I_{ph}[1 + 0.5 + j(-0.866)]$

$= I_{ph}[1.5 - 0.866j]$

$I_R = I_{ph}\sqrt{1.5^2 + 0.866^2}$

$$\Rightarrow \boxed{I_R = I_{ph} \times \sqrt{3}}$$

$\theta = \tan^{-1}\frac{0.866}{1.5} = 30^\circ$

$I_R = I_{ph} \times \sqrt{3}\angle 30^\circ \quad I_Y = \sqrt{3} I_{ph}\angle -90^\circ$

$I_B = \sqrt{3} I_{ph}\angle 150^\circ$

& $V_L = V_{ph}$ (from fig)

Note:

→ Problems - if not mentioned anything, take it as line voltage & line current

→ Impedance / phase $Z = \frac{V_{ph}}{I_{ph}}$.

Power in 3φ s/m

$1\phi \Rightarrow P = VI \cos\phi = V_{ph} I_{ph} \cos\phi$

$3\phi \Rightarrow$ balanced ⇒ power in all the phases - equal

so $P = 3 V_{ph} I_{ph} \cos\phi$

Star connected s/m

$V_L = \sqrt{3} V_{ph} \quad I_L = I_{ph}$

$$P = 3 \times \frac{V_L}{\sqrt{3}} I_L \cos\phi = \sqrt{3} V_L I_L \cos\phi$$

Delta connected s/m $\quad V_L = V_{ph} \quad I_L = \sqrt{3} I_{ph}$

$$P = 3 \times V_L \times \frac{I_L}{\sqrt{3}} \cos\phi$$

$$P = \sqrt{3} V_L I_L \cos\phi$$

⇒ Any balanced load either Y or Δ, Power

$$\boxed{P = \sqrt{3} V_L I_L \cos\phi}$$

Comparison between Y & delta connected s/m

Y connection	Δ connection
→ $V_L = \sqrt{3} V_{ph}$, $I_L = I_{ph}$	→ $V_L = V_{ph}$, $I_L = \sqrt{3} I_{ph}$
→ Neutral wire - available	→ NW - not available
→ 3φ, 4 wire s/m - possible	→ 3φ, 4 wire s/m - not possible
→ Both domestic & industrial loads can be handled	→ Only industrial loads
→ Protection through NW	→ NW - absent, protective devices cannot be used.

by

4)

Measurement of power.

Three Wattmeter method : One wattmeter in each phase.

→ total P consumed by the load - algebraic sum of the three wattmeter readings.

One Wattmeter method :

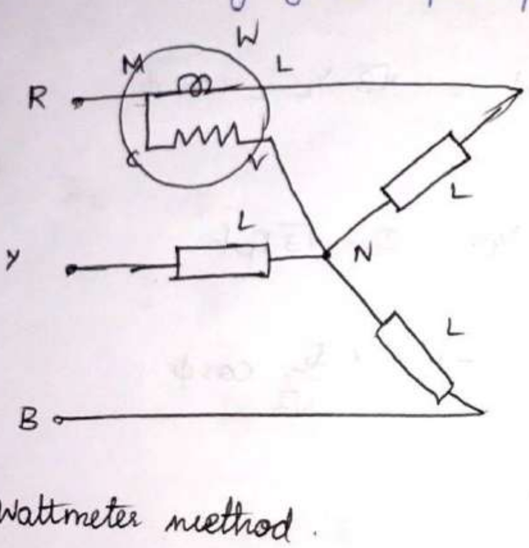
→ Can be used only for star connected balanced loads

→ 1 Wattmeter connected btwn any one of the phases & neutral.

→ Total power (3ϕ) consumed by the load,

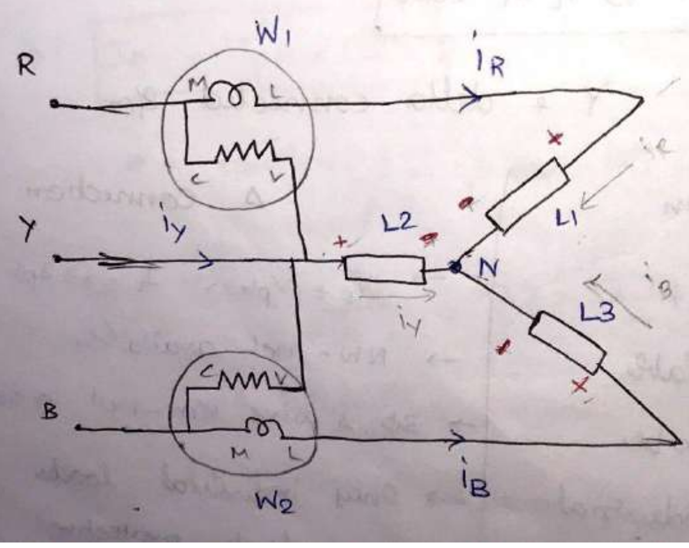
$$P = 3 \times \text{Wattmeter reading}.$$

Wattmeter reading gives power/phase.



Two Wattmeter method.

→ Can be used for balanced/unbalanced load, Y or Δ connected



→ 3 loads L_1, L_2 & L_3 - connected in star.

→ Current coils connected to R & B lines &

Potential coils across RY & BY

→ The sum of the wattmeter readings gives the total power absorbed by three phases.

→ Let V_{RN}, V_{YN} & V_{BN} - instantaneous voltage across the loads.

→ i_R, i_Y & i_B - instantaneous values of corresponding I.

Total ins $P = i_R \times V_{RN} + i_y \times V_{YN} + i_B \times V_{BN}$

⇒ Current through current coil of W_1 is i_R &

W_3 is i_B

⇒ Potential across W_1's potential coil is

$V_{RN} - V_{YN}$

& W_2 is $V_{BN} - V_{YN}$

Instantaneous power measured by W_1 is

$$P_1 = i_R (V_{RN} - V_{YN})$$

Instantaneous power measured by W_2 is

$$P_2 = i_B (V_{BN} - V_{YN})$$

Sum of the instantaneous powers of W_1 & W_2 is

$$P = P_1 + P_2 = i_R (V_{RN} - V_{YN}) + i_B (V_{BN} - V_{YN})$$

$$= i_R V_{RN} - i_R V_{YN} + i_B V_{BN} - i_B V_{YN}$$

$$= i_R V_{RN} + i_B V_{BN} - (i_R + i_B) V_{YN}$$

⇒ Applying KCL, $i_R + i_y + i_B = 0$ ⇒ $i_R + i_B = -i_y$

$$P = i_R V_{RN} + i_B V_{BN} + i_y V_{YN}$$

$$= \text{total ins } P.$$

Power factor measurement.

→ Consider a balanced 3ϕ inductive load at a pf $\cos\phi$ (lagging) connected to a 3 wire, 3ϕ system

→ Phase sequence - RYB.

From phasor diagram,

$$W_1 = V_{RY} I_{RN} \cos(30+\phi) = V_L I_L \cos(30^\circ+\phi)$$

$$W_2 = V_{BY} I_{BN} \cos(30^\circ-\phi) = V_L I_L \cos(30-\phi)$$

$$W_2 - W_1 = \sqrt{3} V_{ph} I_{ph} [\cos(30^\circ-\phi) - \cos(30^\circ+\phi)]$$

$$= \sqrt{3} V_{ph} I_{ph} \; 2 \times \sin 30^\circ \sin\phi$$

$$W_2 - W_1 = \sqrt{3} V_{ph} I_{ph} \sin\phi$$

$\times\sqrt{3}$

$$\sqrt{3}(W_2 - W_1) = 3 V_{ph} I_{ph} \sin\phi \rightarrow (1)$$

$$W_1 + W_2 = \sqrt{3} V_{ph} I_{ph} [\cos(30-\phi) + \cos(30^\circ+\phi)]$$

$$= \sqrt{3} V_{ph} I_{ph} \cdot 2 \cos 30^\circ \cos\phi$$

$$= \sqrt{3} V_{ph} I_{ph} \, 2 \times \frac{\sqrt{3}}{2} \cos\phi$$

$$= 3 V_{ph} I_{ph} \cos\phi \rightarrow (2)$$

(1) ÷ (2)

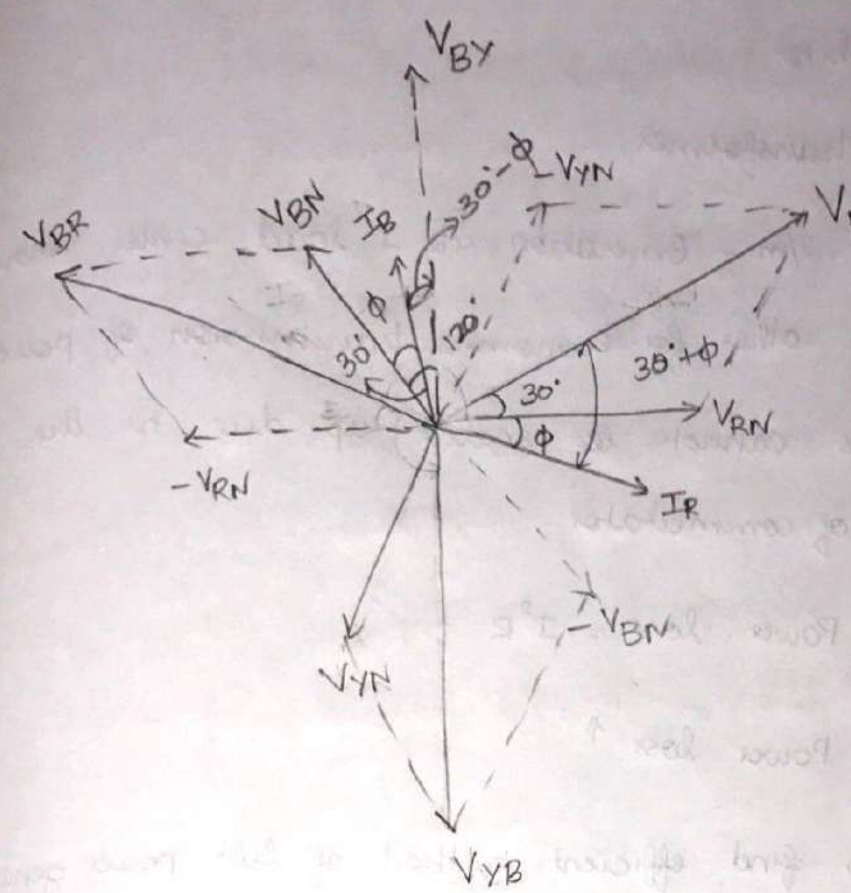
$$\frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2} = \frac{\sin\phi}{\cos\phi}$$

$$\tan\phi = \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2}$$

power factor ⟹ $\cos\phi$

$$\phi = \tan^{-1} \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2}$$

...sor diagram



Effect of PF on wattmeter readings.

Case (i) $\cos\phi = 1 \Rightarrow \phi = 0°$ – Pf - unity - load - resistive.

$W_1 = V_L I_L \cos(30°+0) = \sqrt{3}/2 \, V_L I_L$ Watt

$W_2 = V_L I_L \cos(30°-0) = \sqrt{3}/2 \, V_L I_L$ W

UPF - both wattmeters will show the same reading.

Case (ii) $\cos\phi = 0.5 \quad \phi = 60°$

$W_1 = V_L I_L \cos 90° = 0$

$W_2 = V_L I_L \cos(-30°) = \frac{\sqrt{3}}{2} V_L I_L$

At a pf of 0.5, one wattmeter will show zero reading.

Case (iii) $\cos\phi = 0 \Rightarrow \phi = 90°$

$W_1 = V_L I_L \cos 120° = -0.5\, V_L I_L$

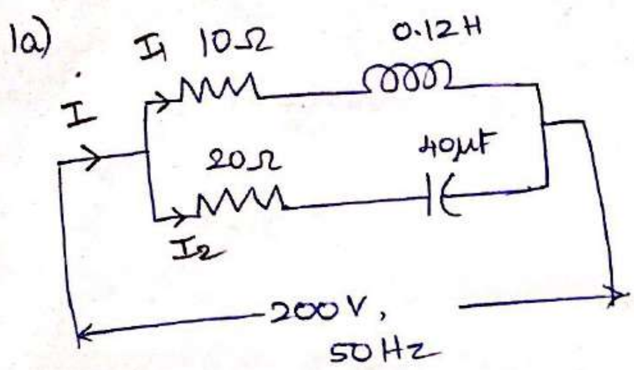
$W_2 = V_L I_L \cos(-60°) = 0.5\, V_L I_L$

At pf = 0 (or) $\phi = 90°$, one wattmeter will show negative reading. Practically not possible.

Interchange either ML (or) CV.

IAT-2 18ELE23 SOLUTION

1a)



To find I_1, I_2 & pf.

Soln

$Z_1 = R + jX_L \quad Z_2 = R - jX_C$

$X_L = \omega L \quad Z_1 = 10 + j(2\pi \times 50 \times 0.12)$

$Z_1 = 10 + j37.68\ \Omega$

$X_C = 1/\omega C$

$$Z_2 = 20 - j\left[\frac{1}{2\pi \times 50 \times 40 \times 10^{-6}}\right]$$

$Z_2 = 20 - j79.62\ \Omega$

$Z1 = 10 + j37.68\ \Omega$
$Z2 = 20 - j79.62\ \Omega$ → (1M)

Parallel ckts, so V will be same.

$V = I_1 Z_1 \qquad V = I_2 Z_2$

$$I_1 = \frac{V}{Z_1} = \frac{200}{10 + 37.68j}$$

$= 1.32 - 4.96j$ A

$I_1 = 5.13\angle -75.14^\circ$ A → (1M)

$$I_2 = \frac{V}{Z_2}$$

$$= \frac{200}{20 - 79.62j}$$

$= 0.59 + 2.36j$ A

$I_2 = 2.44\angle 75.90^\circ$ A → (1M)

To find PF

PF = $\cos\phi$

$\phi = \phi_v - \phi_i$

$I = I_1 + I_2$

$= 1.32 - 4.96j + 0.59 + 2.36j$

$= 1.91 - 2.6j$ A

$I = 3.23\angle -53.7^\circ$ A

$\phi = 0^\circ - (-53.7^\circ) = 53.7$

Pf = $\cos\phi = \cos 53.7$

= 0.59 lagging

Pf = 0.59 → (2M)

(2b) Gvn 3 coils connected in star

$R = 10\Omega \quad L = 0.02H$

$Z = R + jX_L = 10 + j(2\pi \times 50 \times 0.02)$

$Z_{ph} = 10 + 6.28j \ \Omega$

$V_L = 440V \quad f = 50 Hz$

To find V_{ph}, I_{ph}, I_L, P

Y connection, $V_L = \sqrt{3} V_{ph}$,

$I_L = I_{ph}$ → (1M)

$V_{ph} = \frac{440}{\sqrt{3}} = 254.03 V$

$V_{ph} = 254.03 V$ → (1M)

Y connection, $I_L = I_{ph}$

$V_{ph} = I_{ph} Z_{ph}$

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{254.03}{10+6.28j}$

$= 18.22 - 11.44j$ A

$I_{ph} = 21.51 \angle -32.13^\circ$ A

$I_{ph} = 21.51$ A → (1M)

$I_L = 21.51$ A → (1M)

$P = \sqrt{3} V_L I_L \cos\phi$

$\phi = \phi_v - \phi_i = 0^\circ - (-32.13^\circ)$

$= 32.13$

$\cos 32.13^\circ = 0.85$

$P = \sqrt{3} \times 440 \times 21.51 \times 0.85$

$P = 13.882$ kW → (1M)

(3b) Gvn 3φ Δ connection

$P = 60$ kW $\quad I_L = 200$ A at

$V_L = 400$ V.

$P = \sqrt{3} V_L I_L \cos\phi$ → (0.5M)

$Z_{ph} = \frac{V_{ph}}{I_{ph}}$

Δ connection, $V_L = V_{ph}$

$I_L = \sqrt{3} I_{ph}$ → (1M)

$60 \times 10^3 = \sqrt{3} \times 400 \times 200 \times \cos\phi$

$\cos\phi = 0.43$

$\phi = 64.34$

$Z_{ph} = Z\angle\phi$

⇒ $Z_{ph} = \frac{V_{ph}}{I_{ph}}$ → (0.5M)

$I_{ph} = \frac{200}{\sqrt{3}} = 115.47$ A

$Z_{ph} = \frac{400}{115.47} = 3.46 \Omega$

$Z_{ph} = 3.46 \angle 64.34^\circ \ \Omega$

$Z_{ph} = 1.5 + 3.12j \ \Omega$ → (1M)

$R = 1.5 \ \Omega$ → (1M) $X_L = 3.12 = \omega L$

$2\pi f L = 3.12$

$L = 9.94 \ mH$ → (1M)

$I_L = 7.6 \ A$ → (1M)

(7b) Gvn $W_1 = 3000 \ W$

$W_2 = 1000 \ W$ $V_L = 400V$

a) Total Power i/p

$P = W1 + W2$

$= 3000 + 1000$

$P = 4000 \ W$ → (1M)

b) $pf = \cos\phi$

$\phi = \tan^{-1} \dfrac{\sqrt{3}(W_1 - W_2)}{W1 + W2}$ → (1M)

$\phi = \tan^{-1} \dfrac{\sqrt{3}(3000 - 1000)}{3000 + 1000}$

$\phi = 40.89^\circ$

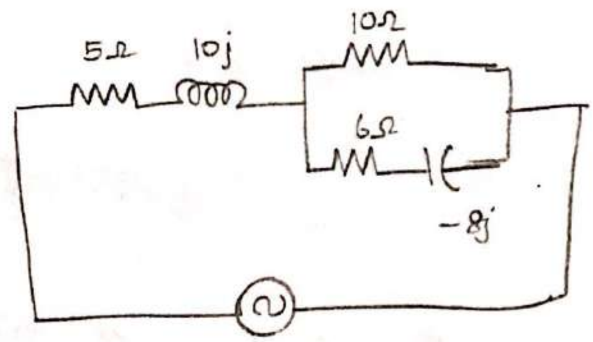
$\cos\phi = pf = 0.76$ –

$Pf = 0.76$ → (1M)

c) $P = \sqrt{3} V_L I_L \cos\phi$ → (1M)

$I_L = \dfrac{4000}{\sqrt{3} \times 400 \times 0.76}$

(7a)



230V, 50Hz

To find I, P, PF

Gvn $V = 230V$

$Z1 = 5 + 10j \ \Omega$ $Z2 = 10 \ \Omega$

$Z3 = 6 - 8j \ \Omega$

$Z_{eq} = Z1 + (Z2 \| Z3)$

$= Z1 + \dfrac{Z2 Z3}{Z2 + Z3}$

$= 5 + 10j + \dfrac{(10)(6-8j)}{10 + 6 - 8j}$

$Z_{eq} = 10 + 7.5j \ \Omega$ → (1M)

$Z_{eq} = 12.5 \angle 36.87^\circ \ \Omega$

$I = \dfrac{V}{Z_{eq}} = \dfrac{230}{10 + 7.5j}$

$I = 14.72 - 11.04j \ A$

$I = 18.4 \angle -36.87^\circ \ A$ → (1M)

$P = V_{rms} I_{rms} \cos\phi \rightarrow$ (1M)

$= 230 \times 18.4 \times \cos(-36.87^\circ)$

$= 3385.60$ W

$P = 3.386$ kW $\rightarrow$ (1M)

$pf = \cos\phi = \cos 36.87^\circ$

$pf = 0.8$ lagging $\rightarrow$ (1M)

(8b) Gn Δ connected load

$Z_{ph} = 10 + 17.32j\,\Omega \quad V_L = V_{ph} = 400V$

Soln

$P = \sqrt{3} V_L I_L \cos\phi$

$W_1 = V_L I_L \cos(30^\circ + \phi)$

$W_2 = V_L I_L \cos(30^\circ - \phi)$ (2M)

(1) $P = \sqrt{3} V_L I_L \cos\phi$

Delta connection, $V_L = V_{ph}$

$I_L = \sqrt{3} I_{ph}$

(1M)

$I_{ph} = \frac{V_{ph}}{Z_{ph}}$ $\quad V = IZ$

$= \frac{400}{10 + 17.32j}$

$= 10 - 17.32j$ A

$I_{ph} = 20\angle{-60^\circ}$ A

$I_{ph} = 20$ A

$I_L = \sqrt{3} I_{ph} = \sqrt{3} \times 20$

$I_L = 34.64$ A

$P = \sqrt{3} \times 400 \times 34.64 \cos 60^\circ$

$P = 12$ kW $\rightarrow$ (1M)

$W_1 = 400 \times 34.64 \cos 90^\circ$

$W_1 = 0$ W $\rightarrow$ (0.5M)

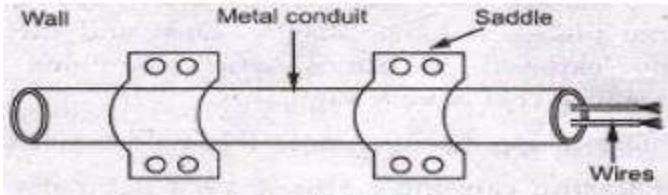
$W_2 = 400 \times 34.64 \times \cos(-30^\circ)$

$W_2 = 12$ kW $\rightarrow$ (0.5M)

(iv) 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 :

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.



Surface conduit wiring

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.

Advantages:

- 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.

Disadvantages:

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

FACTORS AFFECTING THE CHOICE OF WIRING SYSTEM:

The choice of wiring system for a particular installation depends on technical factors and economic viability.

1. Durability: Type of wiring selected should conform to standard specifications, so that it is durable i.e. without being affected by the weather conditions, fumes etc.

2. Safety: The wiring must provide safety against leakage, shock and fire hazards for the operating personnel.

3. **Appearance:** Electrical wiring should give an aesthetic appeal to the interiors.

4. Cost: It should not be prohibitively expensive.

5. Accessibility: The switches and plug points provided should be easily accessible. There must be provision for further extension of the wiring system, if necessary.

6 Maintenance Cost: The maintenance cost should be a minimum

7. Mechanical safety: The wiring must be protected against any mechanical damage

Specification of Wires:

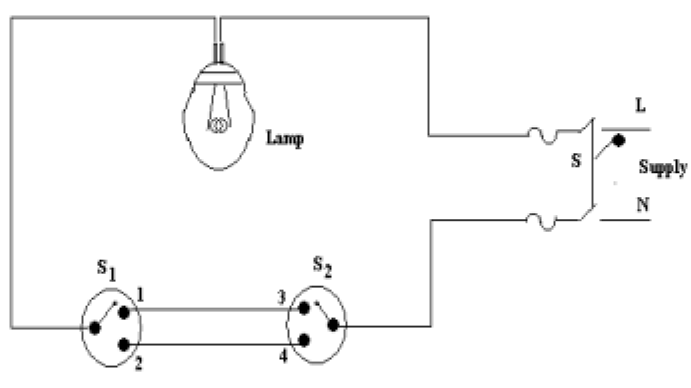
The conductor material, insulation, size and the number of cores, specifies the electrical wires. These are important parameters as they determine the current and voltage handling capability of the wires. The conductors are usually of either copper or aluminum. Various insulating materials like PVC, TRS, and VIR are used. The wires may be of single strand or multi strand. Wires with combination of different diameters and the number of cores or strands are available.

Ex: 1/20 or 3/22
The numerator indicates the number of strands while the denominator corresponds to the diameter of the wire in SWG (Standard Wire Gauge). SWG 20 corresponds to a wire of diameter 0.914mm, while SWG 22 corresponds to a wire of diameter 0.737 mm.

A 7/0 wire means, it is a 7-cored wire of diameter 12.7mm (0.5 inch). The selection of the wire is made depending on the requirement considering factors like current and voltage ratings, cost and application.
Example: Application: domestic wiring
1. Lighting - 3/20 copper wire
2. Heating - 7/20 copper wire
The enamel coating (on the individual strands) mutually insulates the strands and the wire on the whole is provided with PVC insulation. The current carrying capacity depends on the total area of the wire. If cost is the criteria then aluminum conductors are preferred. In that case, for the same current rating much larger diameter of wire is to be used.

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.
(i)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**. N

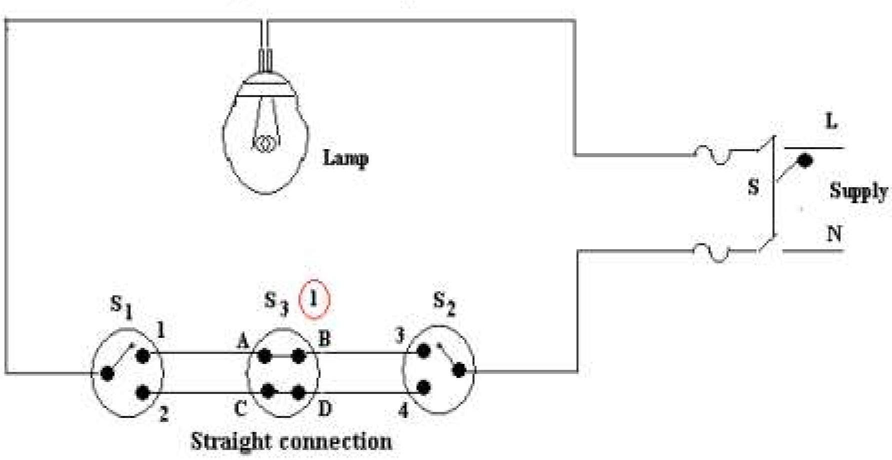
- ow if **S2** is changed to position **3** with **S1** at position **2** the circuit continuity is broken and the lamp is off.
- Thus the lamp can be controlled from two different points.

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

(ii)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 CD is connected as shown in figure 1(b).

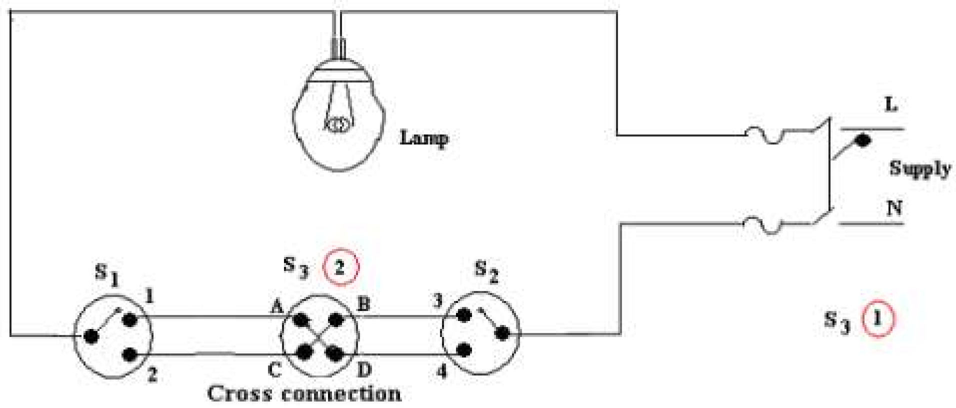
As explained in two ways control the lamp is ON if the circuit is complete and is OFF if the circuit does not form a closed loop.

Three -way control of lamp



Straight connection

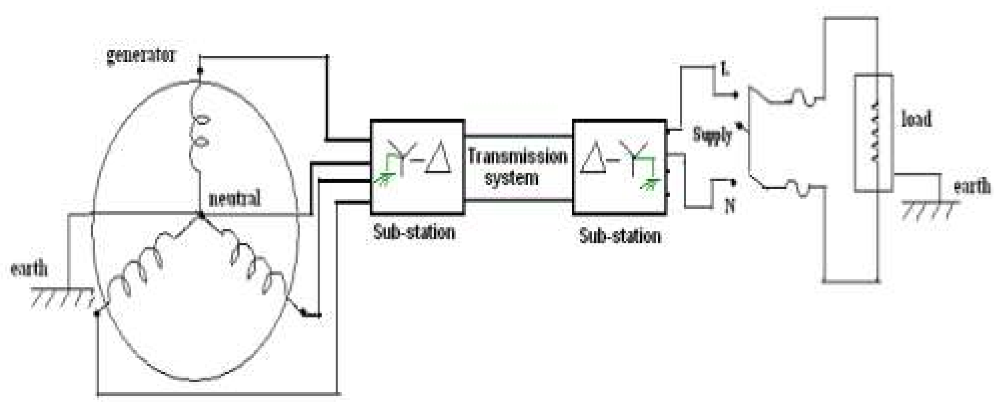
The condition of the lamp depends on the positions of the switches **S_1**, **S_2**, and **S_3**.



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 body of equipment to zero, thus protecting 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 connected to copper plate placed at depth of 2.5 to 3meters from the ground level.

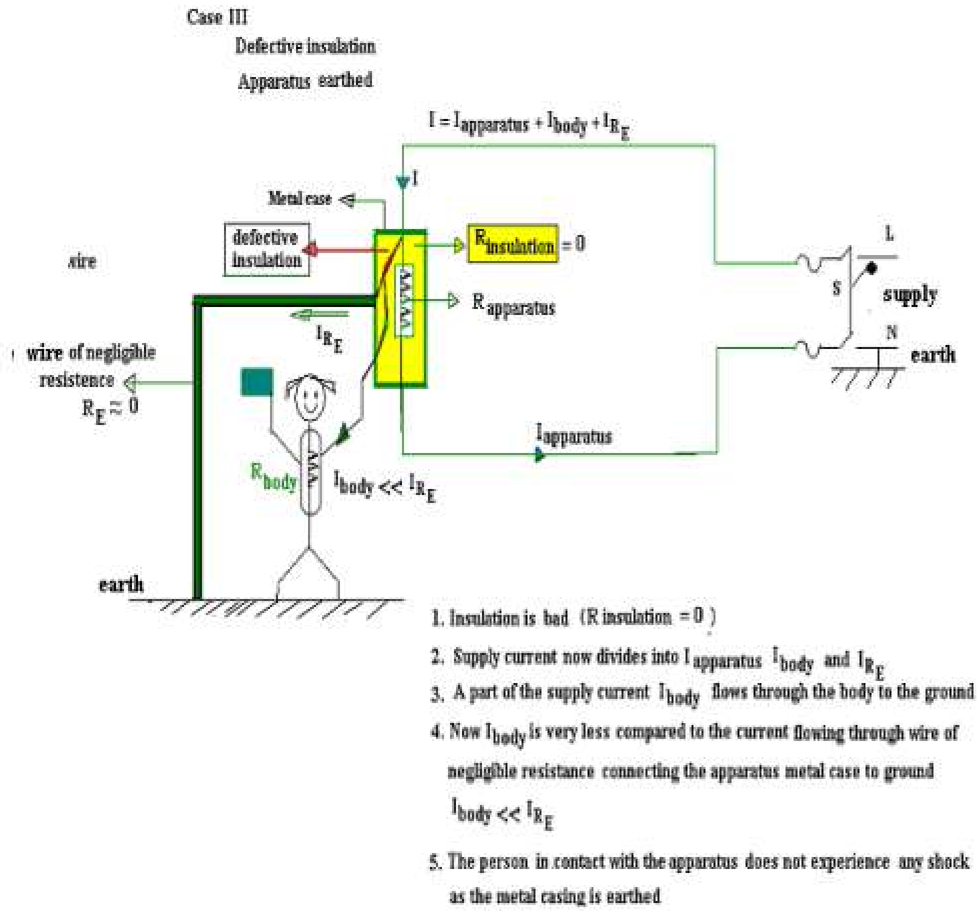


BLOCK DIAGRAM

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:



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.
1. Plate earthing 2. Pipe earthing

1. 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.

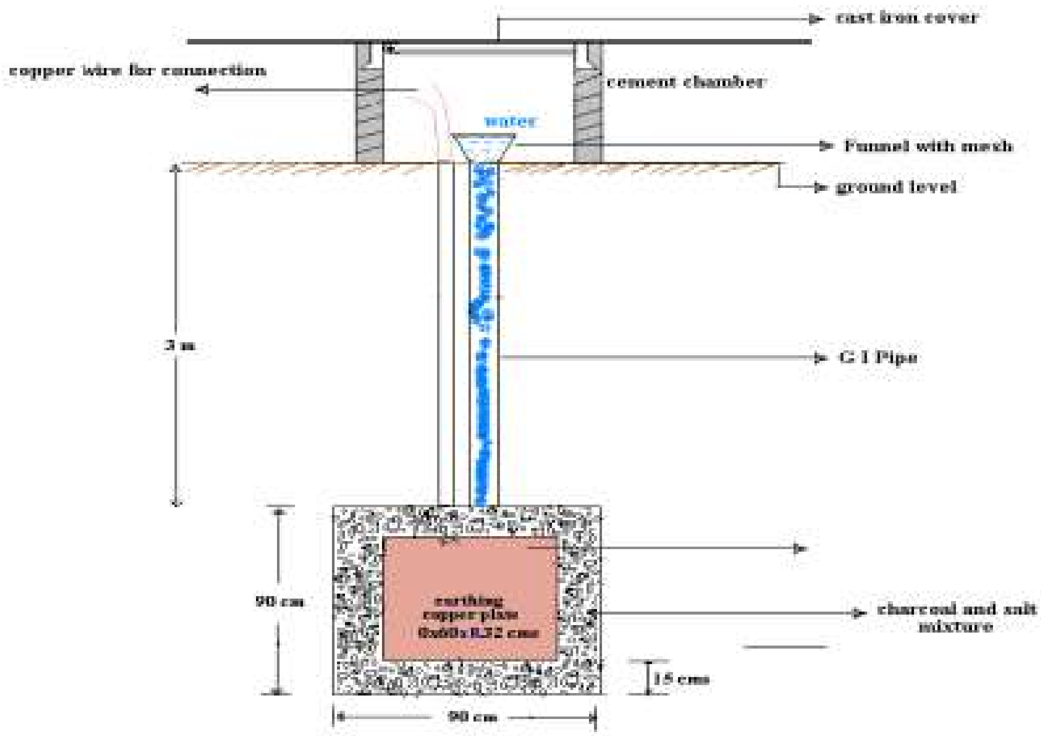
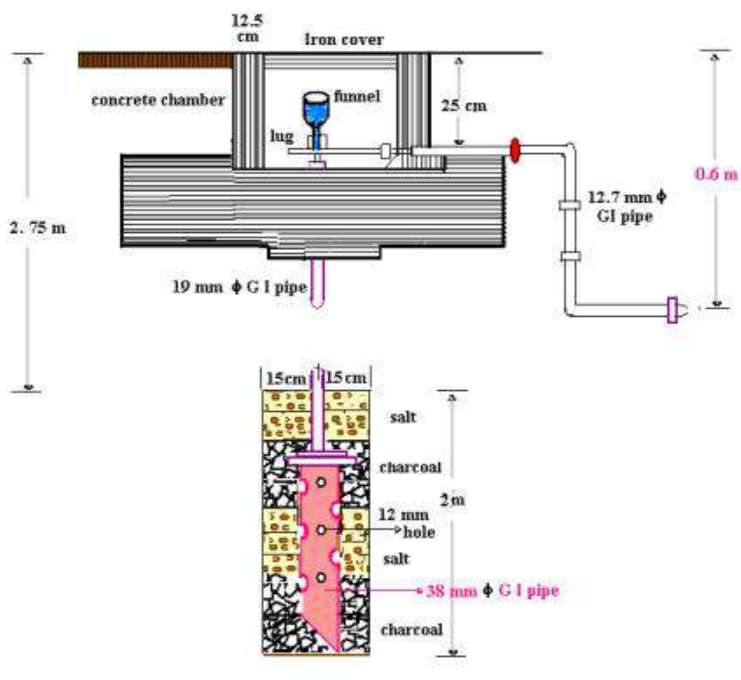


PLATE EARTHING

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.

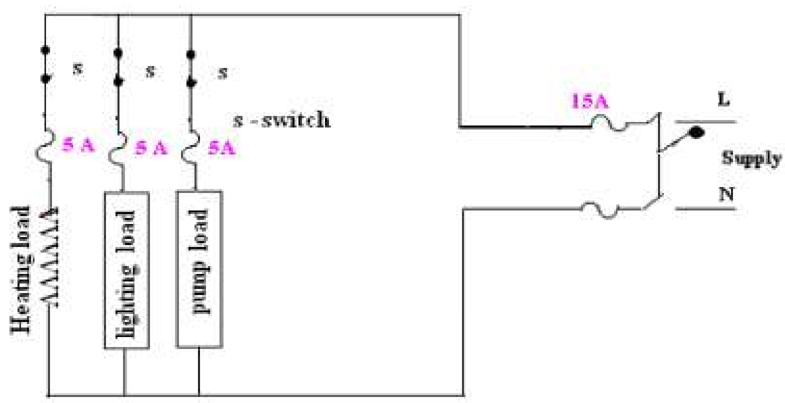
PROTECTIVE DEVICES

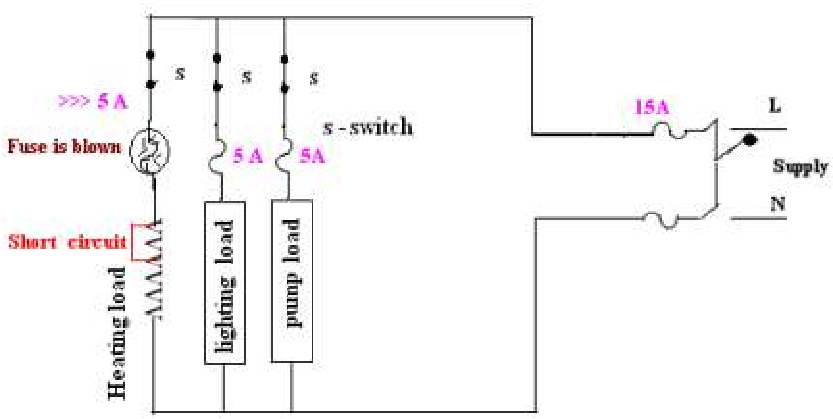
Protection for electrical installation must be provided in the event of faults such as short circuit, overload and earth faults. The protective circuit or device must be fast acting and isolate the faulty part of the circuit immediately. It also helps in isolating only required part of the circuit without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

1. Fuses
2. Relays
3. Miniature circuit breakers (MCB)
4. Earth leakage circuit breakers (ELCB)

FUSE

The electrical 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 equipments.

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

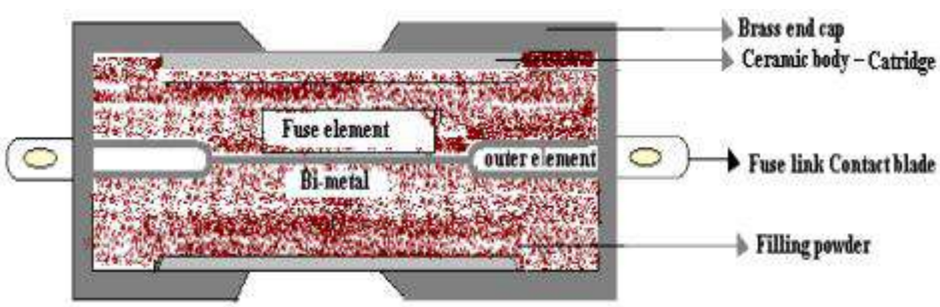
Expulsion fuses: These consist of fuse wire placed in hollow tube of fiber lined with asbestos. These are suited only for outdoor use for example, protection of high voltage circuits.

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.



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