CBCS SCHEME

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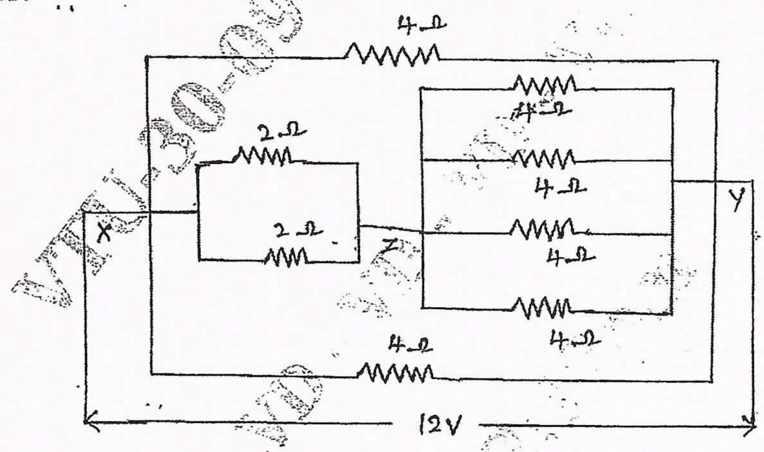
BEEE103/203

First/Second Semester B.E./B.Tech.Degree Examination, June/July 2023

Elements of Electrical Engineering

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. VTU Formula Hand Book is permitted.
3. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	State and explain Kirchoff's laws.	6	L2	CO1
	b.	Find the total resistance of the circuit across the terminals X and Y. Also find the power consumed by the circuit if a 12 V battery is connected across XY.  Fig. Q1(b)	6	L2	CO1
	c.	Brief about, (i) Magnetic Flux (ii) Magnetic Flux Density (iii) Magneto motive force (iv) Magnetic flux density	8	L1	CO1
		OR			
Q.2	a.	Similarities between electric and magnetic circuits.	8	L2	CO1
	b.	Two coils having 150 and 200 turns are wound on a closed magnetic core of cross section 1.5×10^{-3} m^2 and mean length 3 m. The relative permeability is 2000. Calculate (i) The mutual inductance between the coils (ii) Voltage induced in the second coil if the current changes from 0 to 10 A in the First coil in 20 ms.	6	L3	CO1
	c.	Derive an expression for mutually induced emf.	6	L3	CO1
		Module – 2			
Q.3	a.	Derive the relation between V and I when AC is applied to RLC series circuit. Draw Phasor diagrams.	8	L3	CO2
	b.	An AC quantity is given by the expression i(t) = 40 sin (314t)A. Determine maximum value of current, peak to peak value, angular velocity, frequency, time period and also determine the value of instantaneous current at the time 3 milli seconds.	6	L3	CO2
	c.	Classify the types of power in AC circuit.	6	L2	CO2

		OR			
Q.4	**a.**	A resistance of 15 Ω is connected in series with an inductance of 0.25 H across 220 V, 50 Hz ac supply. Find (i) Total impedance (ii) Current through the circuit (iii) Voltage across the resistance (iv) Voltage across the inductance (v) Power factor (vi) Phase angle between voltage and current (vii) Active reactive and apparent power (viii) Equation for instantaneous voltage and current.	**8**	**L3**	**CO2**
	b.	Derive the relation between V and I when AC is applied to RL series circuit.	**6**	**L3**	**CO2**
	c.	Define average and rms values of sinusoidal voltage. Also derive the respective expressions.	**6**	**L2**	**CO2**
		Module – 3			
Q.5	**a.**	How do you generate 3-phase supply? Give the 3-phase expression and the advantages of 3-phase.	**8**	**L2**	**CO2**
	b.	3 coils each having resistance of 10 Ω and inductance of 0.02 H are connected in star across 440 V, 50 Hz supply. Calculate the line current and total power consumed.	**6**	**L2**	**CO2**
	c.	Define the following terms with respect to 3-phase supply: (i) Line current (ii) Line voltage (iii) Phase current (iv) Phase voltage (v) Total 3-phase power with a help of circuit diagram.	**6**	**L2**	**CO2**
		OR			
Q.6	**a.**	3 similar coils each having resistance of 10 Ω and 8 Ω inductive reactance are connected in star across 400 V, balanced 3 ϕ supply. Determine : (i) Line current (ii) Total power (iii) Reading of each of two watt meter connected to measure power.	**6**	**L3**	**CO2**
	b.	Obtain the relationship between the line and phase values of voltage and current in delta connection.	**8**	**L3**	**CO2**
	c.	Find the total power, power factor of the circuit shown.	**6**	**L3**	**CO2**

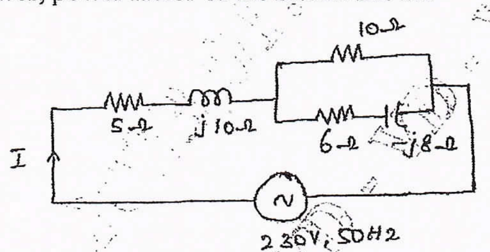


Fig. Q6 (c)

		Module – 4			
Q.7	**a.**	Explain the construction and working of Kelvin's double bridge.	**7**	**L2**	**CO4**
	b.	With a neat sketch, explain current transformer.	**6**	**L2**	**CO4**
	c.	Write short notes on Domestic wiring.	**7**	**L2**	**CO5**
		OR			
Q.8	**a.**	Explain the construction and working of Megger.	**6**	**L2**	**CO4**
	b.	Explain the construction of Maxwell's Bridge and derive the expression for unknown inductance.	**8**	**L2**	**CO4**
	c.	Explain two way and three way control of lamp with truth table.	**6**	**L2**	**CO5**

		Module – 5			
Q.9	a.	Define earthing, with neat diagram explain plate earthing.	6	L2	CO5
	b.	List out the power rating of household appliances including air conditioners, PC's, Laptops and Printers. Find total power consumed.	8	L2	CO5
	c.	With a neat circuit diagram, explain the operation of Earth Leakage Circuit Breaker (ELCB).	6	L2	CO5
		OR			
Q.10	a.	With diagram, explain the working of fuse and characteristics of fuse material.	6	L2	CO5
	b.	Define "unit" used for consumption of electrical energy and explain the two part tariff with its advantages and disadvantages.	8	L2	CO5
	c.	Write short notes on Miniature circuit Breaker and list its merits and demerits.	6	L2	CO5

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Module - 1

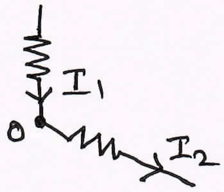
1a) State and explain Kirchoff's Laws. 6M

Ans:- Kirchoff's Current Law

"At any node of any active network, the algebraic sum of all the currents is equal to zero".

$$\sum I = 0$$

Consider currents I_1 & I_2. I_1 is entering towards junction 'O' & I_2 is leaving from junction.



Current incoming consider with '+ve' sign

current outgoing consider with '-ve' sign

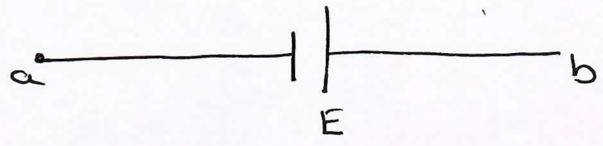
$$I_1 - I_2 = 0 \quad , \quad I_1 = I_2$$

"At any node or junction of any network, the sum of the currents entering the node is equal to the sum of the currents leaving the same node".

Kirchoff's Voltage Law

"Around any closed path of any active network, the sum of all voltage drops is equal to the sum of all voltage rises".

$$\sum E + \sum IR = 0$$



Consider a voltage source connected between a & b. When source is traced from a to b, voltage rises so that ~~indu~~ E is positive. When the same source is traced from b to a voltage falling, so E is negative.

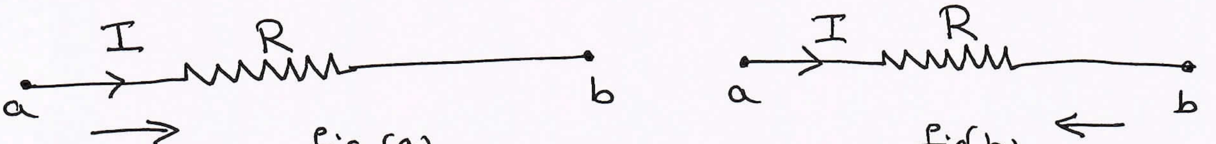


fig (a) fig (b)

The current flowing direction & circuit tracing direction is same IR drop is '-ve' (fig a). Current & circuit tracing directions opposite IR drop is '+ve' (fig b).

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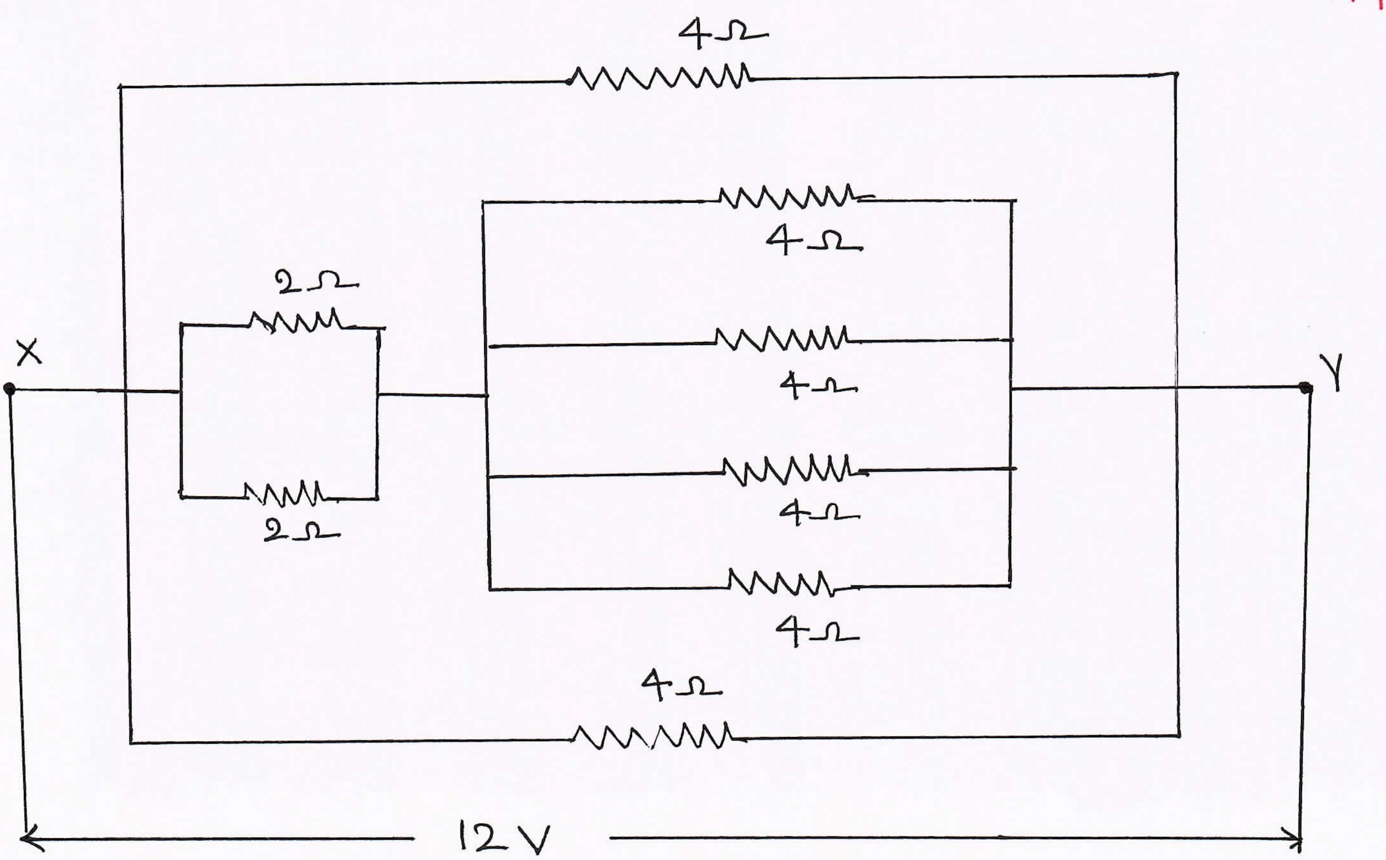
1 b) Find the total resistance of the circuit across the terminals X & Y. Also find the power consumed by the circuit if a 12 V battery is connected across XY. 6M



Ans :- 4 Ω is parallel with 4 Ω

$$(4 \| 4) = \frac{4 \times 4}{4+4} = 2\,\Omega$$

This 2 Ω parallel with 4 Ω

$$(2 \| 4) = \frac{4 \times 2}{4+2} = 1.33\,\Omega$$

This 1.33 Ω parallel with 4 Ω

$$(1.33 \| 4) = \frac{4 \times 1.33}{4+1.33} = 1\,\Omega$$

This 1 Ω is in series with (2 ∥ 2) combination

$$= 1 + \left[\frac{2 \times 2}{2+2}\right] = 2\,\Omega$$

This 2 Ω is parallel with 4 Ω

$$(2 \| 4) = \frac{4 \times 2}{4+2} = 1.33\,\Omega$$

This 1.33 Ω parallel with 4 Ω

$$(1.33 \| 4) = 1\,\Omega$$

Total resistance across X & Y point is 1 Ω

Total power consumed by circuit (P)

$$P = \frac{V^2}{R_{eq}} = \frac{12^2}{1} = 144 \text{ Watts.}$$

1c) Brief about i] Magnetic flux ii] Magnetic flux density iii] Magneto Motive Force

i] Magnetic Flux (ϕ)

The imaginary lines of force around magnet is called as magnetic flux. Symbolic representation of flux is 'ϕ'. unit of flux is Weber (Wb).

ii] Magnetic Flux Density (B)

The magnetic flux density at any point in a magnetic field is the number of flux lines crossing a unit area described about that point, at right angles to the plane of the surface described. Symbolic representation is 'B'.

$$B = \frac{\text{Magnetic flux}}{\text{Cross sectional area}} = \frac{\phi}{a} \ Wb/m^2$$

Unit of flux density is Wb/m^2 or Tesla.

iii] Magneto Motive Force (MMF)

Magneto motive force is the force that establishes magnetic field or flux in a given medium.

MMF = Current × Number of turns = I N

MMF = Flux × Reluctance = ϕ R

Unit of mmf is Ampere Turn (AT)

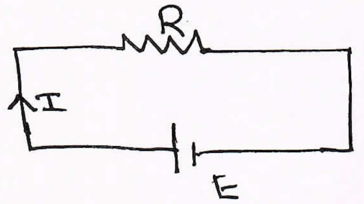
Q2 a) Similarities between electric & magnetic circuits.

8M

Ans :-

Electric Circuits

1]



2] Electro Motive Force

EMF = $I \times R$

3] Flowing of electrons

Current (I)

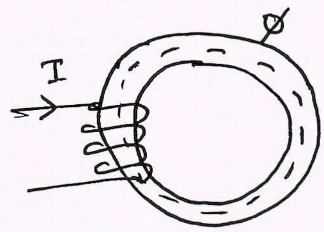
4] Resistance $R = \frac{\rho l}{a}$

5] Current density (J)

$J = \frac{I}{a}$ Amp/m^2

Magnetic Circuits

1]



2] Magneto Motive Force

MMF = $\phi \times \mathcal{R}$

3] Imaginary lines of force

flux (ϕ)

4] Reluctance $\mathcal{R} = \frac{l}{\mu_0 \mu_r a}$

5] Flux density (B)

$B = \frac{\phi}{a}$ Wb/m^2

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b) Two coils having 150 & 200 turns are wound on a closed magnetic core of cross section $1.5 \times 10^{-2} m^2$ & mean length 3m. The relative permeability is 2000. Calculate

i] ~~Normal~~ Mutual Inductance between the coils

ii] Voltage induce in the second coil if the current changes from 0 to 10A in the First coil in 20 msec.

6M

Ans :-

$N_1 = 150$ turns

$N_2 = 200$ turns

$a = 1.5 \times 10^{-2} m^2$

$l = 3m$

$\mu_r = 2000$

$\mu_0 = 4\pi \times 10^{-7}$ H/m

Mutual ~~keng'~~ Inductance of Coil (M)

$$M = \frac{N_1 N_2 \mu_0 \mu_r a}{l}$$

$$= \frac{200 \times 150 \times 4\pi \times 10^{-7} \times 2000 \times 1.5 \times 10^{-2}}{3}$$

~~$M = 0.2827\ H$~~

$$M = 0.377\ H$$

ii] Voltage induced in the second coil when current is changing from 0 to 10A, in 20 m sec

$$e_{12} = -M \frac{di_1}{dt}$$

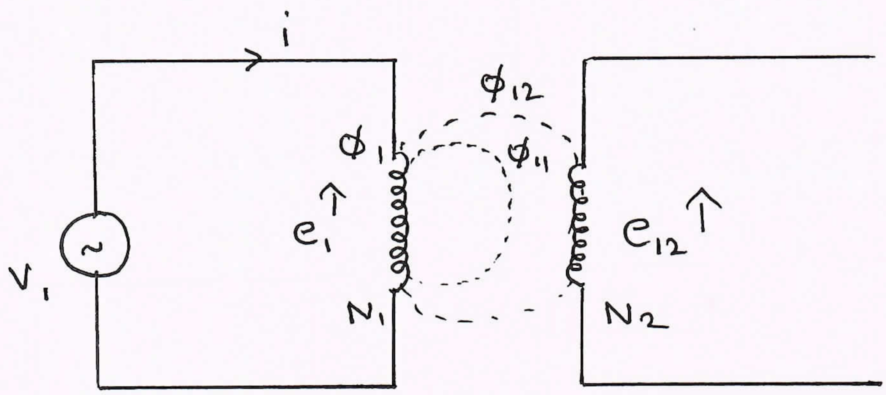
$$= -0.377 \frac{(0-(-10))}{20 \times 10^{-3}}$$

$$e_{12} = -0.377 \times \frac{10}{20 \times 10^{-3}}$$

$$e_{12} = 188.5 \text{ Volts}$$

2 c) Derive an expression for mutually induced emf. 6M

Ans:- "One source ability to induce emf in two coils which is physically separated is called as mutual inductance".



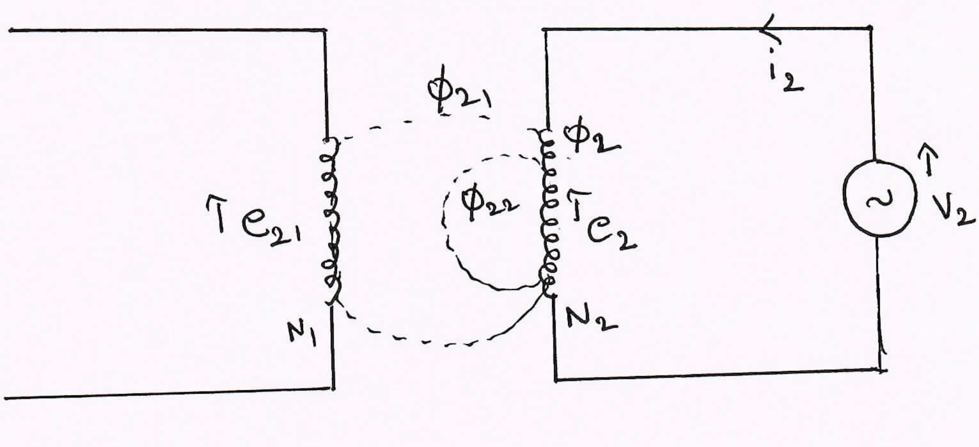
Self induced emf $e_1 = -N_1 \frac{d\phi_1}{dt}$

Main flux $\phi_1 = \phi_{11} + \phi_{12}$

Mutual induced emf $e_{12} = -N_2 \frac{d\phi_{12}}{dt}$

$e_{12} = -M_{12} \frac{di_1}{dt}$

Mutual inductance $M_{12} = N_2 \frac{d\phi_{12}}{di_1}$



$\phi_2 = \phi_{21} + \phi_{22}$

$e_2 = -N_2 \frac{d\phi_2}{dt}$

$$e_{21} = -N_1 \frac{d\phi_{21}}{dt}$$

$$e_{21} = -M_{21} \frac{di_2}{dt}$$

$$M_{21} = N_1 \frac{d\phi_{21}}{di_2}$$

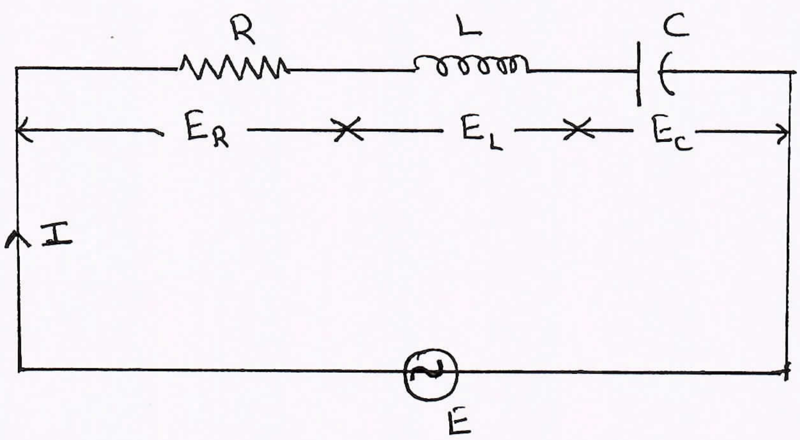
Coupling is bilateral $M_{12} = M_{21} = M$

Module 2

3 a) Derive the relation between V & I when AC is applied to RLC series circuit. Draw the phasor diagram.

8M

Ans:-



i] $X_L > X_C$

Impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}\ \Omega$

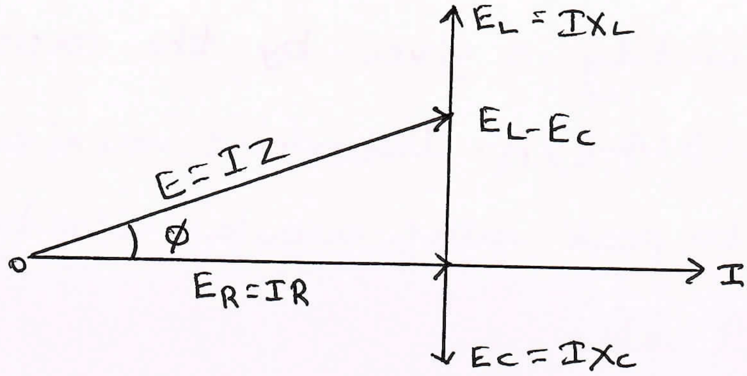
Current $I = \frac{E}{Z}$

Power consumption $P = EI\cos\phi$

$e = E_m \sin\omega t$

$i = I_m \sin(\omega t - \phi)$

$X_L = 2\pi f L\ \Omega$ $X_C = \frac{1}{2\pi f C}\ \Omega$



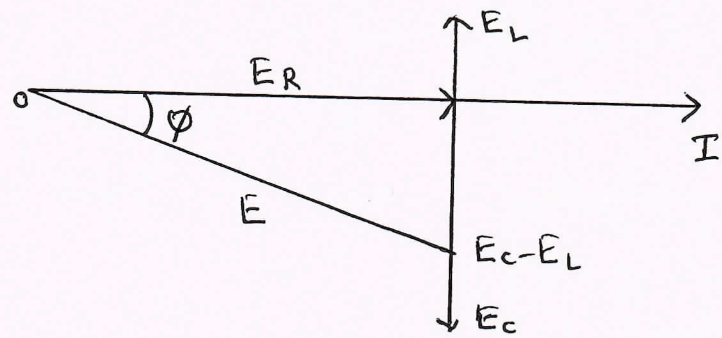
ii] $X_C > X_L$

$$Z = \sqrt{R^2 + (X_C - X_L)^2}$$

$$I = \frac{E}{Z}$$

$$P = EI\cos\phi$$

$e = E_m \sin \omega t \qquad i = I_m \sin(\omega t + \phi)$



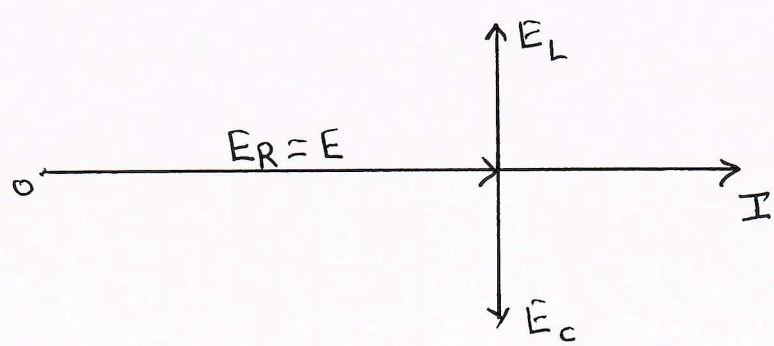
iii] $X_L = X_C$

$$Z = R$$

$$I = \frac{E}{Z}$$

$$P = EI$$

$e = E_m \sin \omega t \qquad i = I_m \sin \omega t$



3b) An AC quantity is given by the expression — $i(t) = 40 \sin(314t)$ A. Determine maximum value of current, peak to peak value, angular velocity, frequency, time period & also determine the value of instantaneous current at the time 3 milli seconds.

Ans:-

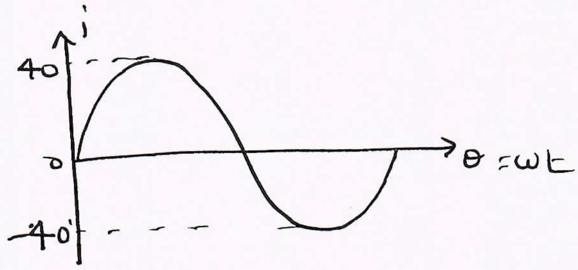
$$i(t) = 40 \sin(314t)$$

$$i(t) = I_m \sin(\omega t)$$

1] Maximum value of current $I_m = 40$ A

2] Peak to Peak value

Peak to peak is +40 to -40.



So that it is $40-(-40)$

$= 80$ A

3] Angular velocity $(\omega) = 314$ rad/sec

4] Frequency $f = \frac{\omega}{2\pi} = \frac{314}{2\pi} = 50$ Hz

5] Time period $T = \frac{1}{f} = \frac{1}{50} = 0.02$ sec

6] Instantaneous current at $t = 3$m sec

$$i(t) = 40 \sin(314 \times 3m)$$

$i(t) = 0.657$ Amps

3c) Classify the types of power in AC circuit. 6M

Ans: - AC Power is classified as 3 types

i] Real power ii] Reactive power iii] Apparent power

i] Real Power or Active Power

It is also called as wattful power. The unit of real power is watts.

$$P = EI \cos\phi \text{ watts}$$

ii] Reactive Power

It is also called as wattless power. Unit of reactive power is volt-Ampere Reactive (VAR).

$$Q = EI \sin\phi \text{ VAR}$$

iii] Apparent Power

Its the phasor sum of real & reactive power.

Unit is Volt-Ampere (VA)

$$S = EI = \sqrt{P^2 + Q^2} \text{ VA}$$

4a) A resistance of 15Ω is connected in series with an inductance of 0.25 H across 220V, 50Hz ac supply. Find

i] Total Impedance

ii] Current through the circuit

iii] Voltage across the resistance

iv] Voltage across inductance

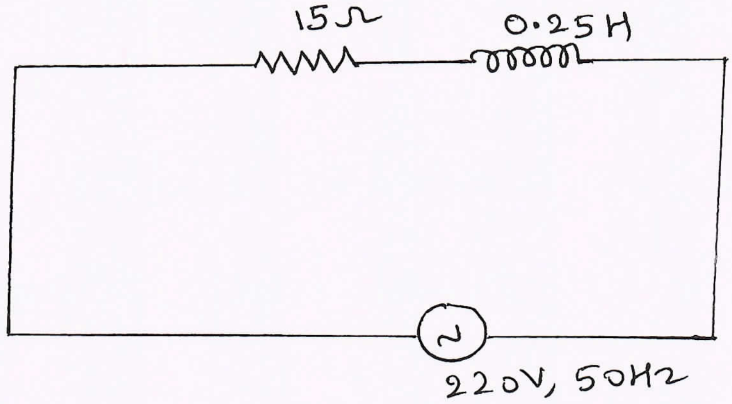
v] Power factor

vi] Phase angle between voltage & current.

vii] Active reactive & apparent power

viii] Equation for instantaneous voltage & current. 8M

Ans:-



i] Total Impedance (Z)

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{15^2 + 78.55^2} = 79.96\,\Omega$$

$$X_L = 2\pi f L = 2\pi \times 50 \times 0.25 = 78.55\,\Omega$$

ii] Current through the Circuit (I)

$$I = \frac{E}{Z} = \frac{220}{79.96} = 2.75 \text{ Amps}$$

iii] Voltage across the resistance $[E_R]$

$$E_R = IR = 2.75 \times 15 = 41.27 \text{ Volts}$$

iv] Voltage across the inductance (E_L)

$$E_L = I X_L = 2.75 \times \sout{79.96}\ 78.55 = 216.01 \text{ Volts}$$

v] Power factor $(\cos\phi)$

$$\cos\phi = \frac{R}{Z} = \frac{15}{79.96} = 0.187 \text{ lagging}$$

vi] Active Power $P = EI\cos\phi = 220 \times 2.75 \times 0.187 = 113.5$

Reactive Power $Q = EI\sin\phi = 220 \times 2.75 \times \sin(79.2)$

$$= 594.28 \text{ VAR}$$

Apparent Power $S = EI = 220 \times 2.75 = 605$ VA vi] Phase angle between voltage & current (ϕ)

$$\cos\phi = 0.187$$

$$\phi = 79.2^\circ$$

vii] Equation of instantaneous voltage & current

$$e = E_m \sin \omega t$$

$$E_m = \sqrt{2} \times 220 = 311.12 \text{ Volts}$$

$$\omega = 2\pi f = 2\pi \times 50 = 314 \text{ rad/sec}$$

$$e = 311.12 \sin 314t$$

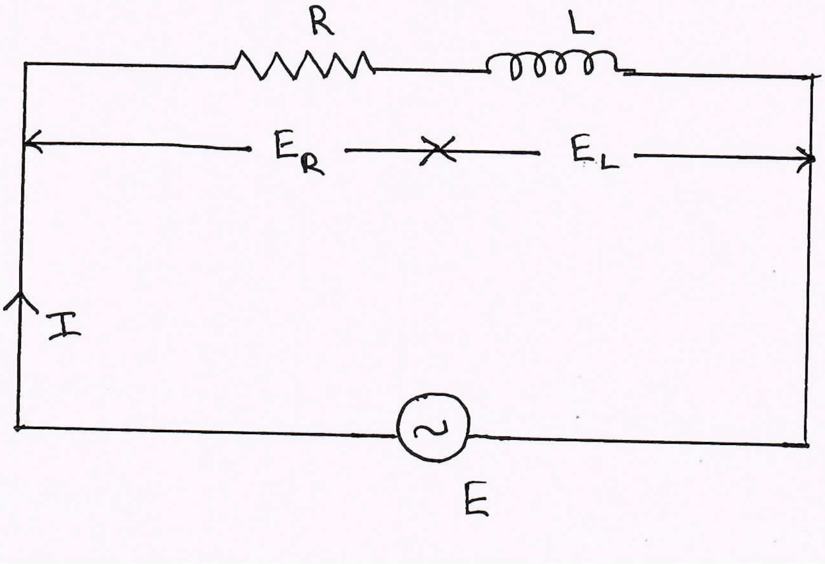
$$i = I_m \sin(\omega t - \phi)$$

$$I_m = 2.75 \times \sqrt{2} = 3.88 \text{ Amps}$$

$$i = 3.88 \sin(314t - 79.2^\circ)$$

4b) Derive the relation between V & I when AC is applied to RL series circuit.

Ans:-



Total impedance $Z = \sqrt{R^2 + X_L^2} \ \Omega$

Inductive reactance $X_L = 2\pi f L \ \Omega$

Total current $I = \frac{E}{Z}$

Power factor $\cos\phi = \frac{R}{Z}$ lagging

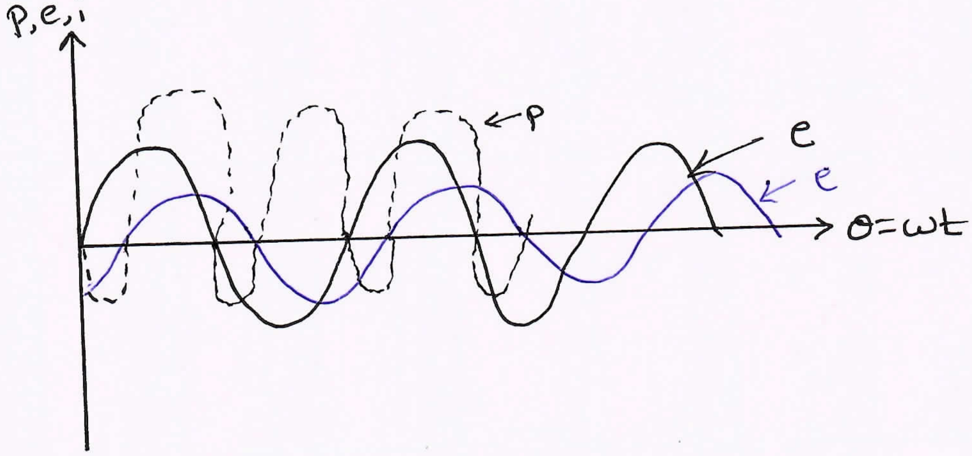
Power $(p) = e \times i$

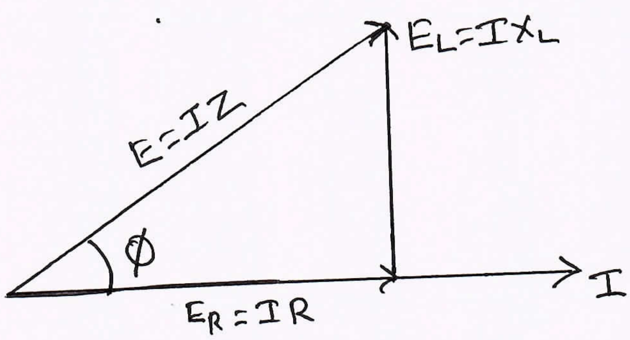
$= E_m \sin \omega t \times I_m \sin(\omega t - \phi)$

$= \frac{1}{2} E_m I_m \cos\phi - \frac{1}{2} E_m I_m \cos(2\omega t - \phi)$ (second term crossed out, marked 0)

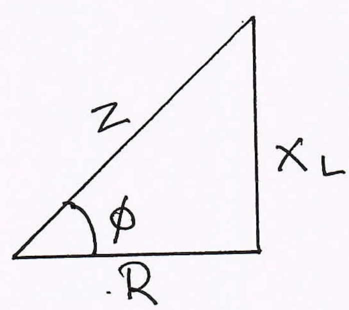
$= \frac{1}{2} E_m I_m \cos\phi$

$p = E I \cos\phi$ watts





Voltage triangle



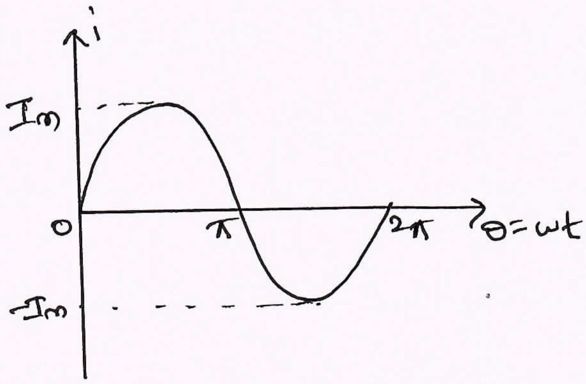
Impedance triangle

4C) Define average & rms values of sinusoidal voltage. Also derive the respective expression.

Ans:- RMS value

"The effective value or rms value of an AC is equal to that steady current, which produces the same amount of heat as produced by the AC when passed through the same resistance for the same time."

$i = I_m \sin\theta$



$$I_{rms} = \frac{1}{2\pi}\int_0^{2\pi} i^2\, d\theta$$

$$I_{rms} = \frac{1}{2\pi}\int_0^{2\pi} I_m^2 \sin^2\theta\, d\theta$$

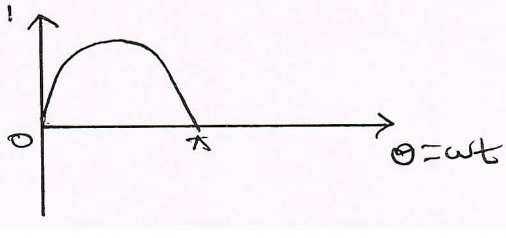
$$I_{rms} = \frac{I_m^2}{2\pi}\int_0^{2\pi} \frac{1-\cos 2\theta}{2}\, d\theta$$

$$I_{rms} = \frac{I_m^2}{4\pi}\left[\theta - \frac{\sin 2\theta}{2}\right]_0^{2\pi}$$

$$I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707 I_m$$

Average Value

"The average value of an AC is equal to that steady current, which transfer the same amount of charge, as transferre by AC across the circuit and in the same time."



$$I_{avg} = \frac{1}{\pi}\int_0^{\pi} i\, d\theta$$

$$= \frac{1}{\pi}\int_0^{\pi} I_m \sin\theta\, d\theta$$

$$I_{avg} = \frac{I_m}{\pi}\left[-\cos\theta\right]_0^{\pi}$$

$$I_{avg} = \frac{2}{\pi} I_m = 0.637\, I_m$$

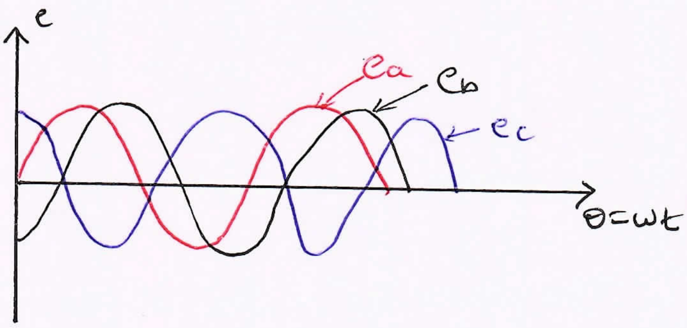
Module - 3

5a) How do you generate 3ϕ supply? Give the 3ϕ expression & the advantage of 3ϕ.

8 M

Ans: - 3ϕ supply is generated through 3ϕ generator or synchronous generator. Main parts of the generator is stator & rotor. An excitation voltage of 110V or 220V DC applied to rotor winding through brushes. This leads to initiation of magnetic flux in rotor, & rotor is coupled to turbine or prime mover, in order to give mechanical input. When rotor rotates, flux also rotates in airgap, stator able to cut the magnetic flux. Hence emf induced in stator winding, each phase winding is $120°e$ apart.

The induced emf in 3 phases are

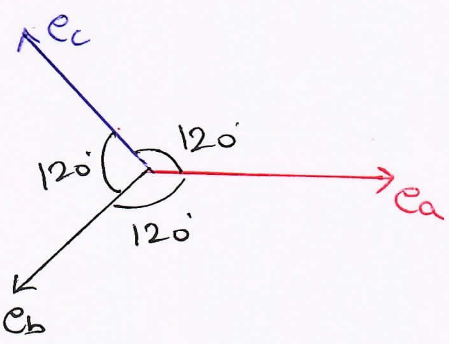


$$e_a = E_m \sin\omega t$$

$$e_b = E_m \sin(\omega t - 120°)$$

$$e_c = E_m \sin(\omega t + 120°)$$

$$e_a + e_b + e_c = 0$$



Merits of 3ϕ supply

1] 3ϕ equipments are more efficient

2] For the same capacity 3ϕ equipment size is lessthan 1ϕ equipment

3] For the same capacity 3ϕ equipment cost is lessthan 1ϕ equipment.

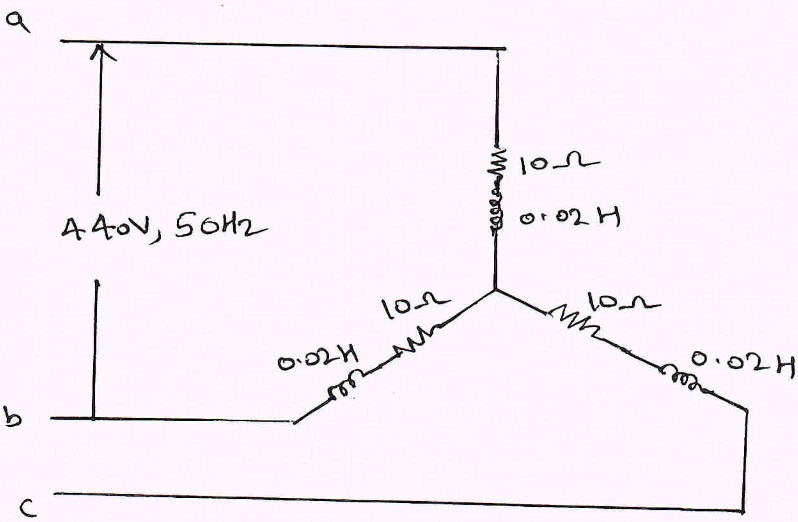
4] 3ϕ motors produces uniform torque.

5] 3ϕ motors self starting in nature.

6] Phase & Line voltages are available in 3ϕ supply.

5b) 3 coils each having resistance of 10Ω & inductance of 0.02 H are connected in star across 440V, 50Hz supply. Calculate the line current & total power consumed.

6M



Resistance per phase $R = 10\Omega$

Inductive reactance per phase $X_L = 2\pi \times 50 \times 0.02 = 6.284\,\Omega$

Line voltage $E_L = 440V$

Impedance per phase $Z_{ph} = \sqrt{R^2 + X_L^2} = \sqrt{10^2 + (6.284)^2}$

$= 11.81 \Omega$

Current per phase $I_{ph} = \frac{E_{ph}}{Z_{ph}}$

Voltage per phase $E_{ph} = \frac{E_l}{\sqrt{3}} = 254 V$

$I_{ph} = \frac{254}{11.81} = 21.51 Amps$

In star connection Line current is equal to phase current.

$I_L = I_{ph} = 21.51 Amps$

Total power consumption $P = \sqrt{3} E_l I_l \cos\phi$

where $\cos\phi = \frac{R}{Z} = \frac{10}{11.81} = 0.846$ lagging

$P = \sqrt{3} \times 440 \times 21.51 \times 0.846$

$= 13,880.4 W$

$= 13.88 kW$

5c) Define the following terms with respect to 3ϕ supply

i] Line Current ii] Line voltage

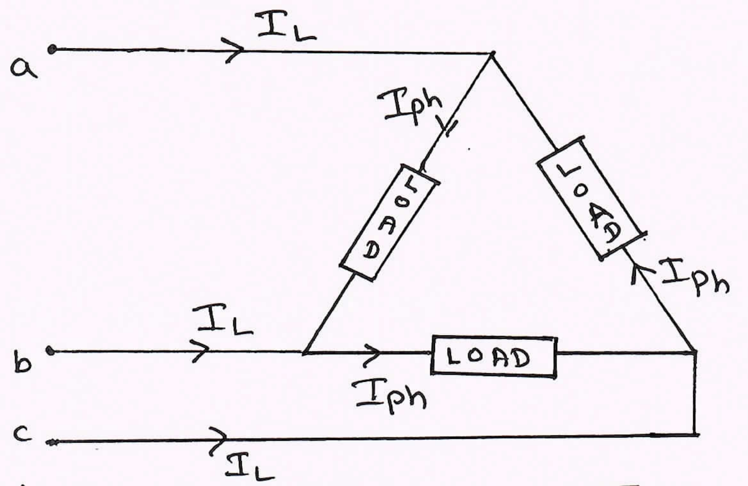
iii] Phase current iv] Phase voltage

v] Total phase power with the help of circuit diagram 6M i] Line Current

In 3ϕ system current through any one line between a 3ϕ source & load. It's denoted by "I_L".

ii] Phase Current

The phase current is the current through any one component comprising a 3ϕ source & load. Denoted by "I_{ph}"



In delta connection $I_L = \sqrt{3}\, I_{ph}$

ii] Line Voltage

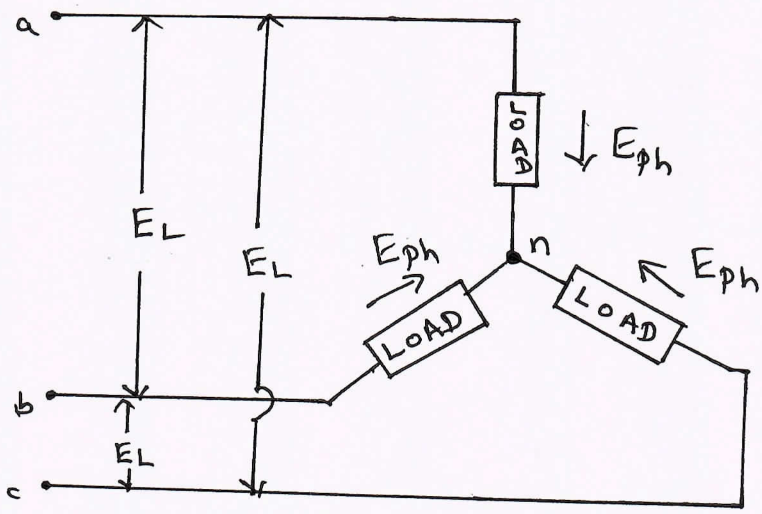
The voltage exist between two higher potential line is called as Line voltage. Denoted by "E_l".

iv] Phase Voltage

The voltage exist between a higher potential & lower potential is called as phase voltage. Denoted by "Eph".

In star connection

$$E_l = \sqrt{3}\ E_{ph}$$



$E_L = E_{ab} = E_{bc} = E_{ca}$

$E_{ph} = E_{an} = E_{bn} = E_{cn}$

v] Total 3 ϕ power

"Total power consumed by 3ϕ equipment is called as total 3ϕ power".

In terms of Line quantity

$$P = \sqrt{3}\ E_l I_l \cos\phi$$

In terms of Phase quantity

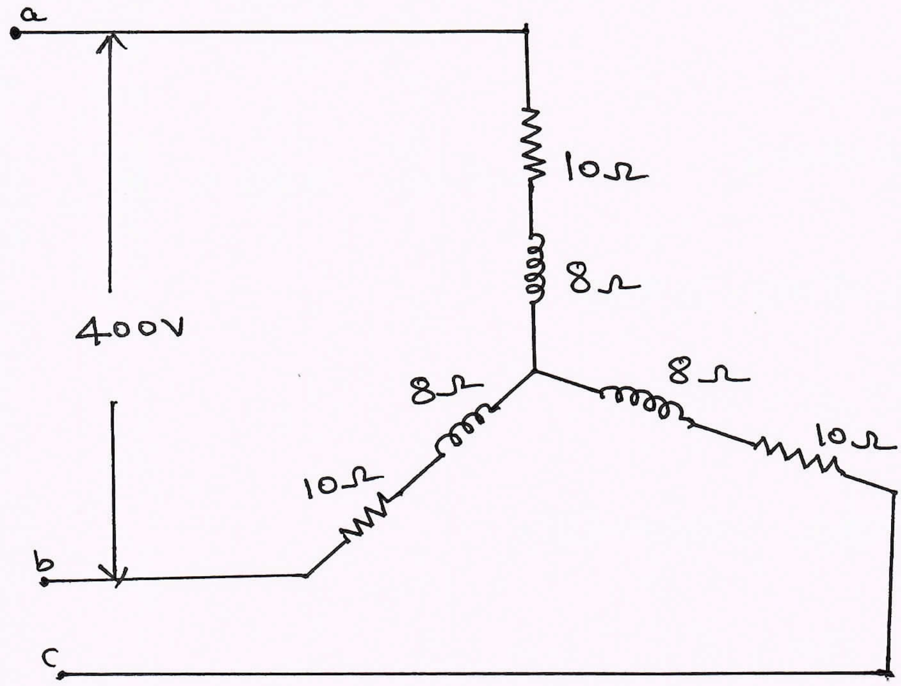
$$P = 3\ E_{ph} I_{ph} \cos\phi$$

Q6a) 3 similar coils each having resistance of 10Ω & 8Ω inductive reactance are connected in star across 400V, balanced 3ϕ supply. Determine:

i] Line current ii] Total power

iii] Reading of each wattmeter connected to measure power.

Ans:-



Line voltage $E_L = 400V$

Phase voltage $E_{ph} = \frac{E_L}{\sqrt{3}} = \frac{400}{\sqrt{3}} = 230.9V$ (Star connection)

Resistance per phase $R = 10\Omega$

Inductive reactance per phase $X_L = 8\Omega$

Impedance per phase $Z_{ph} = \sqrt{R^2 + X_L^2}$

$$Z_{ph} = \sqrt{10^2 + 8^2} = 12.8\ \Omega$$

Phase Current $I_{ph} = \frac{E_{ph}}{Z_{ph}} = \frac{230.9}{12.8} = 18.03\ A$

In star connection Line current is equal to phase current.

$$I_L = I_{ph} = 18.03\ A$$

ii] Total Power (P)

$P = \sqrt{3}\, E_L I_L \cos\phi$ where $\cos\phi = \frac{R}{Z} = \frac{10}{12.8} = 0.781$ lag

$P = \sqrt{3} \times 400 \times 18.03 \times 0.781$

$P = 9{,}747.5$ Watts

iii] Reading of each wattmeter

$W_1 + W_2 = 9747.5$ — I

$$\cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}(W_1 - W_2)}{(W_1 + W_2)}\right)\right]$$

$$0.781 = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}(W_1 - W_2)}{9747.5}\right)\right]$$

$$\cos^{-1}(0.781) = \tan^{-1}\left(\frac{\sqrt{3}(W_1 - W_2)}{9747.5}\right)$$

$$\frac{\tan(38.64^\circ)}{\sqrt{3}} = \frac{W_1 - W_2}{9747.5}$$

$W_1 - W_2 = 0.4621 \times 9747.5$

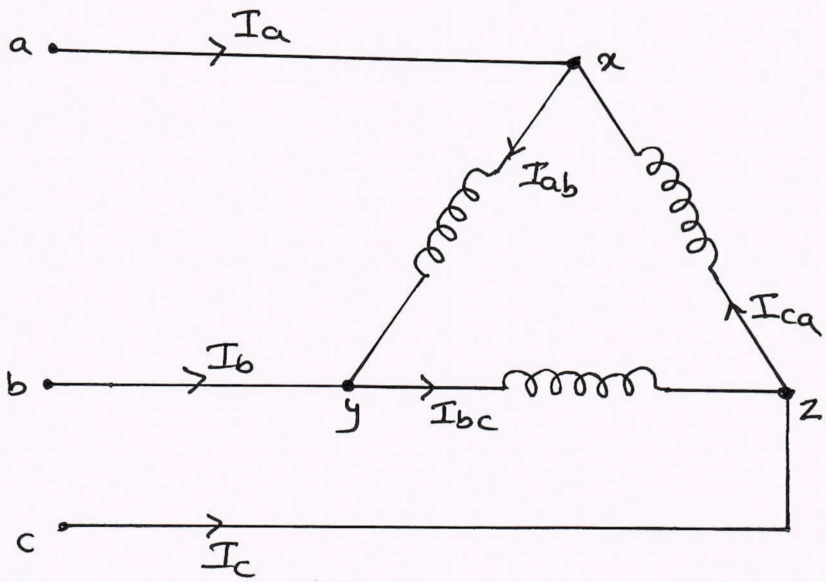
$W_1 - W_2 = 4504.32$ — II

Solving equation I & II

$W_1 = 7125.9\ W$ $W_2 = 2621.6\ W$

6b) Obtain the relationship between the line & phase values of voltage & current in delta connection

8M



I_a, I_b & I_c are line currents (I_L)

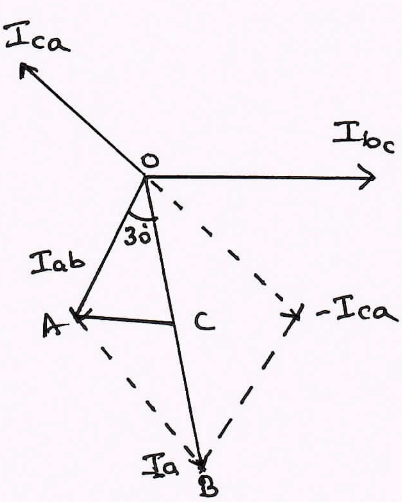
$I_L = I_a = I_b = I_c$

I_{ab}, I_{bc}, I_{ca} are phase currents (I_{ph}

$I_{ph} = I_{ab} = I_{bc} = I_{ca}$

In delta connection $E_l = E_{ph}$

Apply KCL to point 'x'



$I_a - I_{ab} + I_{ca}$

$I_a = I_{ab} - I_{ca}$

Draw AC $\perp^{lar}$ to OB

$\angle AOC = 30°$

$\triangle OAC$

$$\cos 30° = \frac{OC}{OA} = \frac{OB/2}{OA} = \frac{I_a}{2 I_{ab}}$$

$$\frac{\sqrt{3}}{\cancel{2}} = \frac{I_a}{\cancel{2} I_{ab}}$$

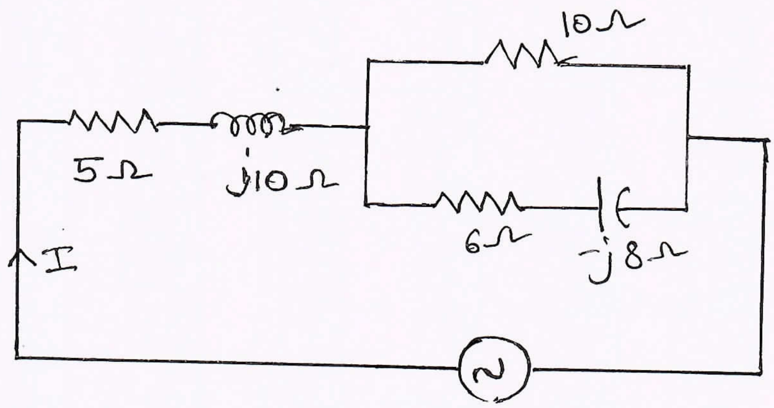
$I_a = \sqrt{3}\, I_{ab}$

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

Total 3ϕ power $P = \sqrt{3}\, E_L I_L \cos\phi$

$= 3\, E_{ph} I_{ph} \cos\phi$

6c) Find the total power, powerfactor of the circuit shown 6M



Ans:-

$Z_1 = (5 + j10)\,\Omega = 11.18 \angle 63.43^\circ\,\Omega$

$Z_2 = (10 + j0)\,\Omega = 10 \angle 0^\circ\,\Omega$

$Z_3 = (6 - j8)\,\Omega = 10 \angle -53.13^\circ$

$Z_{eq} = Z_1 + (Z_2 \| Z_3)$

$$Z_2 \| Z_3 = \frac{Z_2 Z_3}{Z_2 + Z_3}$$

$$= \frac{10 \times 10 \angle -53.13}{(16 - j8)}$$

$= (5 - j2.5)\,\Omega$

$Z_{eq} = (5+j10) + (5-j2.5) = (10+j7.5)\,\Omega = 12.5\angle 36.87^\circ\,\Omega$

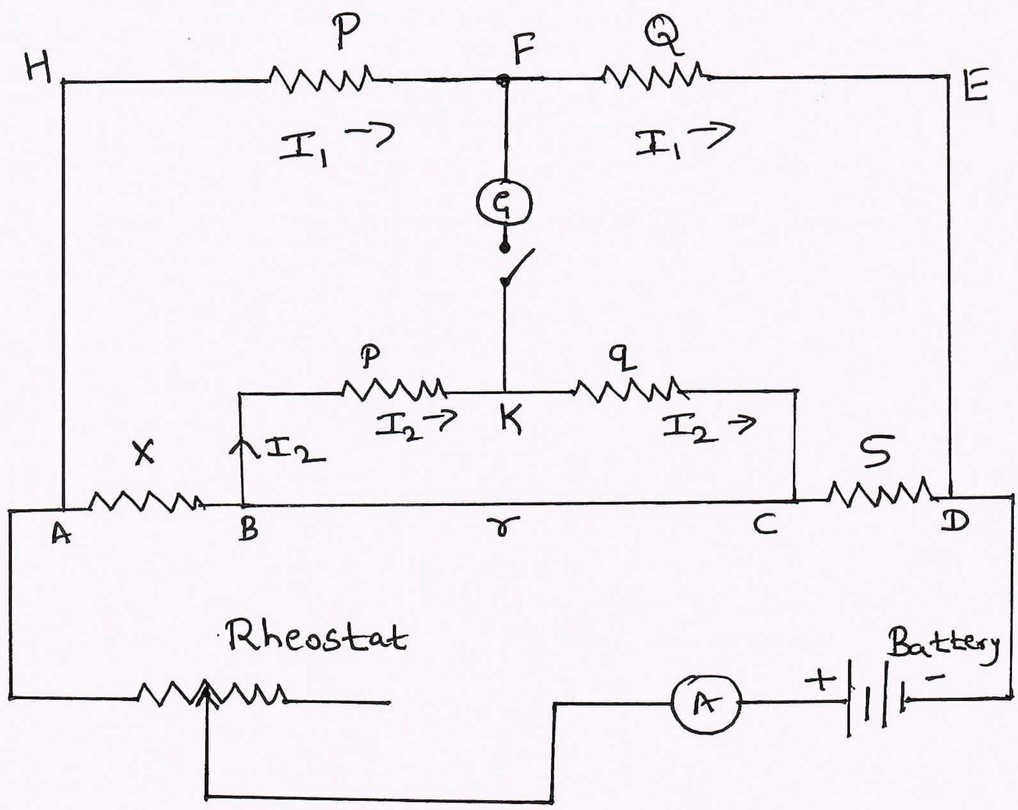
Total current $I = \frac{E}{Z} = \frac{230}{12.5\angle 36.87} = 18.4\angle -36.87$

Power factor $\cos\phi = \cos(36.87) = 0.8$ lagging

Total Power $P = EI\cos\phi = 230 \times 18.4 \times 0.8 = 3{,}385.6\,W$

Module 4

7a) Explain the construction & working of Kelvin's double bridge. 7M



The Kelvin's Double Bridge is use to measure low resistance. X is the resistor under test & S is a standard resistor of the same order of resistance & of the same or the higher current rating than the one under test. The X & S resistances are connected in series with a a short link of low resistance. P, Q & p, q are pure resistance, one pair P-p or Q-q are variable. The rated current pass through X & S using low voltage high current battery. Ammeter & rheostat connected in circuit. A sensitive galvanometer 'G' connected across the dividing point PQ & pq. P/Q is equal to p/q, these ratios being varied until 'G' reads zero.

Under balanced condition, KCL applied to meshes AHFKBA & FEDGKF

$$I_1 P - I_2 p - IX = 0$$

$$IX = I_1 P - I_2 p \quad — I$$

$$I_1 Q - I_2 q - Is = 0$$

$$Is = I_1 Q - I_2 q \quad — II$$

Dividing I by II

$$\frac{IX}{Is} = \frac{I_1 P - I_2 p}{I_1 Q - I_2 q}$$

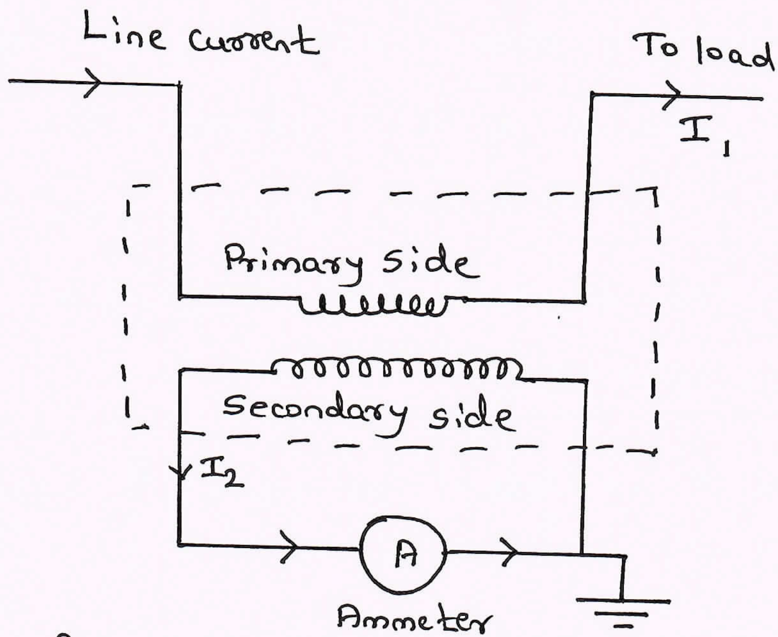
$$\frac{X}{S} = \frac{P(I_1 - \frac{p}{P} I_2)}{Q(I_1 - \frac{q}{Q} I_2)} \qquad \text{where } \frac{p}{P} = \frac{q}{Q}$$

$$\frac{X}{S} = \frac{P}{Q}$$

$$X = S\left(\frac{P}{Q}\right)$$

7 b) With a neat sketch, explain current transformer. 6M

Ans:-



A current transformer (CT) is a type of transformer that is used to reduce or multiply an AC. It produces a current in its secondary which is proportional to the current in its primary. Whenever AC supplies through out the primary winding then alternating magnetic flux can be generated, then AC will be induced within the secondary winding.

Construction :-

Primary Ampere Turns → The number of ampere turns in the transformer ranges from 5,000 to 10,000, so these are decided the primary current.

Core → To achieve the low magnetizing ampere twists, the core materials must include low iron losses & low reluctance. Nickel & iron material is used.

Winding → Two windings are placed closest to reduce leakage reactance. Primary winding made up from copper & secondary is SWG wire.

Insulation → Varnish & tape used as insulation material.

7c) Write short notes on Domestic Wiring 7M

Ans:- Domestic wiring deals with the electrical wiring of electric apparatus used in houses. The method or technique of wiring involving supply, switches, circuit breaker & the above mentioned electrical loads is called domestic wiring.

Factors to be considered for good & Economic wiring

* Safety
* Durability & mechanical protection
* Appearance
* Environmental conditions
* Accessibility
* Cost

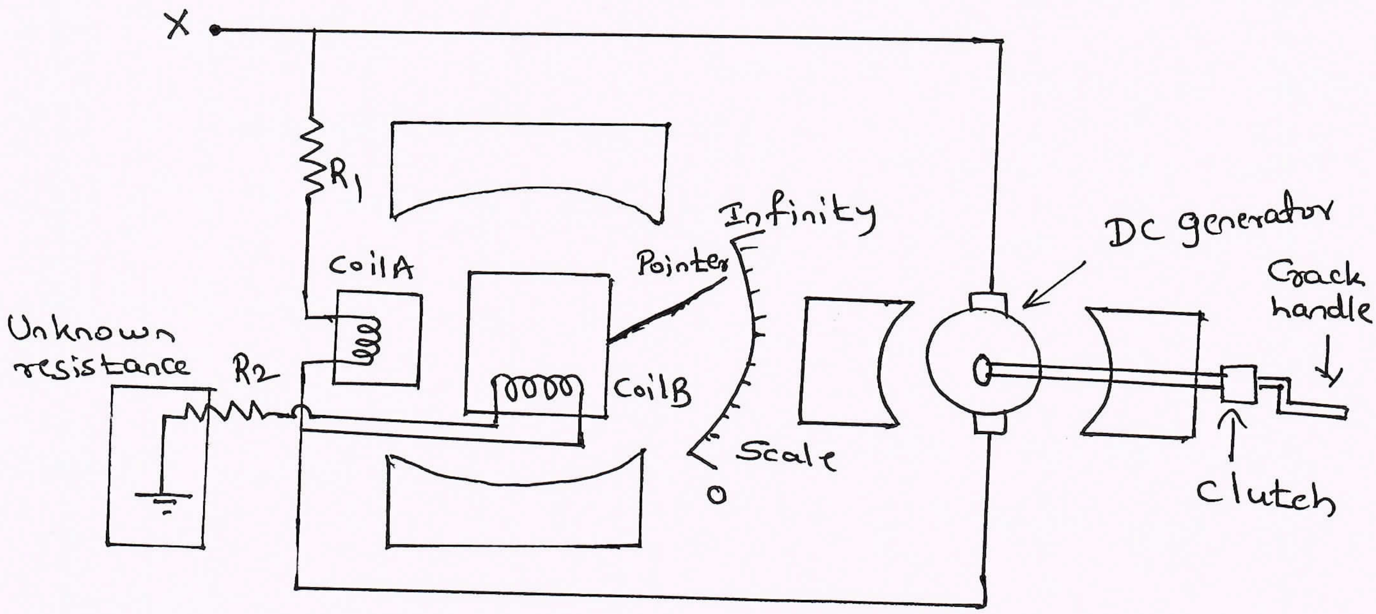
Different types of wiring

* Conduit wiring
* Casing & capping wiring
* Batten wiring
* cleat wiring
* Con-sealed wiring

Q 8 a) Explain the construction & working of Megger 6M

Ans :- Megger is a special type of portable instrument used to measure very high resistance in terms of mega ohms. It is also known as an insulation tester.

Construction



The main parts of the megger

I] DC generator ii] Ohm - meter

The DC generator rotated at speed of 140 to 160 rpm will induce 500V, 600V, or 2kV. An ohmmeter measures the resistance in megaohm. It consists of two moving coils placed at a certain angle to each other & these coils rotate in between two poles of a permanent magnet with the help of a spindle & jewels. In megger one current coil & two pressure coil are connected through R_1 & R_2 in series and parallel.

Working of Megger

Step 1 → The resistance to be measured is connected in series with the deflecting coil & across the generator. When current is provided to both current & pressure coil then the torque produced by these coils are in opposite directions.

Step 2 → If the resistance to be measured is very high then no current will flow through the deflecting coil. Then controlling coil sets itself perpendicular to the magnetic axis & hence sets the pointer at infinity.

Step 3 → When the resistance to be measured is of intermediate value, then the pointer is set to infinity or zero depending on the value of torques produced.

Step 4 → When the resistance to be measured is smaller value then a very high current flows through deflecting coil & due to the resulting torques the pointer will set to zero or infinity.

Merits :-

1] Accuracy of measurement is high

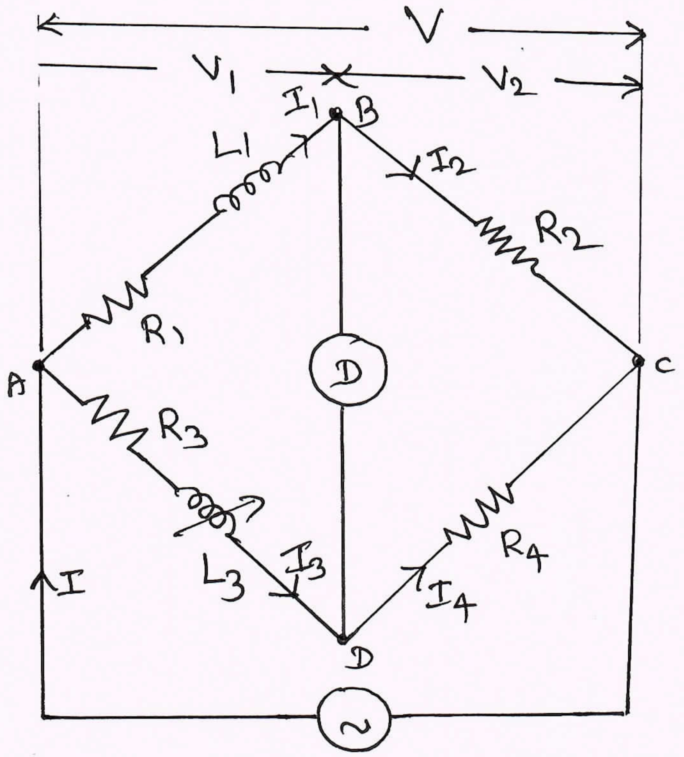
2] Easy operation.

3] Safe to use

Demerits

1] Initial cost is very high

8 b) Explain the construction of Maxwell's Bridge & derive the expression for unknown inductance. 8 M



This method is very suitable for accurate measurement of medium inductance. The unknown inductance is determined by comparing it with a standard self inductance. L_1 is an unknown self inductance of R_1, L_3 is known variable inductance of R_3, whoes resistance is constant. R_2 & R_4 are pure resistance. 'D' is detector. L_1 & L_3 magnetude should be same. To balance the bridge L_3 & R_2 or R_4 vary, bridge can be also balanced by keeping R_3 & R_4 constant, R_1 or R_2 should varie. When bridge is balanced current flows throug 'D' is zero.

$$I_1 = I_2 \quad , \quad I_3 = I_4$$

Voltage across AB = voltage across AD = V_1

$$I_1 Z_1 = I_3 Z_3 = V_1$$

Voltage across B = Voltage across CD = V_2

$$I_2 R_2 = I_4 R_4 = V_2$$

$$I_1 R_2 = I_3 R_4$$

$$\frac{R_1 + j\omega L_1}{R_2} = \frac{R_3 + j\omega L_3}{R_4}$$

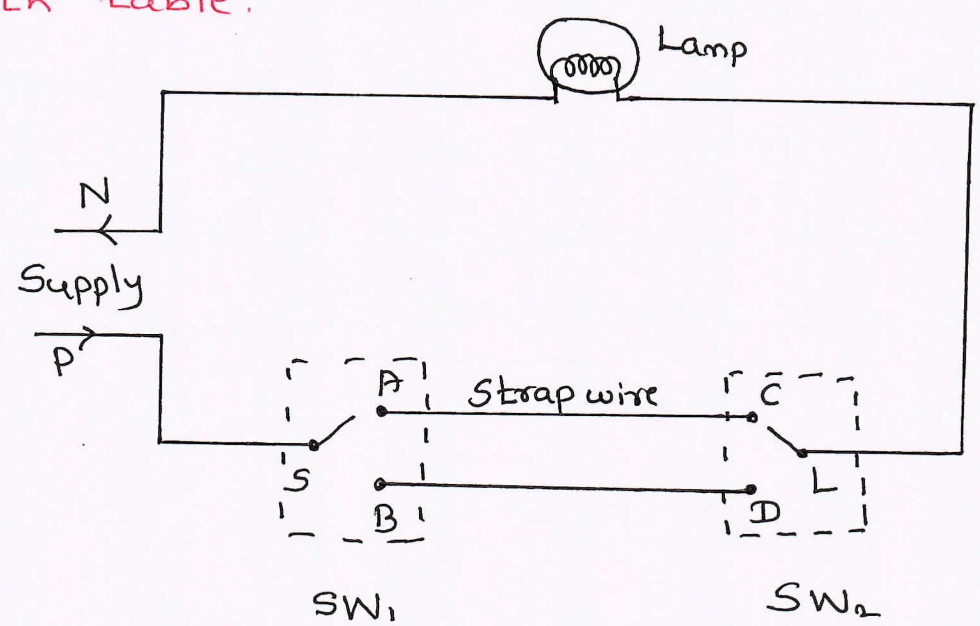
$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

$$R_1 = \left(\frac{R_3}{R_4}\right) R_2$$

$$\frac{\omega L_1}{R_2} = \frac{\omega L_3}{R_4}$$

$$L_1 = \left(\frac{R_2}{R_4}\right) L_3 .$$

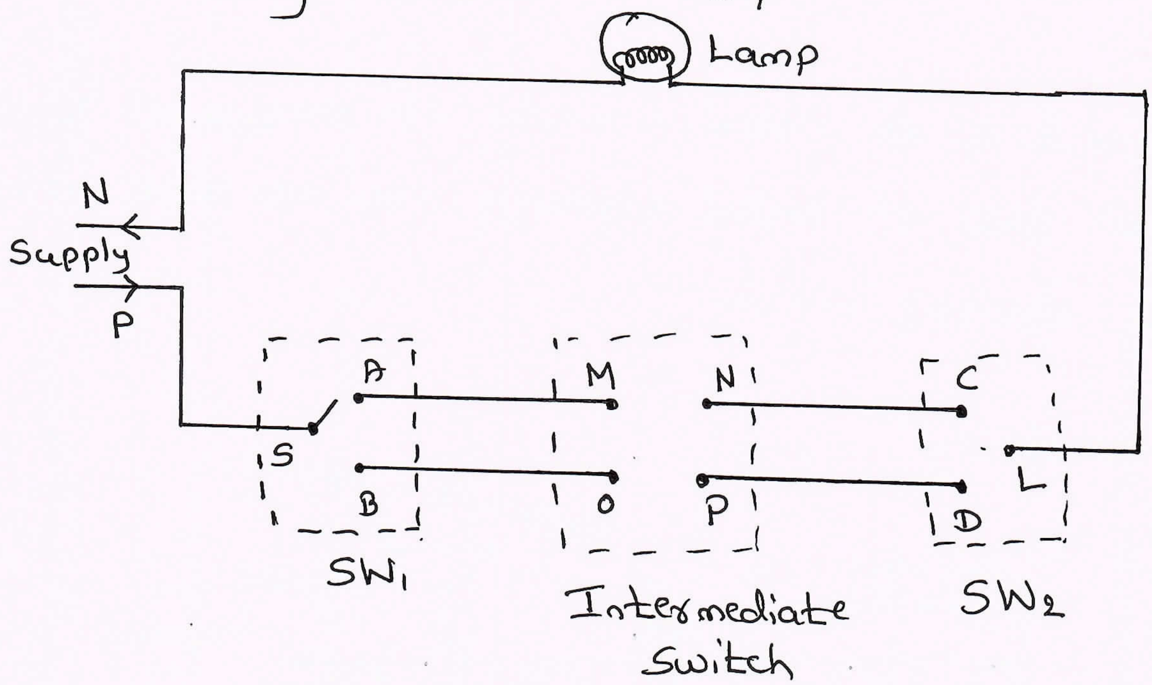
8c) Explain two way & three way control of lamp with truth table. 6M



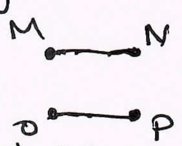
Position of Switch 1	Position of Switch 2	Lamp status
SA	CL	ON
SA	DL	OFF
SB	DL	ON
SB	CL	OFF

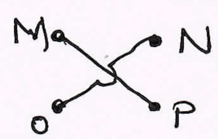
Two way control of lamp used in stair case. Two way switches are placed in different location. It consits 3 terminals. When circuit is completely closed lamp gives light output, if circuit is open lamp not able to give output

Three way Control of lamp



Three way control of lamp nomally used in godown. It consists of an intermediate swith & two ~~tway~~ two way switches. Intermediate switch has straight connection & cross connection





straight connection

Cross connection

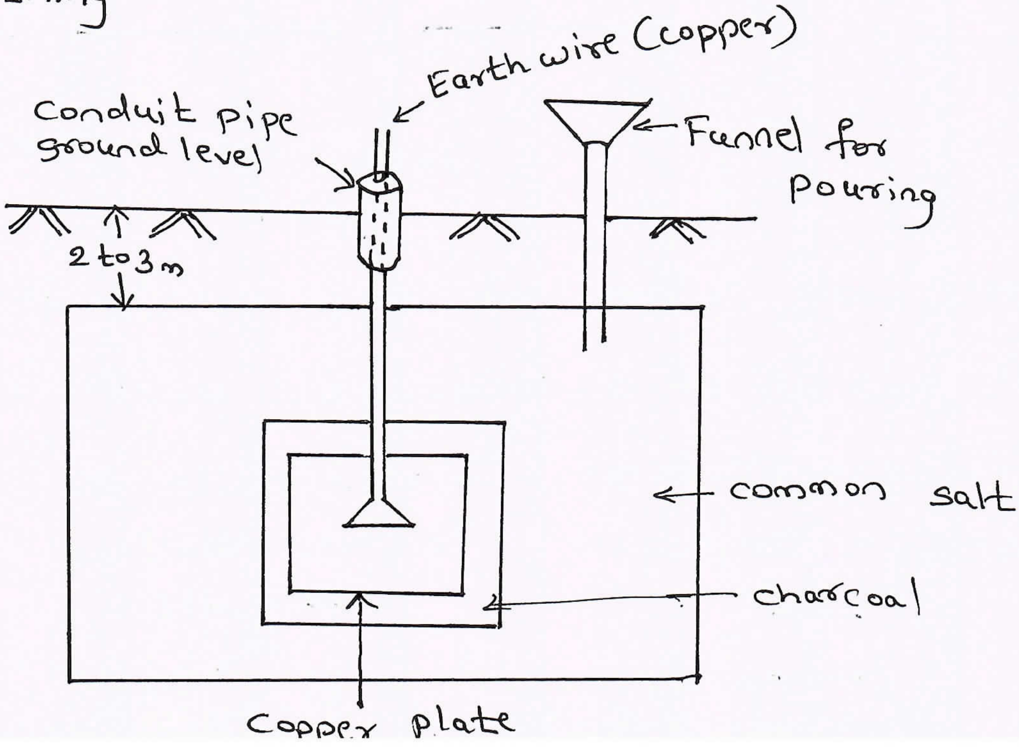
Position of Switch 1	Position of Intermideat switch	Position of Switch 2	Status of lamp
SA	M-N, O-P	CL	ON
SA	M-N, O-P	DL	OFF
SB	M-N, O-P	DL	ON
SB	M-N, O-P	CL	OFF
SA	M-P, N-O	CL	OFF
SA	M-P, N-O	DL	ON
SB	M-P, N-O	DL	OFF
SB	M-P, N-O	CL	ON

Module 5

9a) Define earthing, with neat diagram explain plate earthing. 6M

Ans;- Connecting ~~of~~ metallic body of electrical equipment to general mass of earth through low resistive wire to avoid electric shock.

Plate Earthing



Copper plate is burried at specific depth in ground. Depending upon circuit current carrying capacity. The plate dimensions are 0.3m X 0.3m X 6.35m. charcoal, common salt & sand ~~are~~ alternating layer used to hold the moisture for longer time, it increases conductivit of soil. The thickness of this layer is 30mm & 80mm. GI pip size is about 0.3m X 0.3m x 3.2m. Funnel used to pour the water to trench.

9b) List out the power rating of household appliances including air conditioner, PC's, Laptops & Printers. Find out total power consumed. 8M

Ans:-

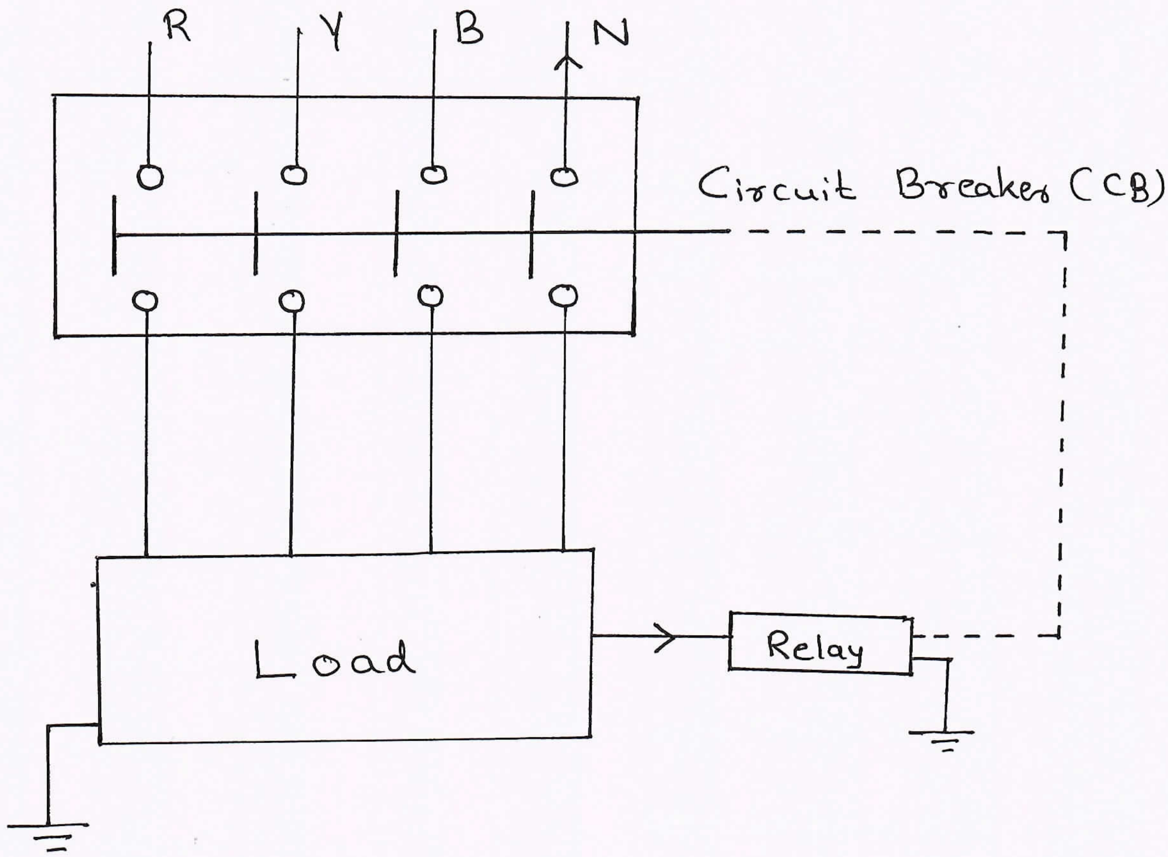
S.No	Appliunces name	Wattage rating
1	Fluorescent lamp	40W
2	LED lamp	3W, 9W, 12W
3	Ceiling Fan	60W, 30W
4	Television	60W
5	Laptop	60W to 250W
6	Water Heater (electric)	1000W
7	Air conditioner	900W to 3.5kW
8	PC's	30W to 70W
9	Printer	250W
10	Refrigerator	300W to 800W

Power consumption calculation

Appliance name	Number of appliances	Wattage rating	Total wattage
Fluorescent lamp	5	40	200W
Ceiling fan	4	60	240W
Refrigerator	1	300	300W
Electric heater	1	1000	1000W
Television	1	60	60

Total wattage = 1800W

9c) With a neat circuit diagram, explain the operation of Earth Leakage Circuit Breaker (ELCB). 6M

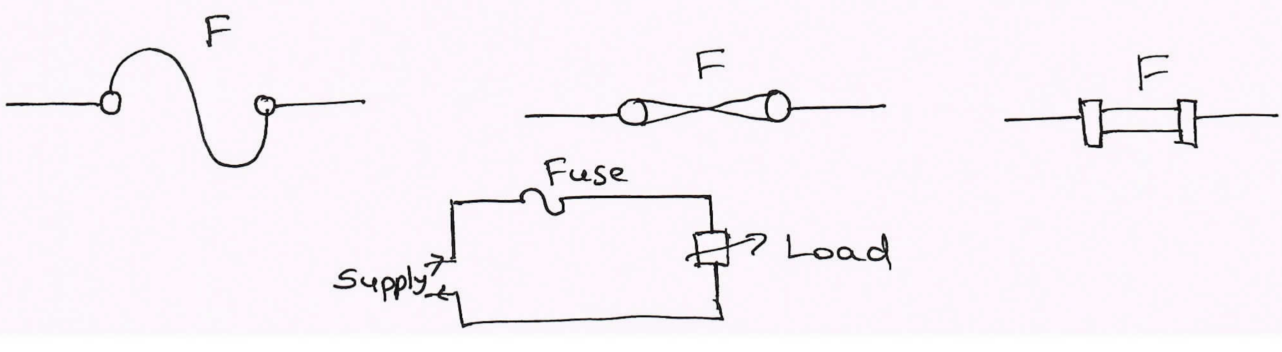


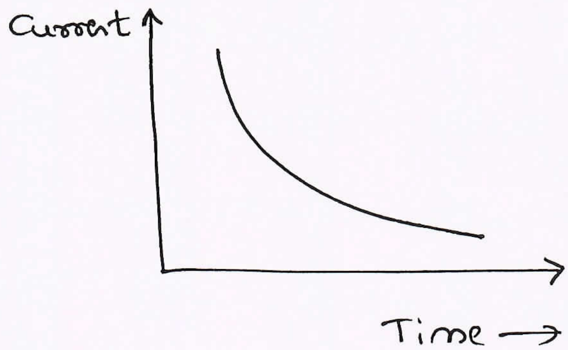
ELCB avoids electric shocks, it detects leakage current flows through body of equipments & disconnects equipment from supply. One terminal of the relay connected to metal body of the equipment to be protected. The other terminal is connected to earth directly, if any insulation failure occurs or phase wire touches metal body of the equipment a voltage appears across the equipment body & earth. The voltage send current to relay, if this voltage crosses predetermined limit, the current through relay becomes sufficient enough for tripping the associated circuit breaker. When CB trips it disconnect the supply to the equipment. This relay detects only the equipment attached to it.

---

10 a) With diagram, explain the working of fuse & characteristics of fuse material. 6M

Ans:- Fuse is weakest link in the circuit. It protects the circuit against over current. Fuses are short pieces of metallic wire. Metal piece is called as fusing element, Its connected in series with supply & load. When excess current flows through fuse element, it melts & break the circuit. If magnetude of excess current is more, time require to melt the fuse element & break the circuit is less, it is called as inverse characteristics.





Inverse characteristics graph

~~Re~~. characteristics of Fuse material

* Good conductivity
* Low melting point
* Low cost
* It should not deteriorate by oxidation
* High resistance.

$$\text{Fusing Factor} = \frac{\text{Fusing current of fuse}}{\text{Rated current of fuse}}$$

10b) Define "unit" used for consumption of electrical energy & explain the two part tariff with its advantages & disadvantages. — 8M

Ans;- The kilo-Watt hour (kWh) is the unit used for electrical energy consumption.

$$1\ kWh = 1\ unit$$

1 kW of power consumed for one long hour is called as one unit.

Two part tariff

Two part tariff mainly consits of two parts. They are

1] Fixed charges

2] Running charges

Fixed charges based on kW or kVA or kVAR demand. it recovers investment to setup transmission & distribution network. Running charges based on kWh energy consumed by user. ~~bgs~~ It recovers workman salary, maintenance cost.

Two part tariff = Fixed charge + Running charge

$$= ₹ (b \times kW + C \times kWh)$$

b = charge per kW of maximum demand

c = charge per kWh of energy consumed

10C) Write short notes on Miniature Circuit Breaker & list its merits & demerits.

6M

Ans:- Main parts of Miniature Circuit Breaker (MCB) are

Actuator lever → It is used to manually trip & reset the CB. It has ON/OFF (1/0) strable position.

Trip mechanism → Bimetalic strip is used to protect the circuit against overloading. Solonide coil trips the circuit under short circuit condition.

Contact → It consists fixed & moving contacts. Under abnormal condition moving contact move away from fixed contact and disconnect the circuit from supply.

Arc divider → While disconnect the circuit from supply under abnormal condition, arc formation occurs between fixed & moving contact. To quinch the arc, divider is used.

Terminal → It has input & output terminals.

Merits

1] Compact in size

2] Fast operation

3] MCB is used as the control switch that turn off automatically

4] Less maintenance

5] Its sensitive & reliable

Demerits

1] High cost

2] It is only used for small current carrying capacity.

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