CBCS SCHEME

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BESCKB204/BESCK204B

Second Semester B.E./B.Tech. Degree Examination, June/July 2023
Introduction to 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.	With neat diagram, explain the general structure of electrical power systems using single line diagram.	8	L1	CO1
	b.	State and explain Kirchoff's laws.	6	L1	CO2
	c.	Two resistors connected in parallel across 100 V DC supply take 10 A from the line. The power dissipated in one resistor is 600 W. What is the current drawn when they are connected in series across the same supply?	6	L3	CO2
		OR			
Q.2	a.	State and explain Ohm's law and mention its limitations.	6	L1	CO2
	b.	With block diagram, explain the Hydel power generations.	6	L1	CO1
	c.	A coil of 12 ohms resistance is in parallel with a coil of 20 ohms resistance. This combination is connected in series with a third coil of 8 ohms resistances. The whole circuit is connected across a battery having an emf of 30 V and internal resistance of 2 ohms, calculate (i) The terminal voltage of the battery and (ii) The power in the 12 ohm coil.	8	L3	CO2
		Module – 2			
Q.3	a.	Define RMS value, Average value, Form factor and Peak factor.	8	L1	CO2
	b.	Show that current 'i' lags the applied voltage 'V' also power consumed is zero by 90° for a pure inductance A.C. circuit?	6	L1	CO2
	c.	Write a short note on advantages of 3-phase system.	6	L1	CO1
		OR			
Q.4	a.	Show that current 'i' leads the applied voltage 'V' also power consumed is zero by 90° for a pure capacitive A.C. circuit.	6	L1	CO1
	b.	With the help of circuit diagram and phasor diagram. Find the phase angle impedence and power in case of series R-L circuit.	8	L1	CO1
	c.	A series R-L circuit takes 384 watts at a power factor of 0.8 from a 120 V, 60 Hz supply. What are the values of R and L?	6	L3	CO2
		Module – 3			
Q.5	a.	Explain the working principle of DC motor with suitable diagrams.	8	L1	CO3
	b.	Derive an EMF equation for DC generator with usual notations.	6	L2	CO3
	c.	An 8-pole lap-connected armature has 960 conductors a flux of 40 mwb per pole and a speed of 400 rpm. Calculate the emf generated, if the armature were wave connected at what speed must it be driven to generate 400 V.	6	L3	CO3
		OR			

Q.6	a.	What is back emf in a DC motor? What is its significance?	6	L1	CO3
	b.	Explain the function of following parts of DC machine : (i) Yoke (ii) Field winding (iii) Commutator (iv) Pole shoe (v) Pole core (vi) Brush	8	L1	CO4
	c.	Derive an expression for armature torque in a DC motor.	6	L2	CO4
		Module – 4			
Q.7	a.	Derive an EMF equation of transformer with usual notations.	6	L2	CO3
	b.	With neat diagram, explain the construction of a core type and a shell type single phase transformer.	8	L2	CO3
	c.	Explain the production of rotating magnetic field in air gap of three phase induction motor.	6	L2	CO3
		OR			
Q.8	a.	Explain the working principle of single phase transformer.	6	L2	CO3
	b.	With a neat sketch, explain the constructional features of three phase induction motor.	8	L2	CO3
	c.	A 200 KVA, 10000 V/400 V, 50 Hz single phase transformer has 100 turns on the secondary calculate, (i) The primary and secondary currents. (ii) The number of primary turns. (iii) The maximum value of flux.	6	L3	CO3
		Module – 5			
Q.9	a.	With neat circuit diagram and switching table explain two-way and three-way control of lamps.	6	L1	CO5
	b.	What do you mean be earthing? Explain any one type earthing with a neat diagram.	8	L1	CO5
	c.	Definition of 'unit' used for consumption of electrical energy and explain the two-part electricity tariff.	6	L1	CO5
		OR			
Q.10	a.	What is Domestic wiring and explain casing and capping?	7	L1	CO5
	b.	Write short notes on : (i) Fuse (ii) MCB	6	L2	CO5
	c.	What are the precautions to be taken to prevent electric shocks?	7	L1	CO5

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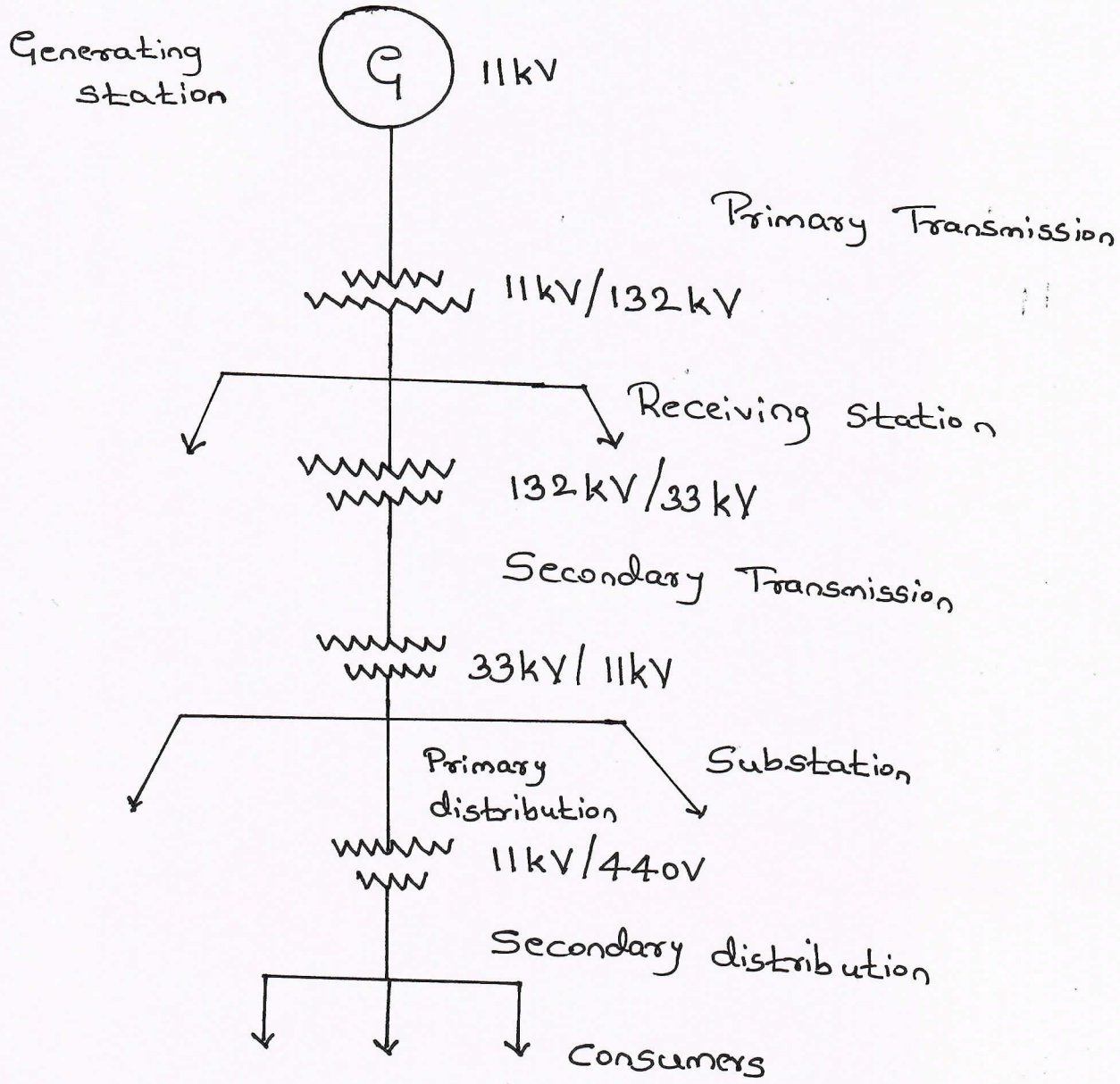
Module 1

1a. With neat diagram, Explain the general structure of electrical power systems using single line diagram. 8M

Ans:- Single Line Diagram of Power System



* Generating Station

Electricity is generated through Turbine - Generator set in generating station. Normally generation voltage is about 3.3kV, 6.6kV, 11kV.

* Primary Transmission

From the generating station to till receiving station is considered as primary transmission. voltage is steped up

to 11kV to 132kV using step up power transformer.

* Secondary Transmission

Receiving station to till substation the stage is considered as secondary transmission. Voltage step down to 132kV to 33 kV. Major components in transmission stage is transmission line, insulator, protective equipments.

* Primary Distribution

33kV is received at substation, further its stepd distributed through feeder's in primary distribution.

* Secondary Distribution

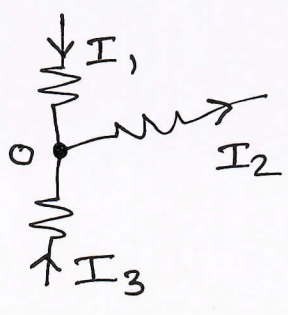
Distribution transforme step downs the 11 kV to 440V in this stage using distribution transformer. Through service mains electrical supply is connected consumers.

1b) State and explain Kirchoff's Law 6M

Ans:- Kirchoff's Current Law (KCL)

"Algebraic sum of all the currents meeting at any junction of an electrical circuit is zero."

$$\sum I = 0$$



Consider I_1, I_2 & I_3, 'O' is junction point. I_1 & I_3 are incoming currents, I_2 outgoing current with reference to 'O' point. Current incoming consider with '+ve' sign, outgoing current with '-ve' sign.

$$I_1 - I_2 + I_3 = 0$$

$$I_1 + I_3 = I_2$$

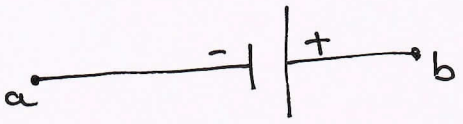
"At any junction of an electric circuit, the sum of all the currents entering the junction is equal to the sum of all the currents leaving the junction".

Kirchoff's Voltage Law (KVL)

"In any closed electrical circuit, the algebraic sum of all the emf & the resistive drops is equal to zero.

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

Consider a voltage source 'E' between a & b point.



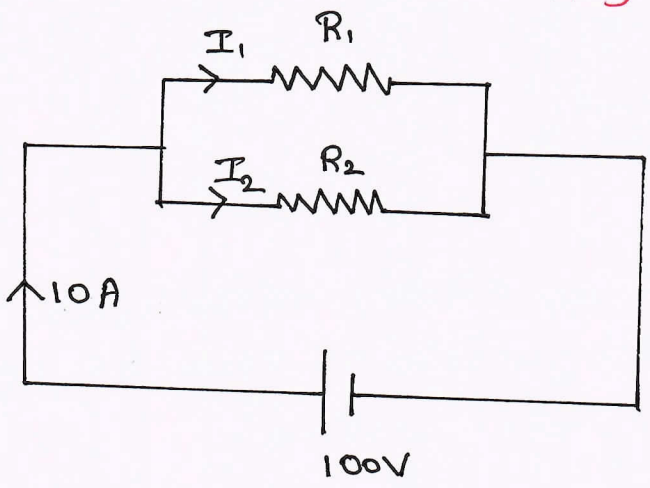
If voltage is rising from '-' to '+' emf E is consider with '+ve sign. If voltage is falling from '+' to '-' emf consider with '-'ve sign.

In the direction from a to b IR drop is '-ve'

from b to a IR drop is '+ve'

1c) Two resistors connected in parallel across 100V DC supply take 10A from the line. The power dissipated in one in one resistor is 600W. What is the current drawn when they are connected in series across the same supply

Ans:-



Consider power consumed by R_1 is 600 Watts ($P_1 = 600W$)

$$P_1 = \frac{V^2}{R_1}$$

where $V = 100V$

$$R_1 = \frac{100^2}{600} = 16.66\,\Omega$$

where $P_1 = V I_1$

$$I_1 = \frac{P_1}{V} = \frac{600}{100} = 6A$$

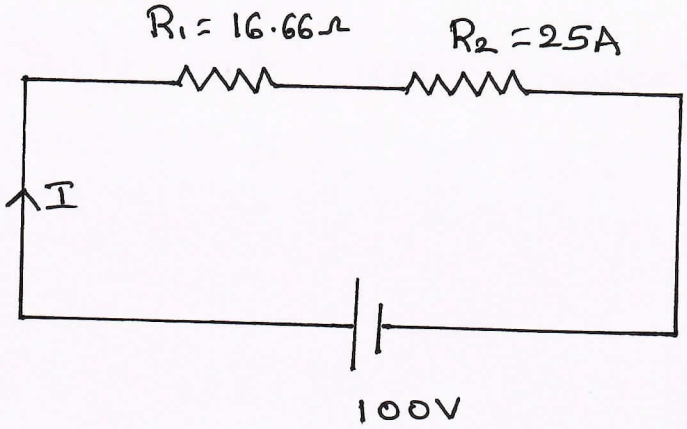
$$I = I_1 + I_2$$

$$10 = I_2 + 6$$

$$I_2 = 4A$$

$$V = I_2 R_2$$

$$R_2 = \frac{100}{4} = 25\,\Omega$$



Total resistance $R_T = 25 + 16.66 = 41.66\,\Omega$

Total current $I = \frac{V}{R_T} = \frac{100}{41.66} = 2.4$ Amps

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2a) State and explain Ohm's Law and mention its limitation.

Ans;- "All physical condition remaining constant, the current flowing through any conductor is directly proportional to the potential difference between two ends of conductor."

$V = IR$

$V \propto I$

V = Applied voltage

I = Total current

R = Resistance

Limitations :

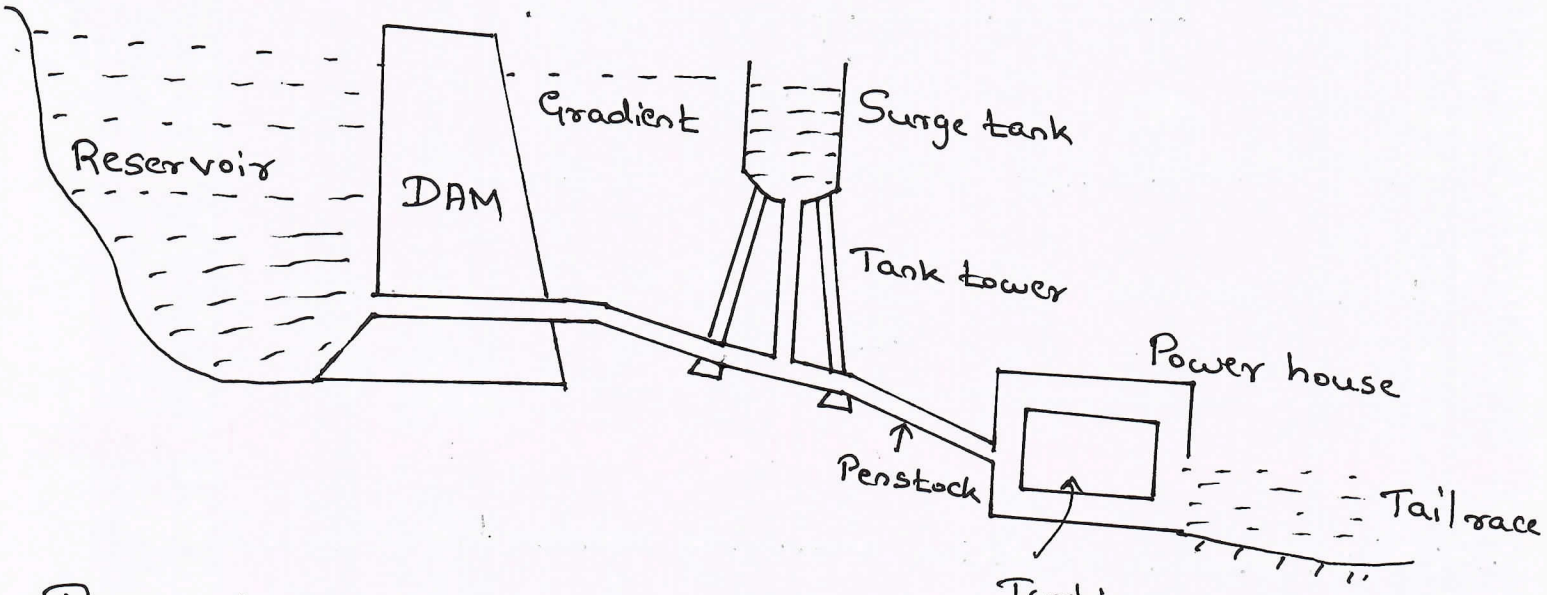
1] It doesn't hold good for semiconducting material like silicon carbide.

2] It doesnt hold good for non-linear devices such as zener diode, voltage regulator etc.....

3] It doesn't hold good for arc lamps.

2b) With block diagram, explain the Hydel power generation. 6M

Ans;-



Reservoir → It stores water which is utilised to run the prime mover to produce electrical power.

Dam → It provides a head of water to be utilized in the water turbine. Through many times high dams may be built solely to provide the necessary head to the plant a dam also increases the reservoir capacity.

Trash Rack → It prevents entry of debris which might damage the wicket gates & turbine runner. It is made up from steel bars.

Fore bay → It serves as a regulating reservoir storing water temporarily when load on the plant is reduced & providing water of initial increase on account increasing load during which time water in the canal is being accelerated.

Surge Tank → An open tank protects the penstock from building of over pressure. It reduce the water hammering effect.

Pen stock → It is made up from steel or concrete material. It supplies the water from dam to power house.

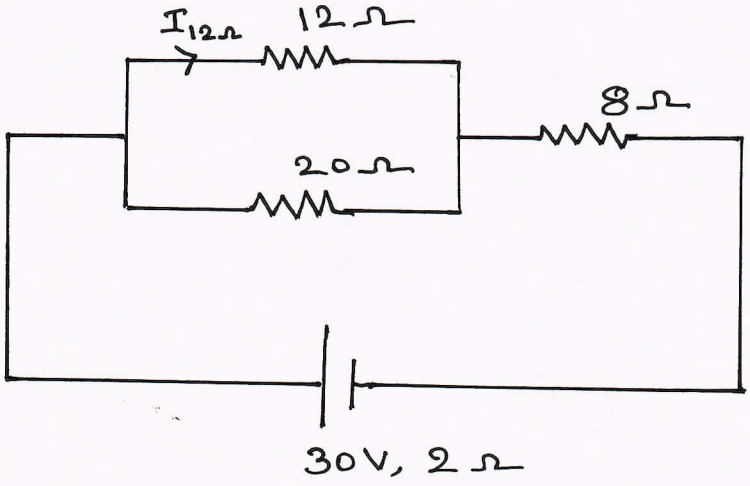
Power House → It consists Turbine generator set. mechanical energy converted into electrical energy in power house.

2 c) A coil of 12 Ω resistance is parallel with a coil of 20 Ω resistance. This combination is connected in series with a 3rd coil of 8 Ω. The whole circuit is connected across a battery having an emf of 30V & internal resistance of 2 Ω. Calculate

i] The terminal voltage of battery

ii] Power in 12 Ω coil.

Ans:-



Total current $I = \frac{V}{R_{eq}}$

$$R_{eq} = [(12 \| 20) + 8 + 2]$$

$$R_{eq} = [7.5 + 8 + 2]$$

$$R_{eq} = 17.5\,\Omega$$

$$I = \frac{30}{17.5} = 1.714 \text{ Amps}$$

ii] Power consumed by $12\,\Omega$ ($P_{12\Omega}$)

$$P_{12\Omega} = I_{12\Omega}^2 \times 12$$

$$I_{12\Omega} = I \times \frac{20}{12+20}$$

$$I_{12\Omega} = 1.714 \times 0.625 = 1.071\ A$$

$$P_{12\Omega} = (1.071)^2 \times 12 = 13.77 \text{ Watts}$$

Module 2

3a) Define RMS value, Average value, Form factor and peak factor.

Ans:- Root Mean Square (RMS) Value

"The 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."

$$I_{rms} = \sqrt{\frac{(i_1^2 + i_2^2 + \dots\dots + i_n^2)}{n}}$$

$$I_{rms} = I_m/\sqrt{2}$$

Average Value

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

$$I_{avg} = \frac{i_1 + i_2 + \dots\dots + i_n}{n}$$

$$I_{avg} = 0.637 I_m$$

Form Factor (K_f)

"It is the ratio of rms value to its average value.

$$K_f = \frac{I_{rms}}{I_{avg}}$$

$$K_f = \frac{0.707 I_m}{} = 1.11 \text{ for pure sine wave}$$

Peak Factor (K_p)

"It is the ratio of maximum value to rms value".

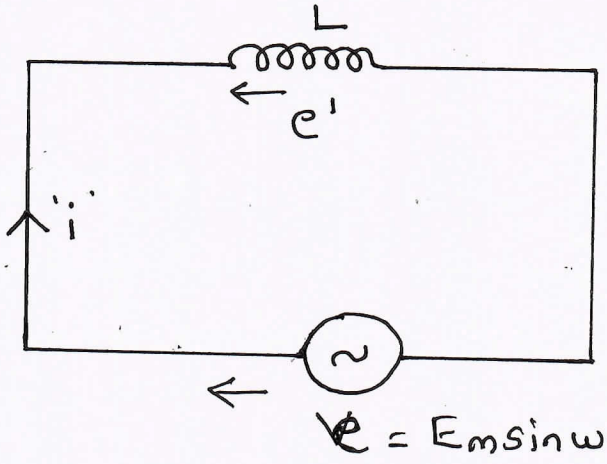
$$K_p = \frac{I_m}{I_{rms}}$$

$$K_p = \frac{I_m}{0.707 I_m}$$

$K_p = 1.414$ For Sine wave

3b) Show that current 'i' lags the applied voltage 'v', also power consumed is zero by 90° for a pure inductance AC Circuit?

Ans:-



Consider a coil of pure inductance 'L' in Henry.

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

$$e' = -N \frac{d\phi}{dt}$$

$$e' = -L \frac{di}{dt} = -e$$

$$e = L \frac{di}{dt}$$

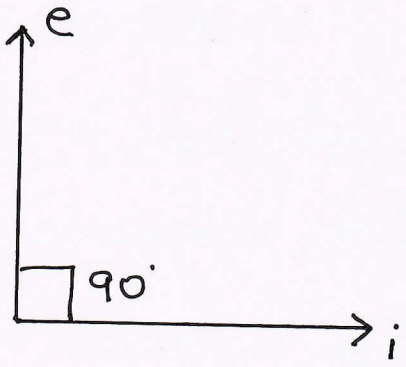
$$di = \frac{e}{L} dt$$

$$i = \int \frac{e}{L}\,dt$$

$$= \int \frac{E_m}{L} \sin\omega t\, dt$$

$$= \frac{E_m}{L} \int \sin\omega t\, dt$$

$$= \frac{E_m}{\omega L} (-\cos\omega t)$$



$$i = \frac{E_m}{X_L} \sin\left(\omega t - \frac{\pi}{2}\right)$$

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

$$I_m = \frac{E_m}{X_L}$$

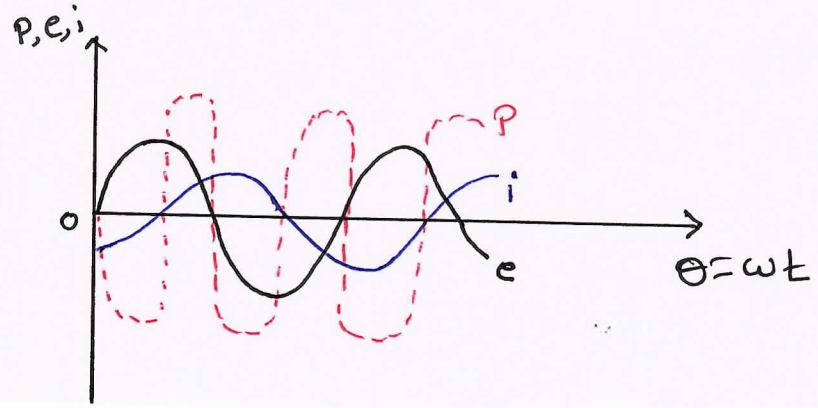
$$i = I_m \sin\left(\omega t - \frac{\pi}{2}\right)$$

Instantaneous Power (p)

$$p = e \times i$$

$$= E_m \sin\omega t \times I_m \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$= -\frac{1}{2} E_m I_m \sin 2\omega t$$



3c) Write a short note on advantages of 3phase - system.

6M

Ans:- Merits of 3ϕ system

1] 3ϕ system is more efficient.

2] 3ϕ system equipment cost is less.

3] 3ϕ Induction motor produces uniform torque.

4] In 3ϕ System Line & Phase voltages are available.

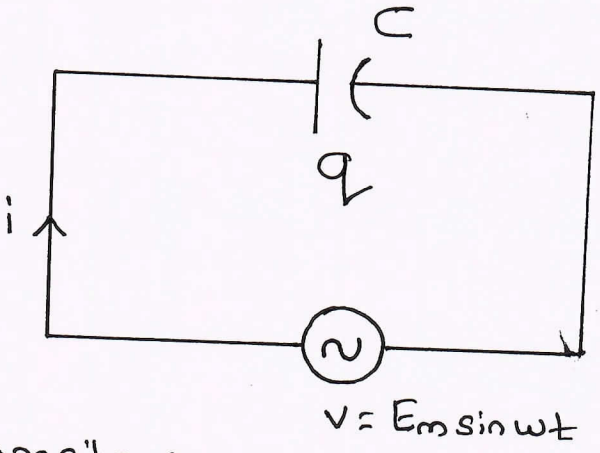
5] When 3ϕ generators are connected in parallel, harmonics are not introduce to the system.

6] 3ϕ motors are self starting in nature.

4a) Show that current 'i' leads the applied voltage 'V' also power consumed is zero by 90° for a pure capacitive AC circuit.

6M

Ans :-



C = Pure capacitance

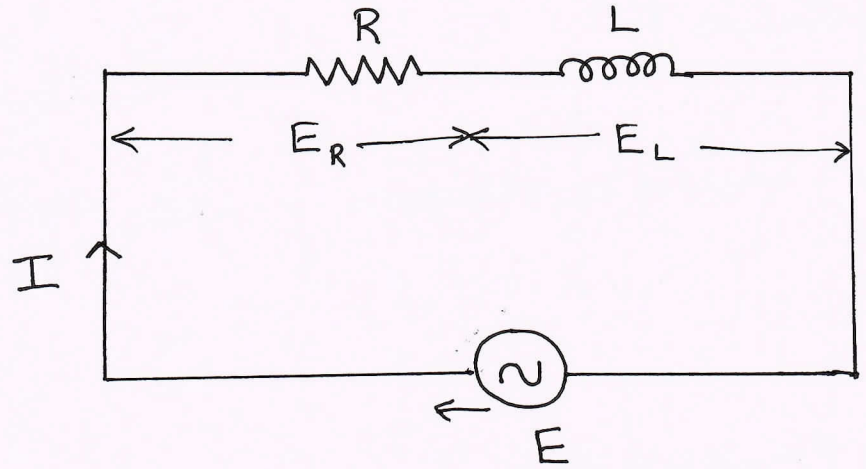
v = Em sinwt

q = charge in coloumb

$$i = \frac{dq}{dt} = \frac{d\,Cv}{dt}$$

(b) With the help of circuit diagram & phasor diagram Find the phase angle impedance & power in case of series R-L circuit.

Ans:-



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

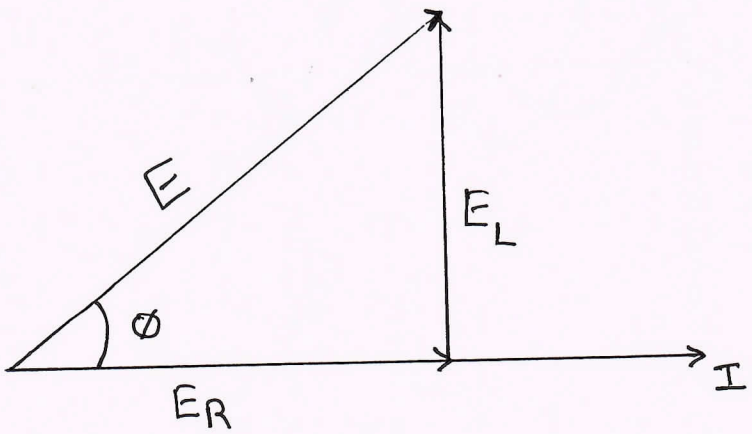
Impedance $Z = \sqrt{R^2 + X_L^2}$ Ω

Inductive Reactance $X_L = 2\pi f L$ Ω

L = Inductance in henry

f = Supply frequency in Hz

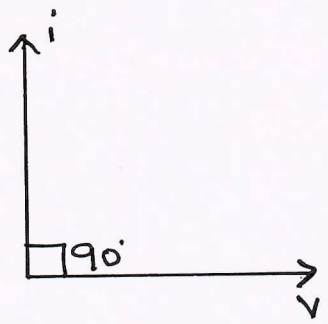
Resistor consumes energy & Inductor stores the energy in the form of electromagnetic energy.



$$i = C\frac{d}{dt}E_m \sin\omega t$$

$$= E_m \omega C \cos\omega t$$

$$= \frac{E_m}{1/\omega C}\sin\left(\omega t + \frac{\pi}{2}\right)$$



$$\frac{1}{\omega C} = X_C = \text{Capacitive reactance} = \frac{1}{2\pi f C}\ \Omega$$

$$I_m = \frac{E_m}{X_C}$$

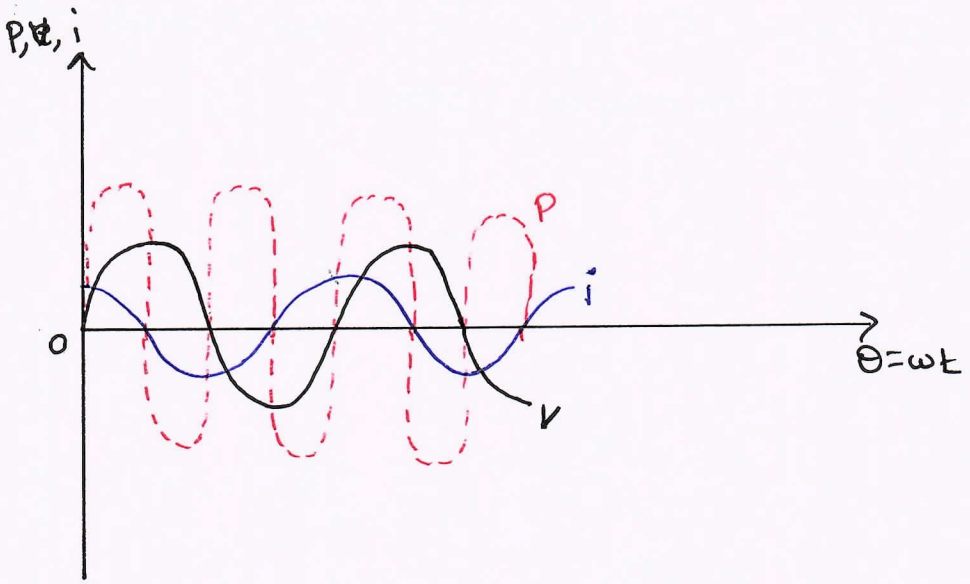
$$i = I_m \sin\left(\omega t + \frac{\pi}{2}\right)$$

The instantaneous powe

$$p = v \times i = E_m \sin\omega t \times I_m \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$p = \frac{1}{2} E_m I_m \sin 2\omega t$$

Pure capacitor never consumes energy

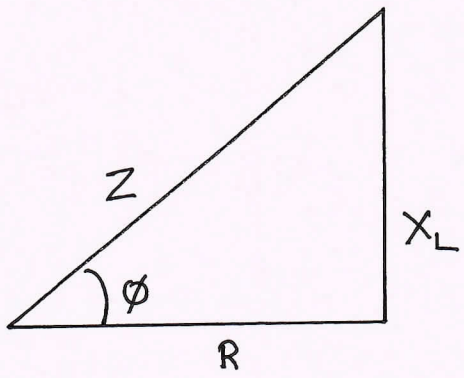


$E_R = IR$

$E_L = IX_L$

$E = IZ$

$\phi = \tan^{-1} \frac{X_L}{R}$



Impedance triangle

Instantaneous Power $p = e \times i$

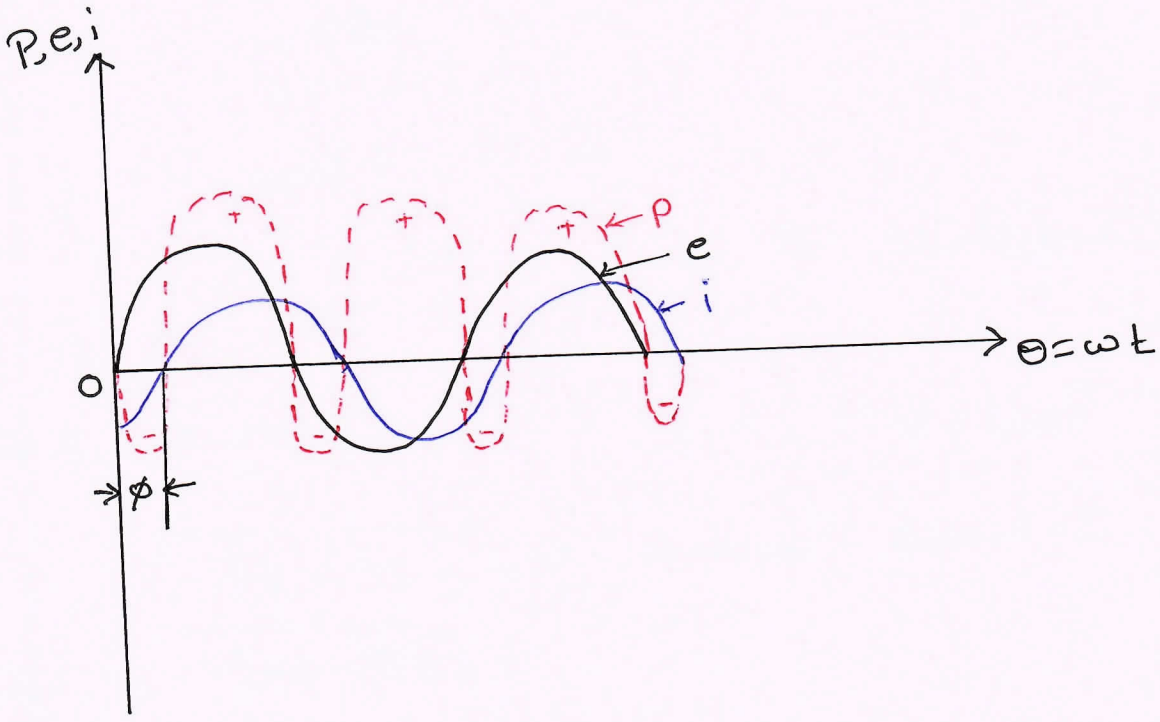
where $e = E_m \sin \omega t$ $\quad i = I_m \sin(\omega t - \phi)$

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

$= \frac{1}{2} E_m I_m \cos\phi - \frac{1}{2} E_m I_m \cos 2\phi$ (0)

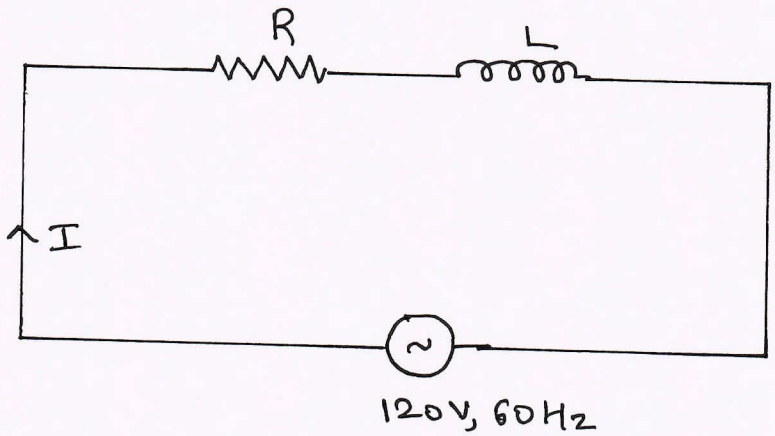
$= \frac{1}{2} E_m I_m \cos\phi$

$P = EI \cos\phi$ Watts



4C) A series R-L circuit takes 384 Watts at a power factor 0.8 from a 120V, 60Hz supply. What are the values of R & L?

Ans:-



Given data's :-

$E = 120V$ $\quad P = 384$ Watts

$f = 60Hz$ $\quad \cos\phi = 0.8$ lagging

Power consumption $P = EI\cos\phi$

Total current $I = \dfrac{P}{E\cos\phi}$

$I = \dfrac{384}{120 \times 0.8}$

$I = 4$ Amps

Impedance $Z = \dfrac{E}{I} = \dfrac{120}{4} = 30\Omega$

Resistance $R = Z\cos\phi = 30 \times 0.8 = 24\Omega$

Inductive Reactance $X_L = \sqrt{Z^2 - R^2}$

$= \sqrt{30^2 - 24^2} = 18\Omega$

Inductance $L = \dfrac{X_L}{2\pi f} = \dfrac{18}{2\pi \times 60} = 0.0477$ Henry

Module 3

5a) Explain the working principle of DC motor with suitable diagrams.

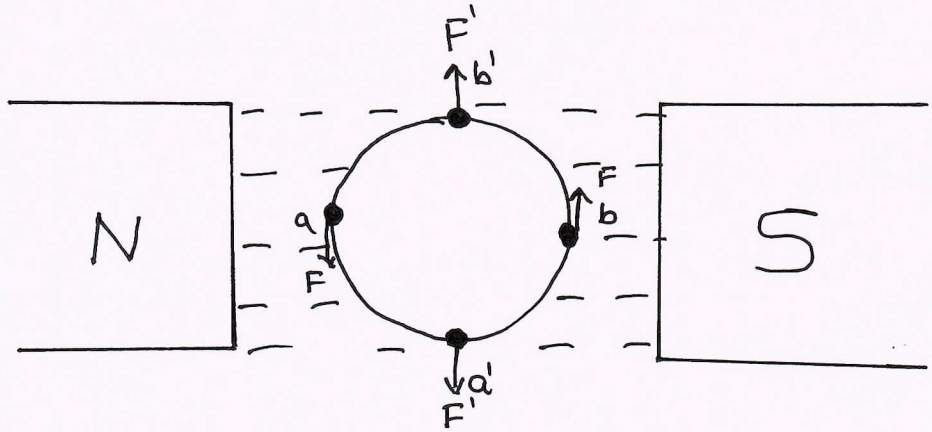
Ans:- "The current carrying conductor placed in magnetic field always experiance the mechanical force, based on this principle motor works.

Where 'l' length conductor, placed in 'B' Tesla magnetic field which carries 'I' amount of current. It will produce mechanical force 'F'.

$$F = BIl$$

Flemings left hand rule applicable for motors.

"Whenever three fingers of left hand fore finger, middle finger & Thumb held mutual perpendicular, Fore finger indicates direction of magnetic field: Middle finger indicates current flowing direction & Thumb indicates direction of motion."



Consider a conductor placed in magnetic field. Initially on point 'a' force acts on downwards, at 'b' point upwards. conductor moves in anticlockwise direction. It occupies position a' & b'. In a' & b' position Force acts in same line but in opposite direction. So conductor not moves, its called as

dead center. So that usually more than one conductor is used in motors.

5b) Derive an EMF equation for DC generator with usual notation. 6M

Ans :- Z = Number of armature conductors

ϕ = Flux per pole in Weber

P = Number of poles

N = Speed in rpm.

A = Number of parallel path

Flux cut by the conductor in one revolution = $d\phi = P\phi$

Time taken to complete one revolution = $\frac{60}{N}$ sec $= dt$

Emf induced in one conductor = $1 \times \frac{d\phi}{dt} = \frac{P\phi N}{60}$

Total emf induced in armature (E_g) = $\frac{P\phi N}{60} \times \frac{Z}{A}$

$$E_g = \frac{P\phi NZ}{60A} \text{ volts}$$

For lap winding ($A = P$)

$$E_g = \frac{\phi ZN}{60} \text{ volts}$$

For wave winding ($A = 2$)

$$E_g = \frac{P\phi NZ}{120} \text{ volts}$$

5c) An 8-pole lap connected armature has 960 conductors a flux of 40mWb per pole & a speed of 400rpm. Calculate the emf generated, if the armature were wave connected at what speed must it be driven to generate 400V. 6M

Ans:- $P = 8$

$Z = 960$

$\phi = 40mWb$

$N = 400rpm$

$A = P = 8$ (lap wound)

Emf induced in armature when its lap connected (E_g)

$$E_g = \frac{\phi Z N}{60} = \frac{40m \times 960 \times 400}{60} = 256V$$

If armature is wave connected ($A=2$), induced emf is 400V.

$$E_g = \frac{\phi Z N P}{120} \text{ Volts}$$

Speed at which generator generates 400V is given by

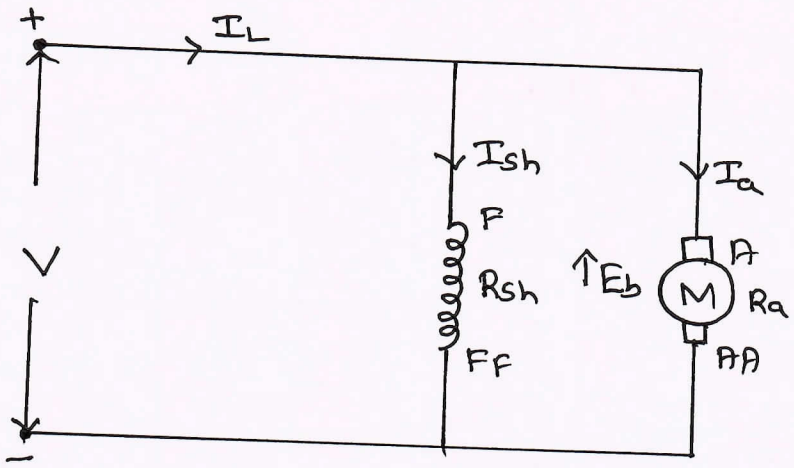
$$N = \frac{E_g \times 120}{\phi Z P}$$

$$N = \frac{400 \times 120}{40m \times 960 \times 8}$$

$$N = 156.25 \text{ rpm}$$

6.a) What is back emf in a DC motor? What is its significance? 6 M

Ans:-



The induced emf in armature of DC motor which opposes armature current to flow through armature is called as back emf (E_b).

DC shunt motor is as shown in the above figure.

$$V = E_b + I_a R_a \quad -I$$

$$I_L = I_{sh} + I_a$$

V = Supply voltage in Volts

E_b = Back emf in Volts

I_a = Armature current in Amps

R_a = " resistance in Ω

Multiply I_a on both side of eqn I

$$V I_a = E_b I_a + I_a^2 R_a$$

$V I_a$ = Electrical input power

$E_b I_a$ = Electrical equivalent of mechanical power developed which includes iron & mechanical loss.

$I_a^2 R_a$ = Armature copper loss.

$$P_m = E_b I_a$$

Mechanical power developed in armature (P_m)

$$P_m = VI_a - I_a^2 R_a$$

$$\frac{dP_m}{dI_a} = V - 2I_a R_a$$

Maximum power developed, when $\frac{dP_m}{dI_a} = 0$

$$V - 2I_a R_a = 0$$

$$I_a R_a = \frac{V}{2} \quad -II$$

Substitute eqn II in eqn I

$$V = E_b + \frac{V}{2}$$

$$E_b = \frac{V}{2}$$

Efficiency of motor $\eta = \frac{E_b I_a}{V I_a} = \frac{E_b}{V}$

If back emf is not produce in the armature, there is no opposition to 'Ia'. So that electrical energy not converted into mechanical energy.

In DC motor back emf plays vital role to produce mechanical energy.

6 b) Explain the function of following parts of DC machine?

i] Yoke ii] Field winding iii] Commutator

iv] Pole shoe v] Pole core vi] Brush

8 M

Ans :- i] Yoke

It is outside cover of DC machine, which protects the motor from mechanical injury. Its made up from cast or mild steel material or cast iron. Its in cylindrical shape. Lifting eye, base plate, terminal boxes are attached to the yoke.

ii] Field Winding

Its wounded over each poles. When its excited through supply it produces flux in each poles.

iii] Commutator

It converts Ac emf to DC emf. It is in cylindrical shape & is built of wedge shape segments, made up of hard drawn copper. Risers have air space between one to another, so that, air can circulate in the space & cool the commutator.

iv] Pole Shoe

It is fixed to the pole core by means of counter sunk screws. Shape of pole shoes reduces the reluctance for magnetic path.

v] Pole core

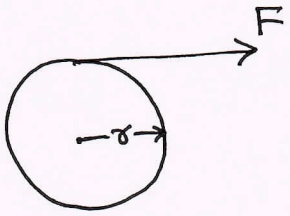
It support the field winding. Its made of alloy steel of high relative permeability. Each poles are laminated.

vi] Brush

The brushes are made up of graphite. Normally two brushes are used to collect the emf from armature, during collection of current it creates voltage drop.

6C) Derive an expression for armature torque in a DC motor. 6M

Ans:- Torque is the product of the force & the radius at which it acts.



Armature torque $(T_a) = F \times r$ Nm

r = shaft radius in meters

F = Tangential force acts on surface of shaft in Newton.

The workdone by 'F' in one revolution is given by

$$W = F \times 2\pi r \quad W\text{-}S$$

Power developed by the armature $= F \times 2\pi r \times \frac{N}{60}$

$$= F r \frac{2\pi N}{60}$$

$$= \frac{T_a N 2\pi}{60}$$

Mechanical power developed $= E_b I_a$

$$I_a E_b = \frac{2\pi N T_a}{60}$$

$$T_a = 0.159 \phi Z I_a (P/A) \text{ Nm}$$

$$= 0.0163 \phi Z I_a (P/A) \text{ kgm}$$

Module 4

7a) Derive an EMF equation of transformer with usual notation

6M

Ans:- When $V_1 = V_m \sin\omega t$ is applied on the primary side $\left(V_1 = \frac{V_m}{\sqrt{2}}\right)$, current flows through primary winding & produce flux ϕ. This flux produces e_1 & e_2 in primary & secondary winding.

$$e_1 = -N_1 \frac{d\phi}{dt}$$

where $\phi = \phi_m \sin\omega t$

$$e_1 = -N_1 \frac{d}{dt} \phi_m \sin\omega t$$

$$= -\omega N_1 \phi_m \cos\omega t$$

$$= \omega N_1 \phi_m \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$= 2\pi f N_1 \phi_m \sin\left(\omega t - \frac{\pi}{2}\right)$$

Maximum value of emf induced on primary side $E_{m_1} = 2\pi f N_1 \phi_m$

RMS value of emf induced in primary side

$$E_1 = \frac{E_{m_1}}{\sqrt{2}} = \frac{2\pi}{\sqrt{2}} f N_1 \phi_m$$

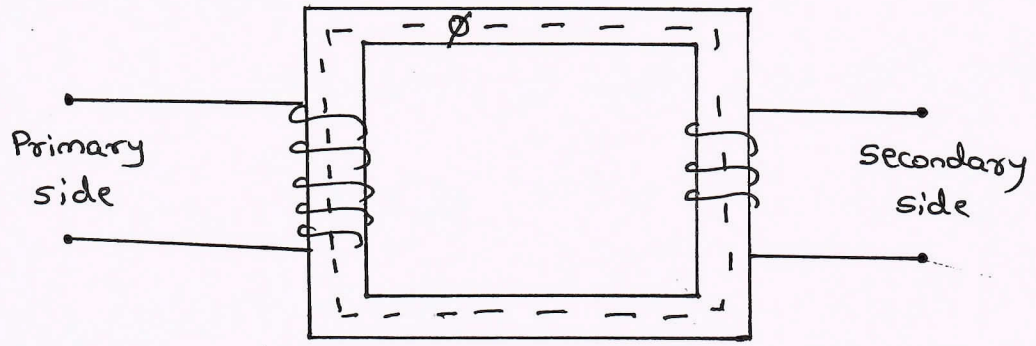
$$E_1 = 4.44 \phi_m f N_1 \text{ volts}$$

$$E_2 = 4.44 \phi_m f N_2 \text{ volts}$$

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = K$$

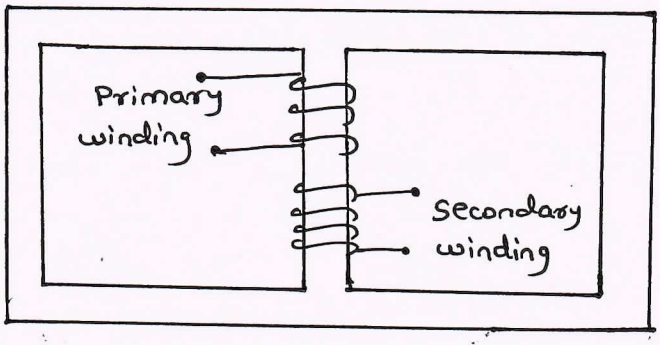
7b) With neat diagram, explain the construction of a core type & a shell type single phase transformer. 8M

Ans:- i] Core Type Transformer



Transformer core in rectangular or square shape & it consists two limbs. Half of the primary & secondary winding placed on each limb. Core mainly transfer the flux from one side to another side. For smaller size transformer rectangular core, for large size cruciform core is employed. Core is always laminated to reduce eddy current loss. L, I, ⊔ type stamping are used to form the core

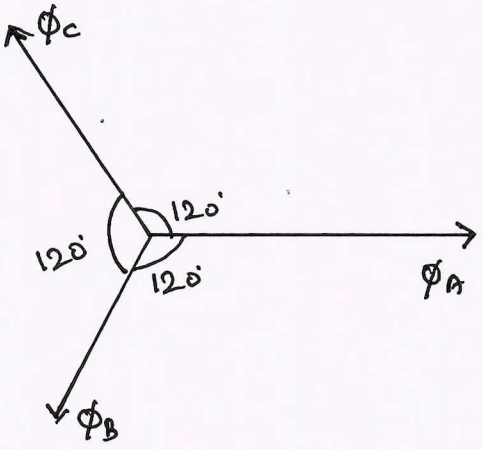
ii] Shell Type Transformer



It consists 3 limbs, winding is placed on central limb. The coils are former wound which are multilayer disc type usually wound in the form of pancakes. Each layers of winding is well insulated to handle high voltage. I, ⊓⊓, L, ⊔ type stampings are used to form core.

7C) Explain the production of rotating magnetic field in air gap of 3ϕ induction motor. 6M

Ansi- When supply is applied to stator of 3ϕ induction motor it produce rotating magnetic field between the rotor & stator airgp airgap. Applied 3ϕ supply is 120° apart. The rotating magnetic field is illustrated below:



$\phi_A = \phi_m \sin \omega t$

$\phi_B = \phi_m \sin(\omega t - 120°)$

$\phi_C = \phi_m \sin(\omega t + 120°)$

$\theta = \omega t$

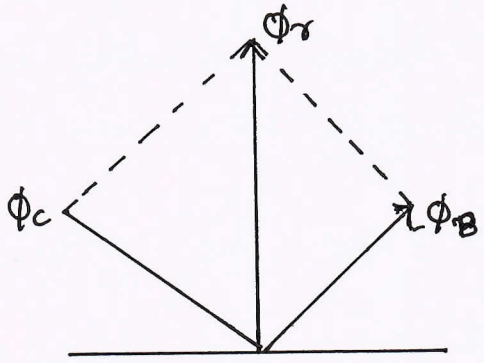
To show the magnetic field is rotating compute different values in θ.

i] $\theta = 0°$

$\phi_A = \phi_m \sin(0°) = 0$

$\phi_B = \phi_m \sin(0° - 120°) = -\phi_m \frac{\sqrt{3}}{2}$

$\phi_C = \phi_m \sin(0° + 120°) = \phi_m \frac{\sqrt{3}}{2}$



$\phi_r = 2\phi_m \cos 30° = 1.5\phi_m$

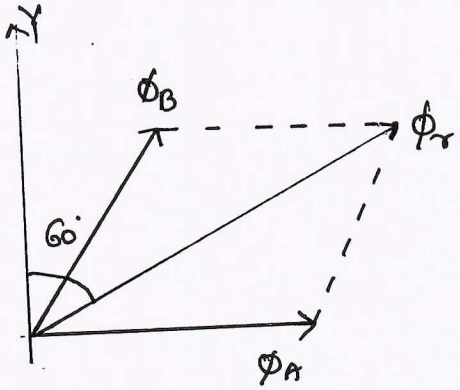
ii] $\theta = 60°$

$\phi_A = \phi_m \frac{\sqrt{3}}{2}$

$\phi_B = -\phi_m \frac{\sqrt{3}}{2}$

$\phi_C = 0$

$\phi_r = 1.5\phi_m$



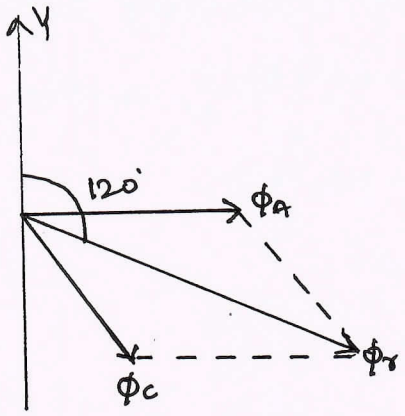
iii] $\theta = 120^\circ$

$\phi_A = \frac{\sqrt{3}}{2}\phi_m$

$\phi_B = 0$

$\phi_C = -\frac{\sqrt{3}}{2}\phi_m$

$\phi_r = 1.5\phi_m$



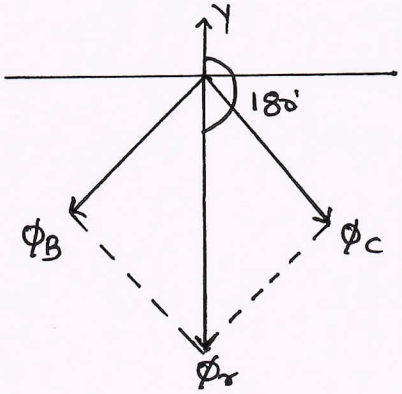
iv] $\theta = 180^\circ$

$\phi_A = 0$

$\phi_B = \frac{\sqrt{3}}{2}\phi_m$

$\phi_C = -\frac{\sqrt{3}}{2}\phi_m$

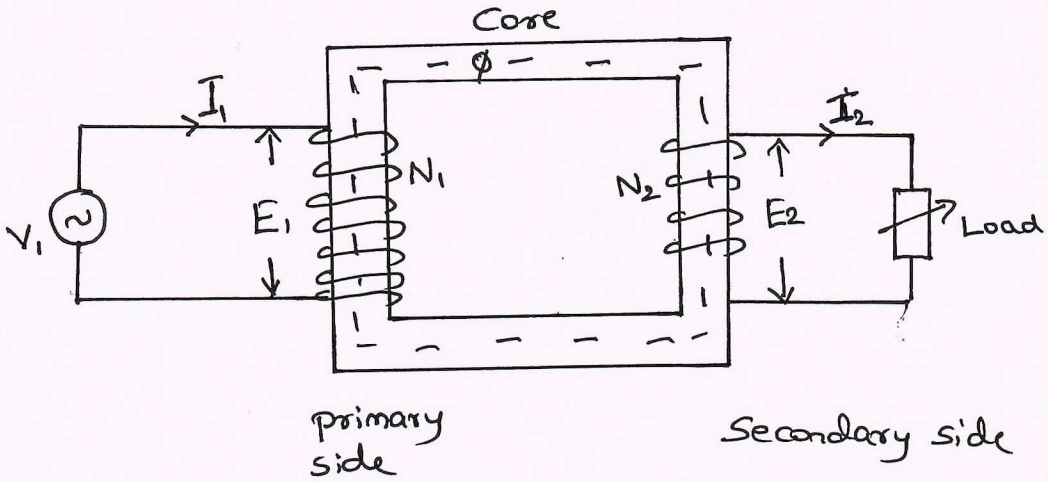
$\phi_r = 1.5\phi_m$



Resultant of magnetic flux is 1.5 times of maximum flux. It rotates at synchronous speed $N_s = \frac{120f}{P}$ rpm.

8a) Explain the working principle of single phase transformer. 6M

Ans:-



Transformer is static electrical equipment. Winding & core are the main parts of transformers. When V_1 is connected on primary side of transformer, primary current I_1 flows through number of turns in primary side N_1. It produces the flux in core, hence

emf induced in primary side E_1. Same flux connect with secondary winding, which induces mutual induced emf E_2.

$$e_1 = -N_1 \frac{d\phi}{dt}$$

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

$$\frac{e_2}{e_1} = \frac{N_2}{N_1} = K = \frac{E_2}{E_1}$$

K = Transformation ratio.

Primary power $E_1 I_1$ = Secondary power $E_2 I_2$

$$\frac{E_2}{E_1} = \frac{I_1}{I_2}$$

$$K = \frac{I_1}{I_2}$$

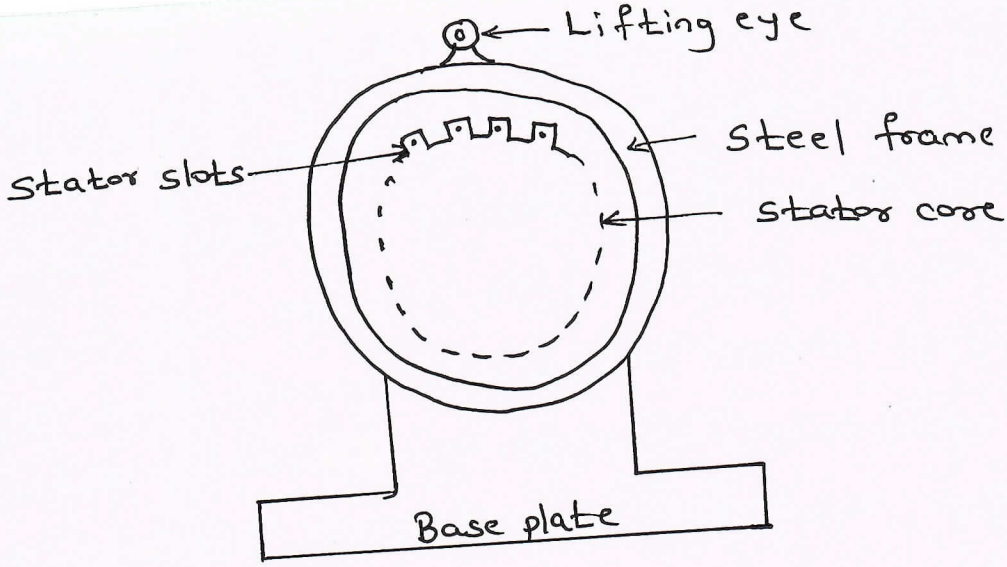
Without altering the power magnetude transformer transfers the power. Frequency on both side always same.

8b) With a neat sketch, explain the constructional features of 3ϕ induction motor.

Ans:- Main parts of 3ϕ induction motor is stator & rotor.

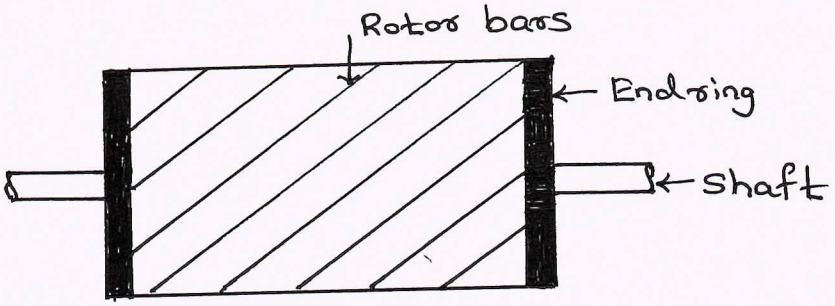
1] Stator

It consists of steel frame & cylindrical core. Thin lamination is used to make the core, to reduce eddy current losses laminations are well insulated. Inner periphery of core consists slots, it holds conductor in it. stator produces rotating magnetic field in airgap.



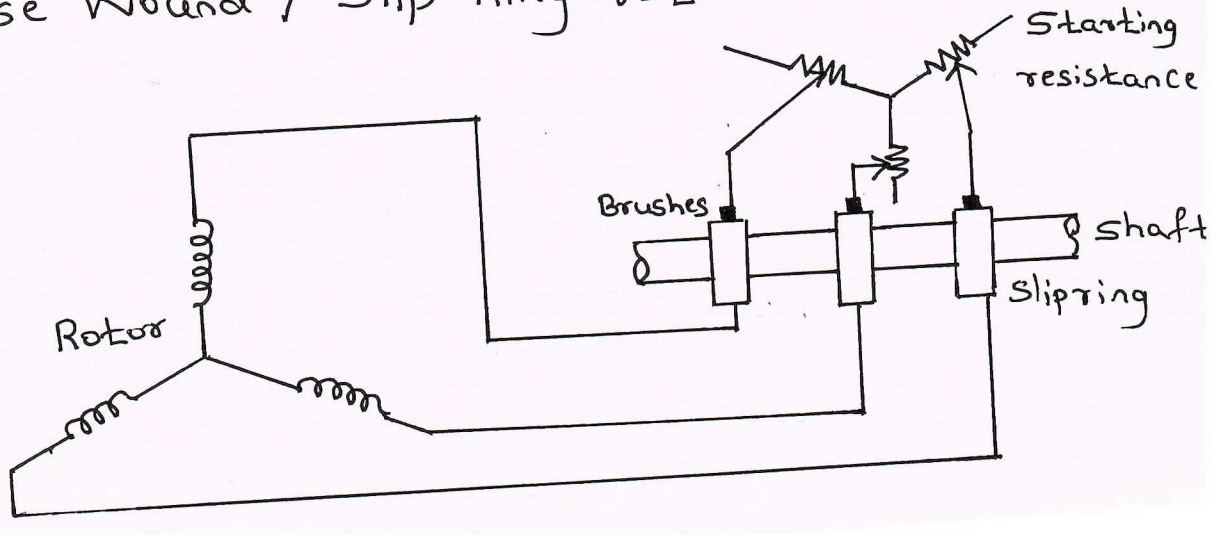
ii] Rotor

a) Squirrel Cage rotor



It consists cylindrical core with parallel slots. Heavy copper or aluminium bars used as rotor conductor. All the bars are braced to two copper end rings & its short circuited. There is no provision to add additional resistance to rotor. To reduce magnetic hum, bars are slightly skewed.

b) Phase Wound / Slip Ring rotor



Star connected rotor winding is connected to slip ring. These slip ring collectes current from rotor winding & through the brushes current dissipated in starting resistance. During the starting brushes are connect with slip ring, once motor picks up its speed three brushes are removed from slip ring, by means of metal collar slip rings are shorted. Where starting torque requirement is more, their slip ring rotor is normally used.

8C) A 200kVA, 10000V/400V, 50Hz single phase transformer ~~has~~ has 100 turns on secondary. Calculate 6M

i] The primary & secondary current

ii] The number of primary current

iii) The maximum value of flux

Ans:- Transformer kVA rating = 200 kVA

Primary voltage $E_1 = 10000V$

Secondary voltage $E_2 = 400V$

Supply Frequency $f = 50Hz$

Secondary turns $N_2 = 100$

i] The Primary Current (I_1)

$$I_1 = \frac{kVA}{E_1} = \frac{200 \times 1000}{10000} = 20 \text{ Amps}$$

The Secondary Current (I_2)

$$I_2 = \frac{kVA}{E_2} = \frac{200 \times 1000}{400} = 500 \text{ Amps}$$

ii] Number of ~~Secondary~~ Primary turns (N_1)

$$\frac{E_2}{E_1} = \frac{N_2}{N_1}$$

$$\frac{400}{10000} = \frac{100}{N_1}$$

$$N_1 = 2500 \text{ turns}$$

iii] The maximum value of flux (ϕ_m) 5

$$E_1 = 4.44\, \phi_m f N_1$$

$$\phi_m = \frac{E_1}{4.44 \times f \times N_1}$$

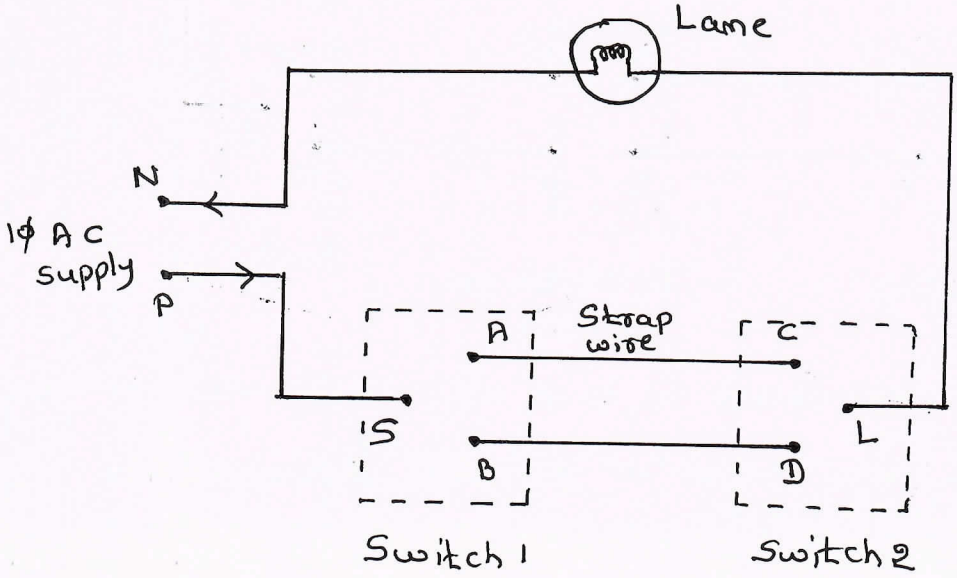
$$\phi_m = \frac{10000}{4.44 \times 50 \times 2500}$$

$$\phi_m = 0.0180 \text{ Weber}$$

Module 5

9a) With neat circuit diagram & switching table explain two-way & three way control of lamps. 6 M

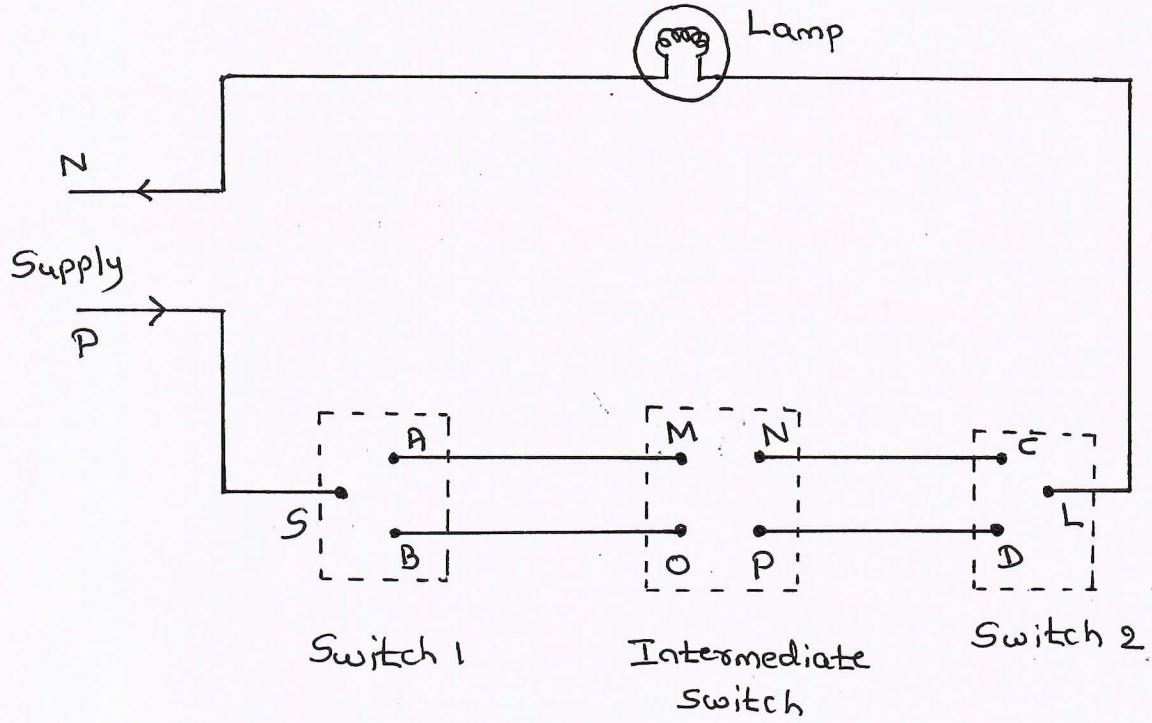
Ans;-



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

Two way control of lamp is also called as stair case wiring. Two switches are employed (two way switch). Two way switches consists 3 terminals. Two switches are connected through strap wire. Lamp gives light output when circuit is completely closed. Switches makes or brake the circuit.

Three Way Control of Lamp



It consists Intermediate & two way switches. Normally 3 way control of lamp used in godown. Intermediate switch has Striaght connection (MN, OP) & Cross connection (MP, ON).

Lamp gives light output when circuit is completely closed.

Position of Switch 1	Position of Intermediate switch	Position of Switch	Lamp status
SA	MN, OP	CL	ON
SA	MN, OP	DL	OFF
SB	MN, OP	DL	ON
SB	MN, OP	CL	OFF
SA	MP, ON	CL	OFF
SA	MP, ON	DL	ON
SB	MP, ON	DL	OFF
SB	MP, ON	CL	ON

9b) What do you mean by earthing ? Explain any one type earthing with neat diagram.

Ans:- "Connecting the metal body of electrical equipment to the general mass of earth to avoid electric shock is called as earthing."

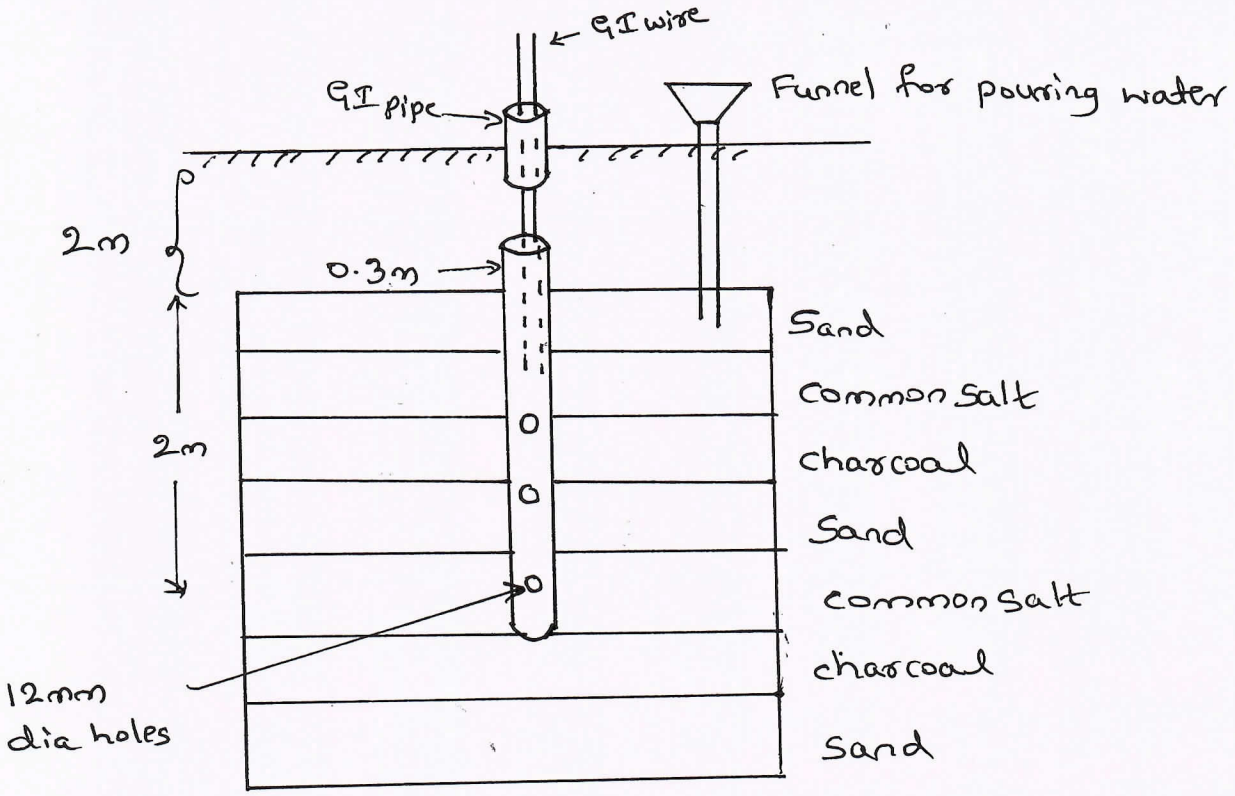
There are two types of earthing

i] Pipe earthing ii] Plate earthing

Pipe Earthing

GI pipe is used in earthing system. The size of the pipe depends on the current to be carried & types of soil. As per ISI standard pipe not less than 2m length & 381 mm diameter. It is burried at the depth of 4.75m, and placed upright in wet ground. The pipe at bottom should be surrounded by

charcoal, coke & salt, sand to hold the moisture content for longer duration. During the summer time, buckets of water is filled inside the earthing pit through funnel, to reduce the resistance.



4c) Definition of 'unit' used for consumption of electrical energy & explain two part tariff. 6M

Ans:- Unit is use to measure energy consumption. One kilo watts of power consumed for one hour is called as an 'unit'.

One unit = 1kWh

'Unit' is commercial unit of energy.

Energy = 1kW Power x 1hour time

= 1kWh.

Two Part Tariff

When the rate of electrical energy is charged on the basis of maximum demand of the consumer & unit consumed is called Two Part Tariff. Fixed & running charges are the two parts of tariff.

The fixed charge is based on maximum demand & running charges based on units of energy consumed.

$$\text{Total charges} = ₹[(b \times kW) + (c \times kWh)]$$

b = charges per kW of maximum demand

c = charges per kWh of energy consumed.

---

10) a] What is Domestic Wiring & explain Casing & capping? 7M

Ans:- Wiring done in domestic premises for providing electrical power for lighting, fans & domestic appliances with all the safety precaution followed is called domestic wiring.

Casing & Capping

In this method, casing is rectangular strip made from teak wood or PVC. It has two grooves in to which the wires are laid. Then casing is covered with a rectangular strip of wood or PVC of the same width called capping. The capping is screwed into casing by means of screws fixed at every 15 cm. The casing is fixed to

the wall & apart from it by 3.5 mm with the help of porcelain discs or cleats.

Merits

1] Neat & Clean appearance

2] Good protection to the conductors from dangerous ~~at~~ — atmospheric condition.

Demerits

1] High risk of fire

2] The method is costly

3] Skilled labour for the installation.

---

10 b) Write short notes on 6M

i] Fuse ii] MCB

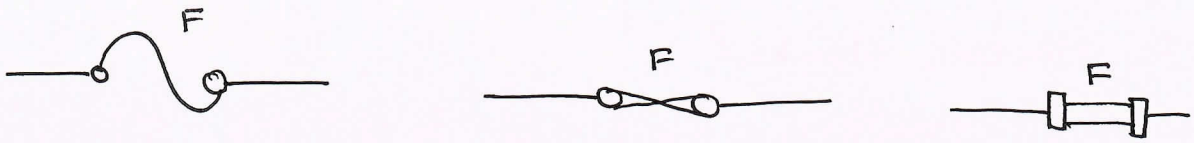
Ans:- Fuse

Fuse is protective device, which protects the circuit against over current. It is weakest link in the circuit. When circuit current exceeds morethan rated value fuse burns & brake, hence it interrup the current.

Requirement of a fuse

* Good conductivity
* Low melting poin
* Low cost
* It should deteriorate by oxidation.

Symbol of fuse



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

Fusing Current → Minimum current at which fusing element melts.

Miniature Circuit Breaker (MCB)

The main demerit in the fuse is after buring of fuse wire it takes time to replace. To overcome demerits in fuse a smart switch is introduced into electrical system. (i.e. MCB). It consists input & output terminals, tripping mechanism, arc quinching mechanism, actuating liver; Bi-metalic strip gives protection against over current & solonide protects the circuit against short circuit. Arc divider is used to quinch the arc which is formed during abnormal condition. MCB ~~is~~ consists relay & circuit breaker in it.

10c) What are the precautions to be taken to prevent electric shocks?

Ans:- Following precautions to be taken to prevent electric shocks are :-

1] All metallic parts of electrical equipments should be properly earthed.

2] Do not use broken switches or plugs, replace them immediatly.

3] Use rubber or plasic hand gloves.

4] Use fuses of correct rating

5] Use only insulated tools like screw driver, cutting pliers.

6] Never touch two different terminals at a time.

7] Do not insert bare wires in the socket hole.

8] Do not use damage lead wires.

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