Ans:- 11

Magnetic circuit.

A closed path comprises of magnetic flux is called magnetic circuit.

(

Magnetic flux: Number of magnetic lines passes through any ~~co~~ cross-section is called magnetic flux.

- Magnetic flux is represented by symbol ϕ
- Its unit is weber (Wb).

$$\boxed{\phi = BA\cos\theta}$$

Reluctance: It is property of the magnetic material which always opposes to the flow of flux.

Its unit is Ampere-Turn per Weber.

It is denoted by symbol 'S'.

$$S_c = \frac{l_c}{\mu A_c}$$ where, l_c = length of the core

A_c = Area of cross section of the core

μ = Relative permeability

MMF (Magnetomotive force):

The magnetic pressure, which sets up the magnetic flux in a magnetic circuit is called MMF.

Its SI unit is Ampere-turn (AT).

$$MMF = \text{flux} \times \text{reluctance}$$

$$\boxed{M.M.F = NI} \text{ AT}$$

Q-12 what is back emf ? what is it's significance in dc motor ?

Ans:- In dc motor when armature rotates, it cuts the main flux so an e.m.f is induced in the armature winding which opposes the supply voltage. It is called back e.m.f. $E_b = \frac{NP\phi Z}{60A}$

→ Due to the back e.m.f dc motor works as a self regulating machine i.e how much current it has to draw from the supply to develope necessary and sufficient torque.

Q-13 what are the applications of dc series and shunt motor ?

Ans. Dc Series motor :- Crane, hoists, elevators, trolley's conveyors, Electric locomotive.

Dc Shunt motor :- Fans and blowers, Centrifugal pumps, lathe machines, Machine tools, Milling machine, drilling machine.

Q-14 what is slip ? why $N_r < N_s$ in 3-ϕ Induction motor ?

Ans:- Slip of induction motor is defined as the difference b/w Synchronous speed (N_s) and actual speed (N_r) of rotor and is expressed as percentage of synchronous speed (N_s)

$$\boxed{\% s = \frac{N_s - N_r}{N_s} \times 100}$$

→ N_r is always less than N_s. If $N_r = N_s$ then there will be no relative motion b/w R.M.F and rotor conductors hence no e.m.f will be induced in rotor and motor will stop.

Q-15 A 4 pole, 3phase, 50Hz star connected induction motor has a full load slip of 4%. Calculate full load speed of motor.

Ans:- $P = 4$, $S = 0.04$, $N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500$ r.p.m

$N_r = N_s(1-s)$

$N_r = 1500(1-0.04)$

$\boxed{N_r = 1440 \text{ r.p.m}}$ |Ans|

Q-16 what is the use of condenser in fan?

Ans:- Due to condenser the angle (α) between two currents main winding current (I_m) and starting winding current (I_A) i.e increases. $T \propto \sin\alpha$ hence torque increases.

Q-17 How can we change the direction of rotation of 3-phase induction motor.

Ans. By interchanging any two phases, the direction of rotation will be reversed.

Q-18 what is the importance of earthing?

Ans. Earthing brings the equipment to zero potential and avoid the shock to the operator. under any fault condition.

Q-19 Calculate the backup of battery of 100 AH connected to load of 100W and supply voltage is 12V.

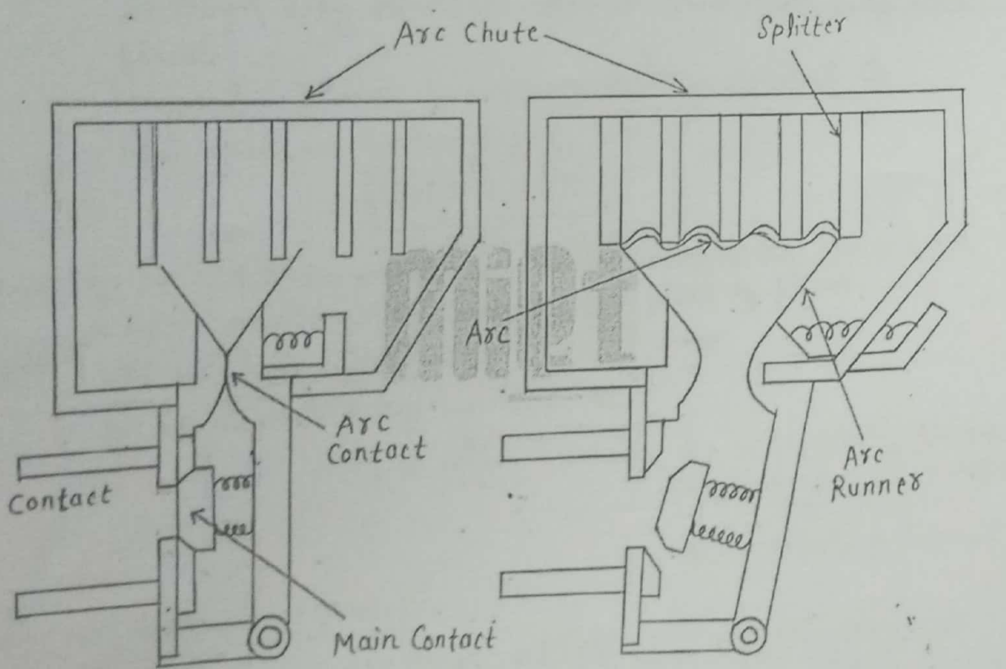
Ans. Battery Back up $= \frac{100(AH) \times 12(V)}{100(W)} = 12$ Hours |Ans|

Q20: What is ACB ?

Ans:- 20

ACB (Air Circuit Breaker)

Air Circuit Breaker (ACB) is an electrical device used to provide Overcurrent and short-circuit protection for electric circuits over 800 Amps to 10 k Amps. These are usually used in low voltage applications below 450 V. We can find these systems in Distribution Panels (below 450V).



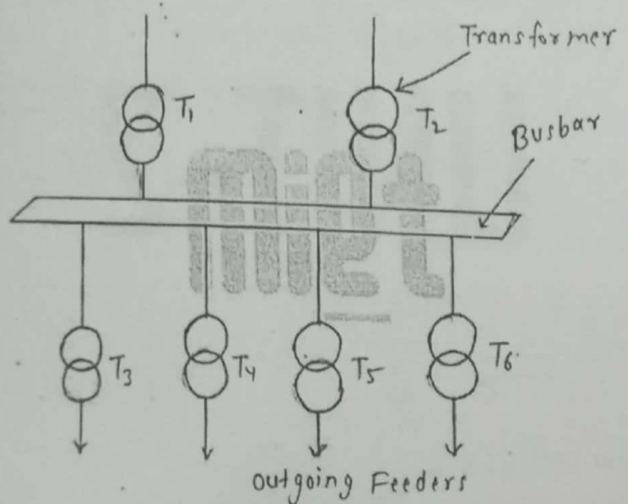
Ans:-

Q 21 :- Define the Bus-Bar.

Ans:- 21

BUSBAR

An electrical busbar is a conductor or a group of conductors used for collecting electric power from the incoming feeders and distributes electric power to the outgoing feeders. In other words, it is a type of electrical junction where all incoming and outgoing electrical current meet.



Types of electrical Busbar :

(1) Single Busbar System.
(2) Double Busbar System.
(3) Ring Busbar System.

BEE-101/201

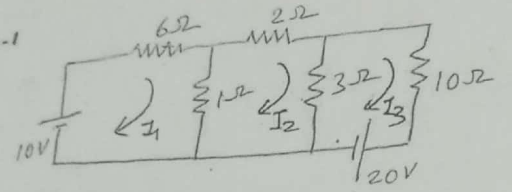
LONG

QUESTIONS ANSWERS

UNIT-1

Ans:-1
1.

Find the current in all branches using mesh analysis



KVL in mesh 1

$$6I_1 + (I_1 - I_2) = 10$$
$$7I_1 - I_2 = 10$$
$$I_1 = \frac{10 + I_2}{7} \quad \text{---} (1)$$

KVL in mesh 3

$$3(I_3 - I_2) + 10I_3 = -20$$
$$-3I_2 + 13I_3 = -20$$
$$I_3 = \frac{-20 + 3I_2}{13} \quad \text{---} (3)$$

KVL in mesh 2

$$(I_2 - I_1) + 2I_2 + 3(I_2 - I_3) = 0$$
$$-I_1 + 6I_2 - 3I_3 = 0 \quad \text{---} (2)$$

Now, put 1 and 3 in 2

$$-\frac{10 + I_2}{7} + 6I_2 - 3\frac{(-20 + 3I_2)}{13} = 0$$
$$-130 - 13I_2 + 546I_2 + 420 - 63I_2 = 0$$
$$470I_2 = -290$$

$$\underline{I_2 = -0.6170212}$$
$$\underline{I_1 = 1.340425}$$
$$\underline{I_3 = -1.68085}$$

using eq (1) and (3)

Now,

$I_{(6\Omega)} = I_1 = \underline{1.340425\,Amp}$

$I_{(2\Omega)} = I_2 = \underline{-0.6170212\,Amp}$

$I_{(10\Omega)} = I_3 = \underline{-1.68085\,Amp}$

$I_{(1\Omega)} = (I_1 - I_2) = 1.340425 + 0.6170212$
$= \underline{1.95745\,Amp}$

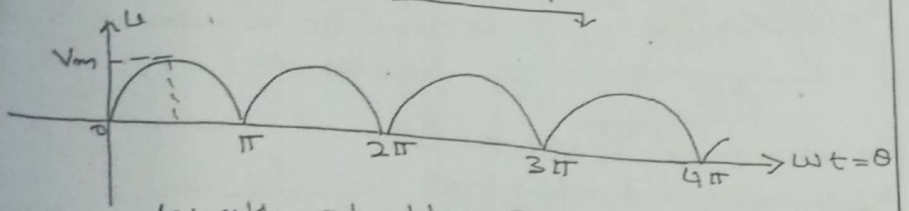
$I_{(3\Omega)} = (I_2 - I_3) = -0.6170212 + 1.68085$
$= \underline{1.0638288\,Amp}$ ans

{ -ve current indicates direction of current is reverse than assumed }

UNIT-2

-2 Find out r.m.s and average value
(i) full wave Rectifire o/p
(ii) Half wave Rectifire o/p

-2 (i) FULL WAVE RECTIFIER



length of the Base → π

$v = V_m \sin\theta$

(a) r.m.s Value

$$V_{rms}^2 = \frac{\int_0^{\pi} v^2 \, d\theta}{\int_0^{\pi} d\theta}$$

$$= \frac{1}{\pi} \int_0^{\pi} \frac{2 V_m^2 \sin^2\theta}{2} \, d\theta$$

$$= \frac{V_m^2}{2\pi} \int_0^{\pi} 2\sin^2\theta \, d\theta$$

$$= \frac{V_m^2}{2\pi} \int_0^{\pi} (1 - \cos 2\theta) \, d\theta$$

$$= \frac{V_m^2}{2\pi} \left[\theta - \frac{\sin 2\theta}{2} \right]_0^{\pi}$$

$$V_{rms}^2 = \frac{V_m^2}{2\pi} [\pi - 0]$$

$$\boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$$

(ii) Average Value :-

$$V_{avg} = \frac{1}{\pi} \int_0^{\pi} v(\theta) \, d\theta$$

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

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

$$= \frac{-V_m}{\pi} \left[\cos\pi - \cos 0 \right]$$

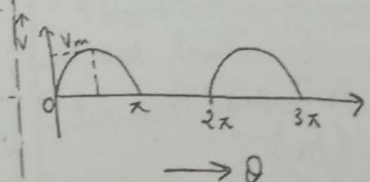
$$= -\frac{V_m}{\pi} [-1 - 1] = \frac{2V_m}{\pi}$$

$$\boxed{V_{avg} = \frac{2V_m}{\pi}}$$

Form Factor $(K_f) = \frac{V_{rms}}{V_{avg}} = 1.11$

Peak Factor $(K_p) = \frac{V_{max}}{V_{rms}} = 1.414$

(ii) HALF WAVE RECTIFIER



Length of Base → 2π

$$v = \begin{cases} V_m \sin\theta, & 0 \text{ to } \pi \\ 0, & \pi - 2\pi \end{cases}$$

R.m.s Value :-

$$V_{rms}^2 = \frac{1}{2\pi} \int_0^{2\pi} v^2(\theta) \, d\theta$$

$$= \frac{1}{2\pi} \int_0^{\pi} V_m^2 \sin^2\theta \, d\theta + \int_{\pi}^{2\pi} 0 \, d\theta$$

$$= \frac{V_m^2}{2\pi} \int_0^{\pi} \frac{2\sin^2\theta}{2} \, d\theta$$

$$= \frac{V_m^2}{4\pi} \left[\int_0^{\pi} (1 - \cos 2\theta) \, d\theta \right]$$

$$= \frac{V_m^2}{4\pi} \left(\theta - \frac{\sin 2\theta}{2} \right)_0^{\pi}$$

$$= \frac{V_m^2}{4\pi} (\pi - 0)$$

$$\boxed{V_{rms} = \frac{V_m}{2}}$$

AVERAGE VALUE :-

$$V_{avg} = \frac{1}{2\pi} \int_0^{2\pi} v(\theta) \, d\theta$$

$$= \frac{1}{2\pi} \left[\int_0^{\pi} V_m \sin\theta \, d\theta + \int_{\pi}^{2\pi} 0 \, d\theta \right]$$

$$= \frac{1}{2\pi} \left[\int_0^{\pi} V_m \sin\theta \, d\theta \right]$$

$$= \frac{V_m}{2\pi} \left[-\cos\theta \right]_0^{\pi}$$

$$= -\frac{V_m}{2\pi} \left[\cos\pi - \cos 0 \right]$$

$$= -\frac{V_m}{2\pi}[-1-1] = \frac{V_m}{\pi}$$

$$\boxed{V_{avg} = \frac{V_m}{\pi} = .637 V_m}$$

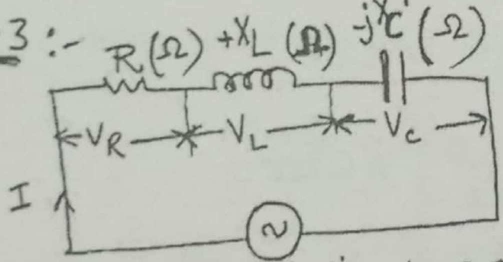
Form factor $(K_F) = \frac{V_{rms}}{V_{avg}} = 1.57$

Peak factor $(K_P) = \frac{V_{max}}{V_{rms}} = 2$

Q3:-

Explain the phenomenon of resonance in series R-L-C ckt. Derive resonant frequency and draw resonance curve. Why series R-L-C circuit at resonance is called acceptor ckt?

A3:-



$v = V_m \sin \omega t$, $f = f_r$ Hz (Variable Frequency)

Resonance is the condition in a series R-L-C ckt that when supply frequency is varied then at a particular frequency called Resonant frequency (f_r), the current is maximum and net reactance of the ckt is zero.

Circuit behaves as a purely resistive ckt and power factor is unity.

RESONANT FREQUENCY :-

At Resonant Frequency,

$V_L = V_C$.

$X_L - X_C = 0$

$\rightarrow \boxed{X_L = X_C}\ \Omega$

$I X_L = I X_C$

$\rightarrow \boxed{V_L = V_C}$

$\rightarrow \boxed{Z = R}\ (\Omega)$, minimum

$V = V_R$ (volt)

Current is maximum

$\rightarrow \boxed{I_{max} = \frac{V}{R}}$ (Amp)

$\rightarrow$ Voltage and current are in same phase.

$\phi = V \wedge I = 0°$

$\rightarrow \cos\phi = 1$ (Unity)

RESONANT FREQUENCY :-

Frequency at which resonance occurs is called Resonant Frequency (f_r)

At $f = f_r$

$X_L = X_C$

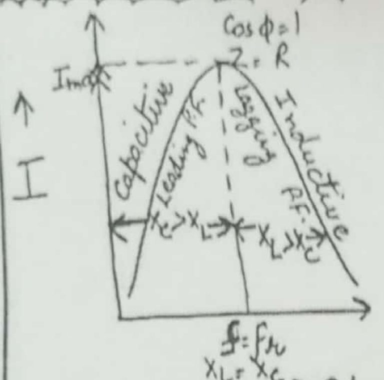
$\omega_r L = \frac{1}{\omega_r C}$

$\omega_r = \frac{1}{\sqrt{LC}}$ (rad/sec)

as $\omega = 2\pi F$

$$\therefore \boxed{f_r = \frac{1}{2\pi\sqrt{LC}}}\ Hz$$

RESONANCE CURVE :-



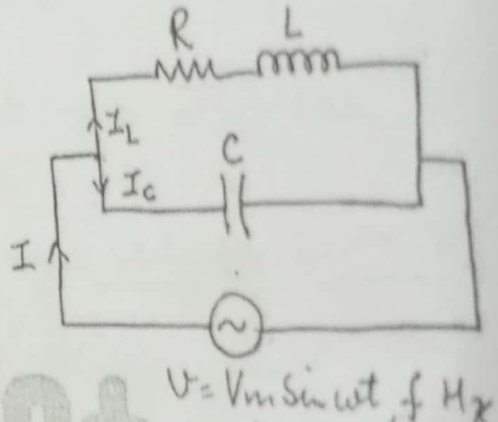
The curve drawn in b/w the supply current and supply freq-uency is called Resonance Curve.

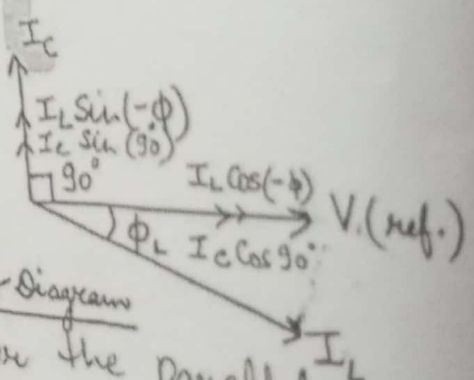
SERIES R-L-C Ckt at Resonance As ACCEPTOR CIRCUIT.

In series R-L-C ckt, at resonant frequency, impedance is mini-mum $\boxed{Z = R}$ (Ω) and current is maximum $\boxed{I_{max} = \frac{V}{R}}$. So, it accepts the signals of a particu-lar frequency. Hence, it is called acceptor ckt.

Q4:- Derive the resonant frequency in parallel R-L-C Circuit and define dynamic Impedance. Why parallel R-L-C ckt at resonance is called rejector ckt?

A.4:-





Phasor Diagram

For the parallel resonance in R-L-C ckt, the reactive component of supply current is Zero.

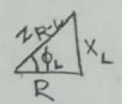
$\therefore$

$$I_C \sin 90 + I_L \sin(-\phi_L) = 0$$

$$I_C - I_L \sin \phi_L = 0$$

$\therefore I_C = I_L \sin \phi_L$

$$\frac{V}{X_C} = \frac{V}{Z_{R-L}} \cdot \frac{X_L}{Z_{R-L}}$$



Impedance Δ

$$(Z_{R-L})^2 = X_L \cdot X_C$$

$$= \omega L \cdot \frac{1}{\omega C}$$

$$Z_{R-L} = \sqrt{\frac{L}{C}}$$

$$\sqrt{R^2 + (\omega_r L)^2} = \sqrt{\frac{L}{C}}$$

$$R^2 + \omega_r^2 L^2 = \frac{L}{C}$$

$$\omega_r^2 = \frac{L}{L^2 C} - \frac{R^2}{L^2}$$

$$\omega_r = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

$$2\pi F_r = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

Or $\boxed{F_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}}$ Hz

If $\frac{1}{LC} \ggg \frac{R^2}{L^2}$, then $\frac{R^2}{L^2}$ is neglected

$\therefore \boxed{F_r = \frac{1}{2\pi\sqrt{LC}} \text{ Hz}}$ (For Ideal Resonance)

DYNAMIC IMPEDANCE :-

The impedance offered by the parallel circuit at resonance is called Dynamic Impedance of the ckt

$$\boxed{Z_D = \frac{L}{RC}} \ \Omega$$

PARALLEL CKT AT RESONANCE AS REJECTOR CIRCUIT

At resonance frequency, the current is minimum & impedance is maximum. So, it rejects the signals of a particular frequency. Hence, it is called Rejector ckt.

Q5:- Show that Resonant frequency is the geometric mean of upper and Lower Half Power Frequencies.

$$F_r = \sqrt{F_1 F_2}$$

A.S:-
We have,

$$X_L - X_C = \pm R$$

$X_L - X_C = R$ [For upper Half Power Freq.]

$$\omega_2 L - \frac{1}{\omega_2 C} = R \quad -①$$

$X_L - X_C = -R$ [For Lower Half Power Freq.]

$$\omega_1 L - \frac{1}{\omega_1 C} = -R \quad -②$$

Adding eqn ① & ②

$$(\omega_1 + \omega_2)L - \frac{1}{C}\left[\frac{1}{\omega_1} + \frac{1}{\omega_2}\right] = 0$$

$$\therefore (\omega_1 + \omega_2)L = \frac{1}{C}\left[\frac{\omega_2 + \omega_1}{\omega_1 \omega_2}\right]$$

$$\therefore \omega_1 \omega_2 = \frac{1}{LC}$$

But $\omega_r = \frac{1}{\sqrt{LC}}$

$$\therefore \omega_1 \omega_2 = \omega_r^2$$

$$2\pi F_1 \cdot 2\pi F_2 = (2\pi F_r)^2$$

Or $F_1 F_2 = F_r^2$

Or $\boxed{F_r = \sqrt{F_1 F_2}}$ Hz

Ans-06: Derive Q-factor for series and parallel resonance.

Q. factor of RLC Series Resonance:

The Q. factor of RLC series ckt can be defined as the voltage magnification that the ckt produced at resonance

$$Q.\text{ factor} = \frac{V_L}{V} = \frac{V_C}{V}$$

$$= \frac{I_{max} X_L}{I_{max} R} = \frac{X_L}{R} = \frac{\omega_0 L}{R}$$

$$= \frac{1}{R} L \frac{1}{\sqrt{LC}}$$

$$\boxed{Q.\text{ factor} = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

Q. factor of RLC Parallel Resonance:

Q. factor of parallel ckt is defined as the ratio of the circulating current to the line current or as the current magnification.

$$Q.\text{ factor} = \frac{I_L}{I} = \frac{V/Z_L}{V/Z_D}$$

$$= \frac{Z_D}{Z_L}$$

Now we know that for parallel ckt

$Z_D = L/CR$ & $Z_L = \sqrt{\frac{L}{C}}$

$\therefore$ Q factor $= \frac{L/CR}{\sqrt{L/C}}$

$$\boxed{\text{Q factor} = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

Q.7 Prove that for purely inductive and capacitive ckt, the average power is zero

Ans:-

Power in Purely Inductive ckt:

Let the instantaneous value of voltage is given by

$v = V_m \sin\omega t$ —— (1)

$\therefore$ for pure inductive ckt

$i = I_m \sin(\omega t - \pi/2)$ —— (2)

Now the instantaneous power is given as

$p = v \cdot i$

$= V_m \sin\omega t \cdot I_m \sin(\omega t - \pi/2)$

$= V_m \sin\omega t \cdot -I_m \cos\omega t$

$= -\frac{V_m I_m \times 2 \sin\omega t \cos\omega t}{2}$

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

Now average power

$$P_{avg} = \frac{1}{\pi}\left[\int_0^{\pi} -\frac{V_m I_m}{2}\sin 2\omega t \, d\omega t\right]$$

$$\boxed{P_{avg} = 0}$$

Power in Purely Capacitive circuit :-

Let instantaneous value of voltage is

$v = V_m \sin \omega t$ — (1)

$\therefore$ $i = I_m \sin(\omega t + \pi/2)$ — (2)

Now the instantaneous power

$p = v \cdot i$

$= V_m \sin \omega t \cdot I_m \sin(\omega t + \pi/2)$

$= V_m \sin \omega t \cdot I_m \cos \omega t$

$= \frac{V_m I_m \times 2 \sin \omega t \cos \omega t}{2}$

$= \frac{V_m I_m}{2} \sin 2\omega t$

Now

$$P_{avg} = \left[\frac{1}{\pi}\int_0^{\pi} \frac{V_m I_m}{2} \sin 2\omega t\right]$$

$$\boxed{P_{avg} = 0}$$

Q.08 What is power factor? What are the causes and disadvantages of low p.f? Explain any one method to improve the p.f.

Ans.

Power factor :

The ratio of active power and apparent power is known as p.f.

$$\cos\phi = \frac{\text{Active power}}{\text{Apparent power}} = \frac{VI\cos\phi}{VI} = \cos\phi$$

Also

$$\cos\phi = \frac{R}{Z}$$

⇒ It shows that how much percentage of total power is consumed by the ckt.

⇒ It is the practical measure of the efficiency of power distribution system.

We know that

$$P = VI\cos\phi$$

or $I = \frac{P}{V\cos\phi}$, as P and V are constant

$\therefore$ $I \propto \frac{1}{\cos\phi}$

So, If pf is low, current I is very high & vice versa.

Disadvantages of Low Power factor:

(I) Large generator and transformers are required to deliver same load but at low p.f

(II) More conductor material is required for transmission lines due to large current.

(III) Due to high current, more Cu loss occurs at low p.f

(IV) Low p.f results in large voltage drop in transformers, generators, Transmission lines which results in poor voltage regulation.

Causes of Low Power factor:

⇒ All a.c motors and transformers operate at lagging p.f. p.f decreases with decrease in load.

⇒ Industrial heating furnance such as arc and induction furnance operate at very low p.f

Power Factor Can be Improved By:

(I) Using induction motor with phase advancers.

(II) Using parallel capacitor

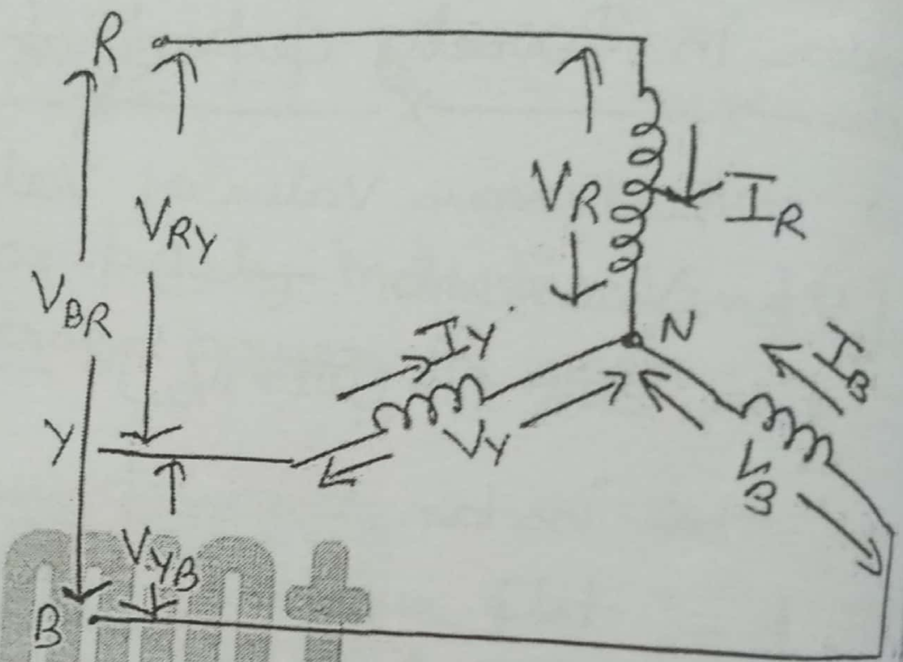
(III) Using Synchronous condensor like parallel capacitor.

Q9 Prove that

(i) for Star connection $V_L = \sqrt{3}\, V_{ph}$

(ii) for Delta connection $I_L = \sqrt{3}\, I_{ph}$

Ans Star Connected system :-



Let V_R, V_Y, V_B are the phase voltages and V_{RY}, V_{YB} & V_{BR} are line voltages.

Now

$\overline{V_{RY}} = \overline{V_R} - \overline{V_Y}$

Apply law of parallelogram

$|V_{RY}| = \sqrt{|V_R|^2 + |V_Y|^2 + 2|V_R||V_Y|\cos 60^\circ}$

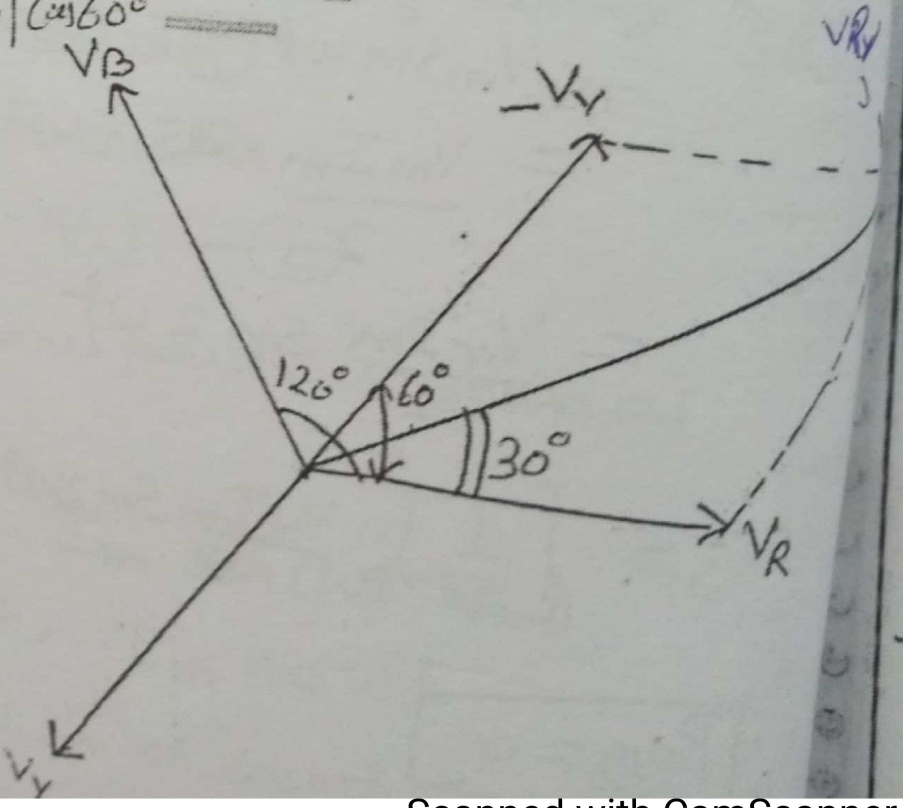
or

$V_{RY} = \sqrt{V_P^2 + V_P^2 + 2V_P^2 \times \frac{1}{2}}$

or $\boxed{V_L = \sqrt{3}\, V_P}$

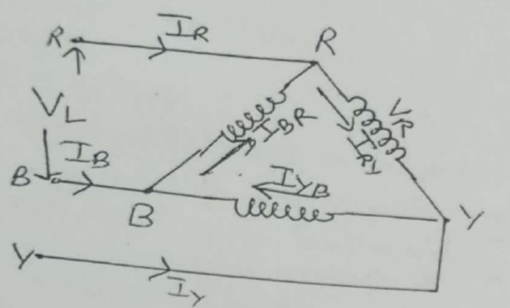
For Star connection

$\boxed{I_L = I_P}$



(II) Delta Connected System:

Let I_R, I_Y & I_B are the line currents and I_{RY}, I_{YB} & I_{BR} are the phas current.



Apply K.C.L at Node 'R'

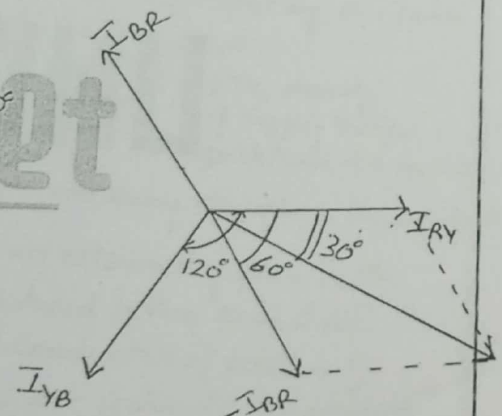
$\overline{I}_R = \overline{I}_{RY} - \overline{I}_{BR}$

Now from phasor diagrams apply law of parallelogram.

$I_R = \sqrt{I_{RY}^2 + I_{BR}^2 + 2I_{RY}I_{BR}\cos 60°}$

$I_L = \sqrt{I_P^2 + I_P^2 + 2I_P^2 \times \frac{1}{2}}$

$\boxed{I_L = \sqrt{3}\, I_P}$



Now one phase comes across the two lines

$\therefore \boxed{V_L = V_{Ph}}$

Q-10 A Star connected 3-ϕ load has per phase impedance of $(8+j6)\Omega$. It is fed from a 400V, 50Hz, 3-ϕ balance supply. Determine I) Line current (II) P.f (III) Active, reactive and apparent power.

Solution Given $V_L = 400V$, $Z_{Ph} = (8+j6)\Omega$

OR $Z_{Ph} = 10\angle 36.86° \ \Omega$

Now for Star connection

$V_L = \sqrt{3}\, V_{Ph}$ or $V_{Ph} = \frac{V_L}{\sqrt{3}}$

$\therefore V_{Ph} = \frac{400}{\sqrt{3}} = 230.94V$

Now phase current

$I_{Ph} = \frac{V_{Ph}}{|Z_{Ph}|} = \frac{230.94}{10}$

$\therefore I_{Ph} = 23.09A$

(i) Line current = Phase current {for Star connection

$\therefore I_L = I_{Ph}$ OR $\boxed{I_L = 23.09A}$

(II) Power factor

$\cos\phi = \frac{R}{Z} = \frac{8}{10} = 0.8$ lagging

(III) Active power

$P = \sqrt{3} V_L I_L \cos\phi = \sqrt{3} \times 400 \times 23.09 \times 0.8 = 12.79$ KW

Reactive power

$Q = \sqrt{3} V_L I_L \sin\phi = \sqrt{3} \times 400 \times 23.09 \times 0.6 = 9.6$ KVAR

Apparent power

$S = \sqrt{3} V_L I_L = \sqrt{3} \times 400 \times 23.09 = 15.99$ KVA

Ans

Q11 A balance 3ϕ star connected load of 18 kW taking a leading current of 60 A, when connected to $3\text{-}\phi$, 440V, 50Hz supply. find the value and nature of load components and pf of the load.

Solution Given $P_{load} = 18\ kW$, $V_L = 440V$, $I_L = 60A$

Now we know that

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

OR

$$18 \times 1000 = \sqrt{3} \times 440 \times 60 \times \cos\phi$$

(III) $\cos\phi = \dfrac{18 \times 1000}{\sqrt{3} \times 400 \times 60} = 0.39$ leading

Now for Star connection

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

And $I_{Ph} = I_L = 60A$

Now $|Z_{Ph}| = \dfrac{V_{Ph}}{I_{Ph}} = \dfrac{254.03}{60} = 4.23\Omega$

And $\cos\phi = \dfrac{R}{Z} \Rightarrow R = Z\cos\phi$

(I) or $\boxed{R = 4.23 \times 0.39 = 1.65\Omega}$

And $Z_{Ph} = \sqrt{R^2 + X^2}$ {$\because$ current is leading

$$X_C = \sqrt{Z_{Ph}^2 - R^2} = \sqrt{(4.23)^2 - (1.65)^2}$$

$\boxed{X_C = 3.9\Omega}$ $\therefore C = \dfrac{1}{2\pi f X_C} = 816\ \mu F$ Ans.

UNIT-3

What are the various losses in transformer? Explain each with formulae.

12→ There are mainly two losses in transformer
1→ Core loss (Iron loss/ Constant loss)
2→ Copper loss (I^2R loss/ Variable loss)

Core losses → Core losses can be divided into two categories

a) Hysteresis loss → These losses occur when the magnetic core is subjected to an alternating flux, so due to alternate magnetization and demagnetization of the magnetic core, it does not follow linear & similar path resulting wastage of energy in every cycle, which is represented by BH curve Area.

$$\boxed{W_h = K_h B_m^{1.6} f V}$$

K_h = Constant
B_m = max flux density
f = freq of supply voltage
V = ~~Voltage~~ Volume of core (m^3)

Hysteresis loss can be minimized using steel of high silicon content

b) Eddy current loss → Due to an alternating flux in the magnetic core emf gets induced in the core itself. As magnetic core is a good conductor of electricity small loops of eddy currents are induced in the magnetic core which are responsible for $I_e^2 R$ losses in core. Eddy currents can be reduced using laminated cores.

Copper Loss (I^2R loss):-
These losses occur due to ohmic resistance of primary & sec. winding. As the current I is variable so these losses are variable losses.

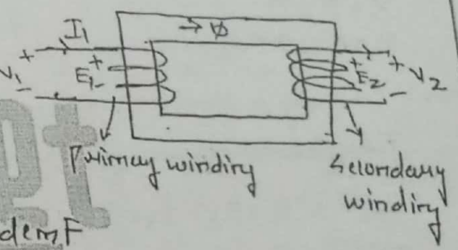
$P_{cu} = I_1^2 R_1 + I_2 R_2$ W
$P_{cu} = I_2^2 R_{2e}$ W
$P_{cu} = I_1^2 R_{1e}$ W

R_{1e} = equivalent resistance referred to primary
R_{2e} = equivalent resistance referred to secondary
I_1 → full load primary current
I_2 → full load secondary current

Q13→ Explain the working of transformer. Derive emf equation of transformer.

Ans-13→ Working:-
1→ When primary winding is excited by an AC voltage source and MMF (I_1N_1) is produced which circulates the flux in the core.
2→ Due to alternating current, flux changes at primary and an EMF gets induced in the primary by Faraday's law of Electromagnetic Induction.
3→ The flux is alternating in nature and it links with secondary so, due to mutual Induction and emf gets induced in the secondary winding.

Derivation



Let ϕ = flux in the core (wb)
f = freq (Hz)
$T = \frac{1}{f}$ = Time period (sec)
E_1 = RMS value of primary induced emf
E_2 = RMS value of secondary induced emf
N_1 = primary no. of turns
N_2 = secondary no. of turns

According to Faraday's law of Electromagnetic induction

Avg EMF per turn $\propto \frac{d\phi}{dt}$

$$\frac{d\phi}{dt} = \frac{\text{change in flux}}{\text{Time required for change in flux}}$$

Consider $1/4^{th}$ cycle ϕ changes from 0 to ϕ_m so $\frac{d\phi}{dt} = \frac{\phi_m - 0}{T/4} = 4f$

For sinusoidal quantity Form factor = $\frac{\text{RMS Value}}{\text{Avg Value}} = 1.11$

RMS Value = 1.11 Avg Value

so RMS value of primary & secondary induced EMF is

$$\boxed{E_1 = 4.44 f \phi_m N_1}$$
$$\boxed{E_2 = 4.44 f \phi_m N_2}$$

N_1 → primary turns
N_2 → secondary turns.

Q-14 15 KVA 2000/100V transformer $R_1 = 1.75\Omega$, $R_2 = 0.0045\Omega$. The leakage reactance are $X_1 = 2.6\Omega$ and $X_2 = 0.0075\Omega$. Calculate

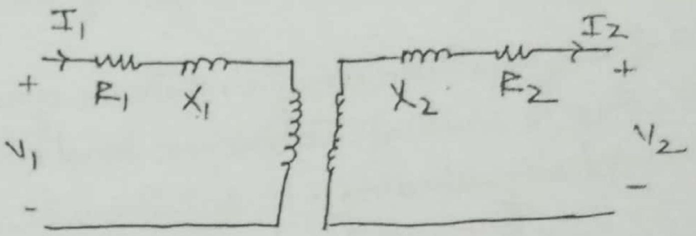
a) Equivalent resistance reffered to primary & secondary

b) Equivalent reactance reffered to primary & secondary

c) Equivalent Impedance reffered to primary and secondary

d) Cu loss.

Ans→15→ Given data



KVA rating = 15 KVA

$R_1 = 1.75\Omega$

$R_2 = 0.0045\Omega$

$X_1 = 2.6\Omega$

$X_2 = 0.0075\Omega$

Case 1) Primary reffered to secondary

Transformation ratio $= K = \frac{V_2}{V_1} = \frac{100}{2000} = .05$

$R_{02} = K^2 R_1 + R_2 = (.05)^2 \times 1.75 + 0.0045 = .008875\Omega$

$X_{02} = K^2 X_1 + X_2 = (.05)^2 \times 2.6 + 0.0075 = 0.014\Omega$

Case 2) Secondary reffered to primary

$R_{01} = R_1 + \frac{R_2}{K^2} = 1.75 + \frac{.0045}{(.05)^2} = 3.55\Omega$

$X_{01} = X_1 + \frac{X_2}{K^2} = 2.6 + \frac{0.0075}{(.05)^2} = 5.6\Omega$

a) $R_{01} = 3.55\Omega$

$R_{02} = 0.008875\Omega$

b) $X_{01} = 5.6\Omega$

$X_{02} = 0.014\Omega$

c) $Z_{01} = R_{01} + jX_{01} = (3.55 + j5.6)\Omega$

$Z_{02} = R_{02} + jX_{02} = (0.008875 + j0.04)\Omega$

d) Cu losses $= I_1^2 R_1 + I_2^2 R_2 = I_1^2 R_{01} = I_2^2 R_{02}$

$V_1 I_1 = 15 \times 10^3$

$I_1 = \frac{15 \times 10^3}{2000} = 7.5A$

So Cu losses $= I_1^2 R_{01} = (7.5)^2 \times 3.55$

$P_{cu} = 199.6875W$

Q15 A 40 kVA transformer has a core loss of 400W and full load copper loss of 800W. If the power factor of the load is 0.9 lagging. Calculate

i) The full load efficiency

ii) Effeciency at Half load unity power factor

iii) kVA supplied at maximum efficiency

iv) Maximum efficiency of 0.9 pf lagging

Ans. Given data

kVA rating = 40 kVA

Core loss = 400 W = P_i

Copper loss = 800 W = P_{cu} (full load)

pf = $\cos\phi$ = 0.9 lagging

$$\eta = \frac{nVI\cos\phi}{nVI\cos\phi + P_i + P_{cu}(n^2)}$$

i) At full load n = 1

$$\eta = \frac{VI\cos\phi}{VI\cos\phi + P_i + P_{cu}} = \frac{40\times10^3\times0.9}{40\times10^3\times.9 + 400 + 800} = 0.9677 \text{ or } 96.7\%$$

ii) At Half load n = 1/2

$\cos\phi = 1$

$$\eta = \frac{\frac{1}{2}\times40\times10^3\times1}{\frac{1}{2}\times40\times10^3 + 400 + 800\times\left(\frac{1}{2}\right)^2} = 0.9708 \text{ or } 97.08\%$$

iii) $$(kVA)_{at\ max\ \eta} = (kVA)_{Full\ load}\sqrt{\frac{P_i}{P_{cu}}} = 40\sqrt{\frac{400}{800}} = 28.28\ kVA$$

iv) at max η $n = \sqrt{\frac{400}{800}} = .707$

$$\eta = \frac{nVI\cos\phi}{nVI\cos\phi + P_i + n^2P_{cu}} = \frac{.707\times40\times.9\times10^3}{.707\times40\times.9\times10^3 + 400 + 800\times(.707)^2} = 96.95\%$$

Question-16 - Explain the Voltage Regulation of Transformer.

Solution :- It is the ratio of change in voltage from No-load to full load to full load voltage. i.e

$$\text{Voltage Regulation} = \frac{E_2 - V_2}{V_2} \text{ p.u}$$

where, E_2 = No-load voltage
V_2 = full load voltage

At lagging p.f load,

$$\boxed{E_2 > V_2}$$

V.R should be +ive :

At leading p.f load,

$$\boxed{E_2 < V_2}$$

V.R should be -ive.

$$\% \text{ Voltage Regulation} = \frac{E_2 - V_2}{V_2} \times 100$$

Voltage regulation can also be obtained by the following expression.

$$\% \text{ V.R} = \frac{I_2 R_{2e} \cos\phi_2 \pm I_2 X_{2e} \sin\phi_2}{V_2}$$

At lagging p.f load,

$$\% \text{V.R} = \frac{I_2 R_{e2} \cos\phi_2 + I_2 X_{e2} \sin\phi_2}{V_2} \times 100$$

At leading p.f load,

$$\% \text{ V.R} = \frac{I_2 R_{e2} \cos\phi_2 - I_2 X_{e2} \sin\phi_2}{V_2} \times 100$$

At unity p.f load,

$$\% \text{ V.R} = \frac{I_2 R_{e2}}{V_2} \times 100$$

Question-17 :- Write down the Expression of the efficiency of a Transformer. Deduce the condition for maximum efficiency of Transformer and prove that.

$$(\text{KVA})_{\text{at max.}} = (\text{KVA})_{\text{rated}} \sqrt{\frac{P_{core}}{P_{ohmic(copper)}}}$$

Solution :- Efficiency of a Transformer can be obtained by the following expression

$$\eta = \frac{x V_2 I_2 \cos\phi_2}{x V_2 I_2 \cos\phi_2 + P_i + x^2 P_{cu}}$$

$$\boxed{V_2 I_2 = S}$$

$$\eta = \frac{x S \cos\phi_2}{x S \cos\phi_2 + P_i + x^2 P_{cu}}$$

in percentage

$$\% \eta = \frac{x S \cos\phi_2}{x S \cos\phi_2 + P_i + x^2 P_{cu}} \times 100$$

Maximum efficiency :- we know the efficiency expression.

$$\eta = \frac{x S \cos\phi_2}{x S \cos\phi_2 + P_i + x^2 P_{cu}}$$

$$= \frac{S \cos\phi_2}{\frac{\cancel{x} S \cos\phi_2}{\cancel{x}} + \frac{P_i}{x} + \frac{x^{\cancel{2}} P_{cu}}{\cancel{x}}}$$

$$= \frac{S \cos\phi_2}{S \cos\phi_2 + \frac{P_i}{x} + x P_{cu}}$$

if efficiency is maximum the denominator should be minimum. so let

$$X = S \cos\phi_2 + \frac{P_i}{x} + x P_{cu}$$

Differentiate X w.r.t x.

$$\frac{dX}{dx} = 0 + (-1)\frac{P_i}{x^2} + P_{cu}$$

$$\frac{dX}{dx} = 0 \; ; \; (-1)\frac{P_i}{x^2} + P_{cu} = 0$$

Hence,

$$P_{cu} = \frac{P_i}{x^2} \; ; \; \boxed{x^2 P_{cu} = P_i}$$

Second derivati would be,

$$\frac{d^2X}{dx^2} = (-1)(-2)\frac{P_i}{x^3} + 0$$

$$\boxed{\frac{d^2X}{dx^2} > 0}$$

So Denominator should be minimum
Hence efficiency should be maximum.

$$\eta_{max} = \frac{xS\cos\phi_2}{xS\cos\phi_L + P_i + P_i}$$

$$\boxed{\% \eta_{max.} = \frac{xS\cos\phi_2}{xS\cos\phi_L + 2P_i} \times 100}$$

At $x^2 P_{cu} = P_i$

$$\boxed{\text{copper loss} = \text{Iron loss}}$$

load would be,

$$x = \sqrt{\frac{P_i}{P_{cu}}} \; ; \; P_{cu} = \text{full load copper loss}$$

So

$$(KVA)_{at\,max} = x \cdot S$$

$$(KVA)_{at\,max.} = (KVA)_{rated}\sqrt{\frac{P_i}{P_{cu}}}$$

$P_i \rightarrow$ Iron loss or core loss

UNIT-4

Question 19 :- Derive E.M.F equation of d.c generator. A 4 pole, lap wound d.c generator has a useful flux of 0.07 Wb. Calculate generated e.m.f when it is rotated at a speed of 900 r.p.m with the help of prime movers. Armature consists of 440 number of conductors. Also calculate the generated e.m.f lap-wound armature is replaced by wave wound armature.

Solution :- E.M.F equation :-

Let,
Z = Total No. of Armature cond^n
P = Total No. of poles
N = Speed of Armature in r.p.m
A = No. of parallel path.
ϕ = flux per pole in Wb.

flux cut by single armature conductor in one complete revolution. i.e

$$d\phi' = P.\phi$$

Time taken by single armature conductor in one complete revolution, i.e

$$dt' = \frac{60}{N} \text{ sec.}$$

Induced e.m.f in single armature conductor would be,

$$e = \frac{d\phi'}{dt'} = \frac{P\phi}{60/N} = \frac{P\phi N}{60}$$

$$\boxed{e = \frac{P\phi N}{60} \text{ Volt}}$$

No. of conductor in series per parallel path

$$= \frac{Z}{A}$$

Total e.m.f would be

$$E_g = e \times (\text{No. of cond}^n \text{ in series})$$

$$= e \times \frac{Z}{A} = \frac{P\phi NZ}{60\,A}$$

$$\boxed{E_g = \left(\frac{PZ}{60A}\right).\phi.N \text{ Volt}}$$

for lap winding, $A = P$
for wave winding, $A = 2$

$$\boxed{E_g = K.\phi.N} \qquad K = \frac{PZ}{60A}$$

Given ↓
$P = 4$; $\phi = 0.07$ Wb ; $N = 900$ r.p.m
$Z = 440$, $A = P$ [Lap winding]
$A = 4$

generated voltage would be,

$$E_g = \frac{P\phi NZ}{60\,A} = \frac{4 \times 0.07 \times 900 \times 440}{60 \times 4}$$

$$\boxed{E_g = 462 \text{ Volt}}$$

if lap-wound is replace by wave-wound. Hence $\boxed{A = 2}$

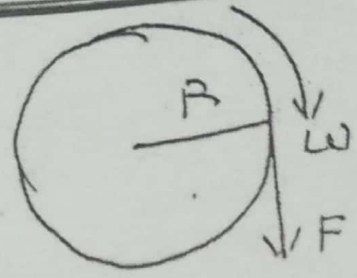
$$E_g = \frac{4 \times 0.07 \times 900 \times 440}{60 \times 2}$$

$$\boxed{E_g = 924 \text{ Volt}}$$

Question 19 :- Derive Torque equation of d.c motor.

Solution :- Torque equation :-

Let a Rotor having radius = R meter, circumferential force = F Newton



Speed of rotor $= N$ r.p.m.

Now $\omega = \frac{2\pi N}{60}$ rad/sec.

work done in one complete revolution i.e W

$W = F \times$ Distance travelled in one revolution.

mechanical $\boxed{W = F \times 2\pi R}$

and power Developed i.e P_m

$$P_m = \frac{W}{t} = \frac{F \times 2\pi R}{(60/N)} = F \times R\left(\frac{2\pi N}{60}\right)$$

$$\because \boxed{P_m = T.\omega}$$

Power Developed in Armature circuit

$$P_e = E_g . I_a$$

At steady state condition $\boxed{P_m = P_e}$

$$T.\omega = E_g . I_a$$

$$T . \frac{2\pi \cancel{N}}{\cancel{60}} = \frac{P\phi \cancel{N} Z}{\cancel{60} . A} . I_a$$

$$T = \frac{1}{2\pi} . \frac{P\phi Z . I_a}{A}$$

$$T = \underbrace{0.159\left(\frac{PZ}{A}\right)}_{K} . \phi . I_a$$

$$\boxed{T = K\phi I_a}$$

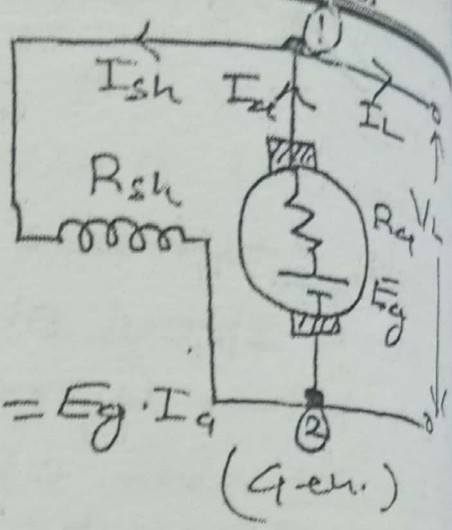
Question 20 :- A 25 kW, 250 Volt d.c shunt generator has armature and field resistance of 0.06 Ω and 100 Ω respectively. Determine total power Developed (a) As a Generator (b) As a motor.

(a) Given

$P_L = 25\,kW$, $V_L = 250V$

$R_{sh} = 100\,\Omega$, $R_a = 0.06\,\Omega$

Note: No Brush drop.



(Gen.)

Power Developed $P_g = E_g \cdot I_a$

$$I_{sh} = \frac{V_L}{R_{sh}} = \frac{250}{100} = 2.5A$$

$$I_L = \frac{P_L}{V_L} = \frac{25\times10^3}{250} = 100A$$

At Node 1

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

$$100 + 2.5 = I_a \; ; \quad \boxed{I_a = 102.5A}$$

Voltage equation

$$E_g = V_L + I_aR_a = 250 + 102.5\times$$

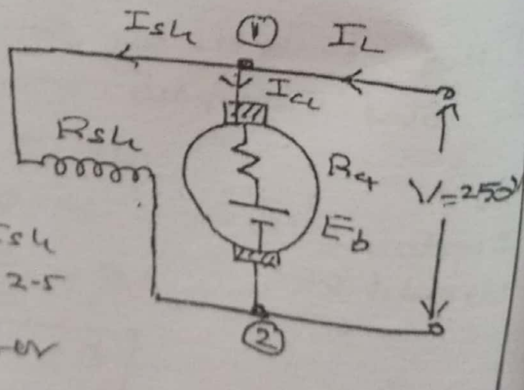
$$\boxed{E_g = 256.15V}$$

Hence,

$$P_g = E_g I_a = 256.15 \times 102.5$$

$$\boxed{P_g = 26.26\,kW}$$

(b) As a motor $P_L = 25\,kW$



$$I_{sh} = \frac{V}{R_{sh}} = \frac{250}{100} = 2.0A$$

$$I_L = \frac{25\times10^3}{250} = 100A$$

At Node 1 (KCL) $I_a = I_L - I_{sh}$

$I_a = 100 - 2.5$

$$\boxed{I_a = 97.5A}$$

Voltage equation of motor

$$E_b = V - I_aR_a = 250 - 97.5\times0.06 = 244.15V$$

Power Developed in motor.

$$P_g = E_b \cdot I_a = 244.15\times97.5 = 23.81\,kW$$

$$\boxed{P_g = 23.81\,kW}$$

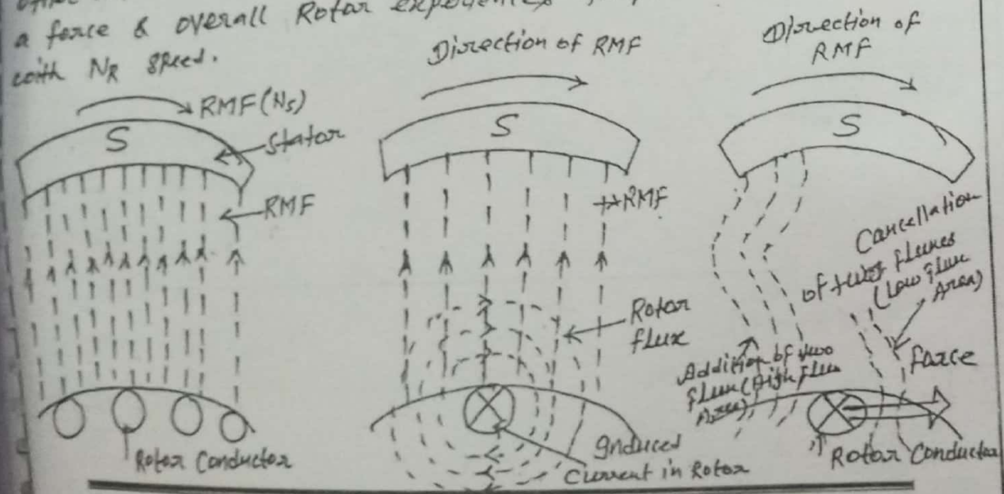
Q. 21:- Explain the working of 3-φ IM. Define slip.
A 8 pole, 3-φ IM of frequency 50HZ has rotor frequency of 2HZ at full load. Find out full load slip and full load speed.

Ans:- ⇒ Induction motor works on the principle of electromagnetic induction.

⇒ When 3-φ supply is given to the three phase stator winding a rotating magnetic field (RMF) of constant magnitude is produced. The speed of RMF is equal to synchronous speed, N_s RPM.

$\boxed{N_s = \frac{120f}{P}}$ where f = supply frequency
P = No. of stator or Rotor poles

⇒ Now rotor is stationary and stator flux RMF is rotating so there exist relative motion b/w RMF & rotor conductor.
⇒ Due to this an emf get induced in the rotor conductor.
⇒ As Rotor ckt is closed, the Induced emf desires a current in the rotor conductor.
⇒ Now any current carrying conductor produces its own flux. So Rotor produces its own flux called Rotor flux.
⇒ The two fluxes stator & Rotor fluxes intersect with each other and due to this rotor conductor will experience a force & overall Rotor experiences torque and start rotating with N_R speed.



⇒ The direction of rotation of rotor will be such that it will oppose the cause (Lenz's law).
⇒ Here the cause is relative motion b/w RMF & Rotor Conductor. Hence to reduce this relative motion rotor rotates in the same direction as that of RMF and tries to catch up the speed of RMF.

☆ $P = 8$, $f_s = 50HZ$, $f_r = 2HZ$ (given)

$S_{fl} = ?$ & $N_{fl} = ?$

$\because f_r = S f_s$

$\therefore 2 = S * 50$

$S = 0.04$ or 4%

$\boxed{S_{fl} = 0.04}$

$\because N_s = \frac{120 f_s}{P}$

$\therefore N_s = \frac{120 * 50}{8} = 750$ RPM

and we know that $S_{fl} = \frac{N_s - N_{r(fl)}}{N_s}$

$0.04 = \frac{750 - N_{r(fl)}}{750}$

$\therefore \boxed{N_{r(fl)} = 720 \text{ RPM}}$

Q.22 a) Draw and explain slip-torque characteristics of 3-φ Induction motor and mention all regions of operations.

b) A 3-φ, 50Hz Induction motor has full load speed of 960 RPM. Calculate :- i) Slip, ii) frequency of rotor induced emf, iii) No. of poles iv) speed of rotor field w.r.t. rotor structure, v) Speed of rotor field w.r.t. stator structure, vi) speed of rotor field w.r.t. stator field.

Soln :- a) We know that, Torque

$$T = K \frac{S E_2^2 R_2}{R_2^2 + (SX_2)^2} \quad \text{or} \quad T \propto \frac{S R_2}{R_2^2 + (SX_2)^2}$$

∵ for constant supply E_2 is constant.

⇒ Now we know that the slip lies between 0 to 1. So the graph obtained by plotting torque against the slip between $S = 0$ to $S = 1$ is called torque-slip characteristics.

⇒ Now this whole slip region is divided into two parts.

① Low slip region :— "S" is very-very small. Therefore $(SX_2)^2$ is also very small as compare to R_2^2 and that can be neglected.

$$\therefore \boxed{T \propto \frac{S R_2}{R_2^2} \propto S} \quad \text{(as } R_2 \text{ is constant)}$$

So torque is directly proportional to slip. It is the graph showing straight line passing through origin. this region of operation is known as stable region.

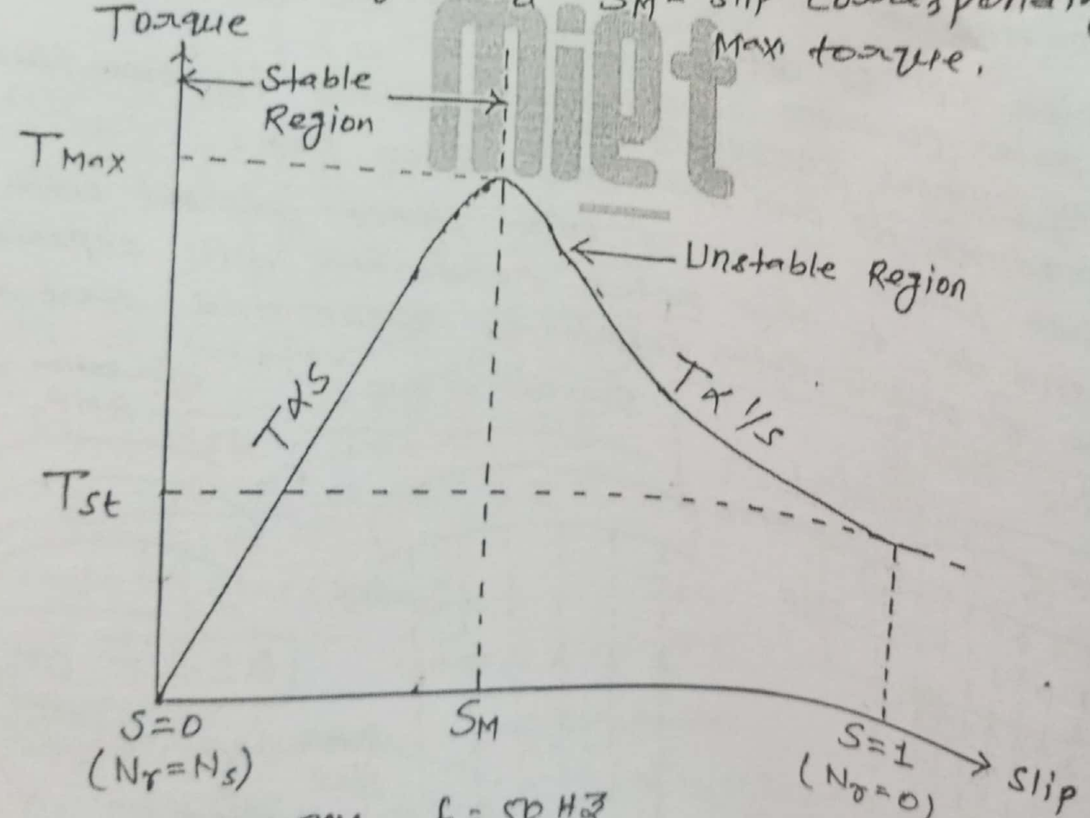
(2) High slip region:- When slip "s" is high i.e. approaching to 1, $(sX_2)^2$ can't be neglected but $(R_2)^2$ is very small as compare to $(sX_2)^2$.

$$\therefore\ T \propto \frac{sR_2}{(sX_2)^2} \propto \frac{1}{s} \Rightarrow \boxed{T \propto \frac{1}{s}}$$

So, in high slip region torque is inversely proportional to the slip. Hence its nature is like rectangular hyperbola. This region is known as unstable region of operation.

★ At starting, $N_r = 0$ and $s = 1$, Therefore torque corresponding to slip, $s = 1$ is known as starting Torque (T_{st}).

T_m = Maximum torque & S_M = slip corresponding to Max. torque.



b) i) $N_r = 960$ RPM, $f_s = 50$ Hz

$$\because\ s = \frac{N_s - N_r}{N_s}$$

P	$N_s = \frac{120f}{P}$ (for 50Hz)
2	3000 RPM
4	1500 RPM
6	1000 RPM ✓
8	750 RPM
10	600 RPM

$\because N_r < N_s$

That's why this is a 6-pole M/c & $N_s = 1000$ RPM

$\therefore \% S = \frac{1000-960}{1000}$

$\boxed{S = 4\% \text{ or } 0.04}$

ii) $f_r = S f_s$

$f_r = 0.04 * 50 = 2Hz$

$\boxed{f_r = 2Hz}$

iii) for $N_r = 960$; $N_s = 1000$ RPM.

$\therefore N_s = \frac{120*f}{P} = \frac{120*50}{P}$

$P = \frac{120*50}{1000} = 6$

$\boxed{P = 6}$

iv) Speed of Rotor field = N_s

Speed of Rotor structure = N_r

$\therefore$ speed of Rotor field w.r.t. Rotor structure = $N_s - N_r$ = $\boxed{40 \text{ RPM}}$

v) Speed of Rotor field = N_s

Speed of Stator structure = 0

$\therefore$ Speed of Rotor field w.r.t. Stator structure = $N_s - 0$

$\Rightarrow \boxed{N_s = 1000 \text{ RPM}}$

vi) Speed of Rotor field = N_s

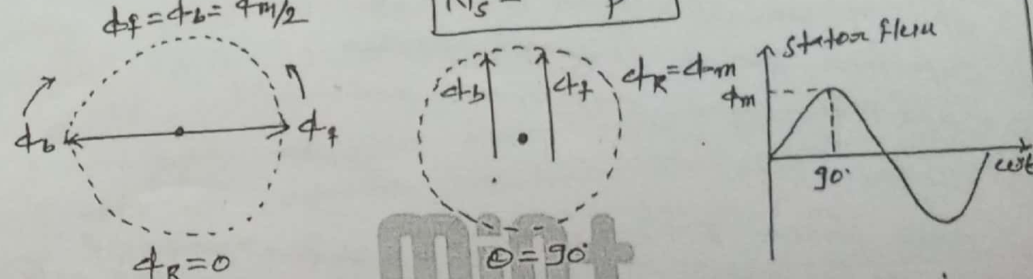
Speed of Stator field = N_s

$\therefore$ Speed of Rotor field w.r.t. Stator field = $N_s - N_s$ = $\boxed{0 \text{RPM}}$

Q. 23 Discuss why single phase Induction motor is not self starting? What are its methods of starting? Explain any two types with phasor diagram.

Ans:-⇒ According to Double field revolving theory any alternating quantity can be resolved into two rotating components which rotates in opposite direction with same speed (N_s) and each having magnitude as half of the maximum magnitude of alternating quantity.

where :- $\boxed{N_s = \frac{120f}{P}}$



⇒ In case of 1-φ I.M. when 1-φ AC supply is given to stator winding, It produces an alternating magnetic field having maximum magnitude of ϕ_m

⇒ Now according to double field revolving theory, this alternating flux can be imagined as of two rotating fluxes each having magnitude $\phi_m/2$ and rotates in opposite direction with a speed N_s.

⇒ Let ϕ_f is the forward component rotating anticlockwise direction and ϕ_b is backward component rotating in ~~anti~~-clockwise direction.

⇒ Now, as We have two rotating fluxes ϕ_f & ϕ_b. Hence get cut by rotor. Due to this an emf induced in the rotor which circulate rotor current.

⇒ Now we know that every current carrying conductor will experience a force if it is placed in magnetic field.

⇒ So due to ϕ_f rotor will experience a torque in anticlockwise direction and due to ϕ_b it will experience some amount of torque in clockwise.

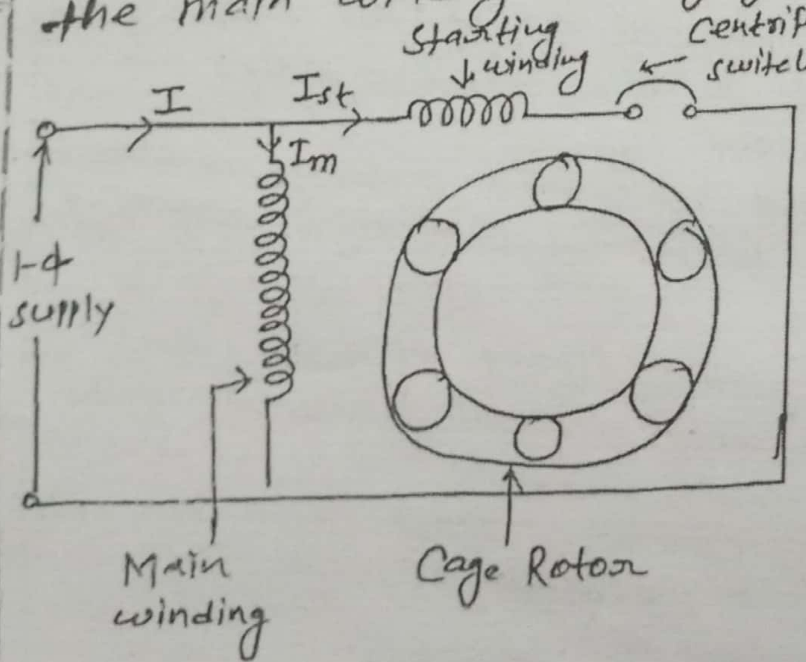
⇒ Thus the net torque experienced by the rotor is zero at start and hence the single-phase IM is not self start.

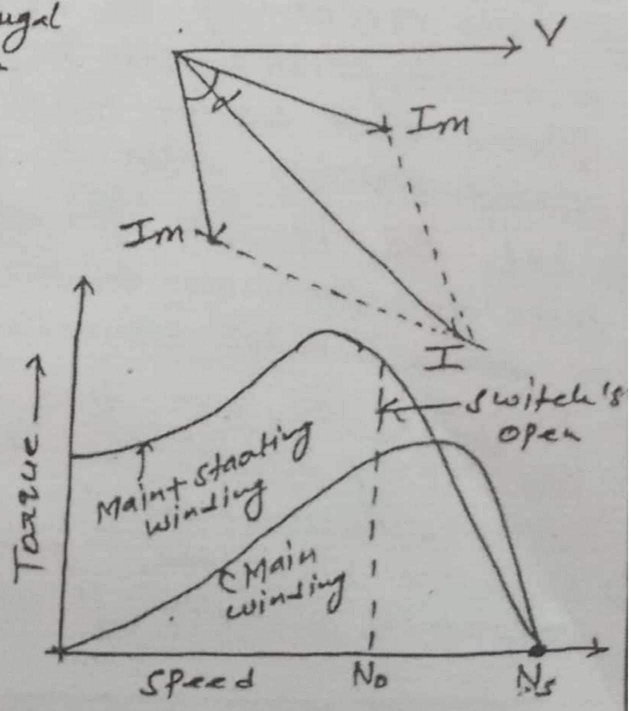
There are various methods to start a 1-ϕ IM:-

i) Split phase induction Motor
ii) Capacitor start induction Motor
iii) Capacitor start capacitor run IM.
iv) Shaded pole IM.

i) Split phase IM :-

* This type of Motor has 1-ϕ stator winding called main winding and one more winding called auxillary winding or starting winding.
* The starting winding is highly resistive while the main winding is highly inductive





Let I_m = current in main winding

I_{st} = current in starting winding

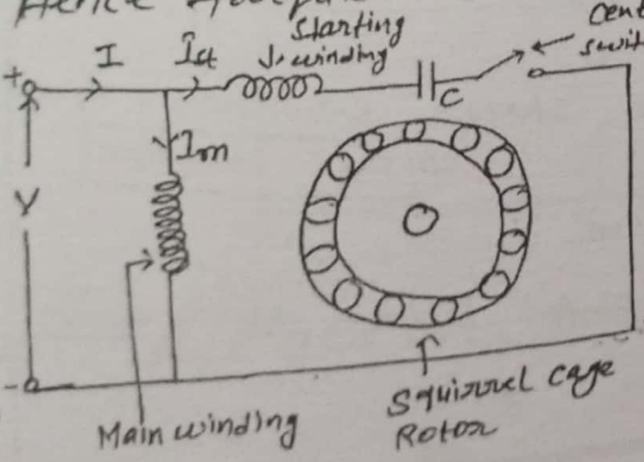
* Now from phasor diagram, we have two curr[ents] I_m & I_{st} and there exists a phase differ[ence] "α" b/w them and $\boxed{I_{st} \propto \hat{I}_a \sin\alpha}$

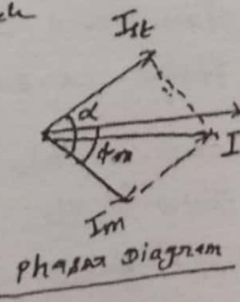
* So due to this starting torque is produc[ed] and motor runs in one particular direction.

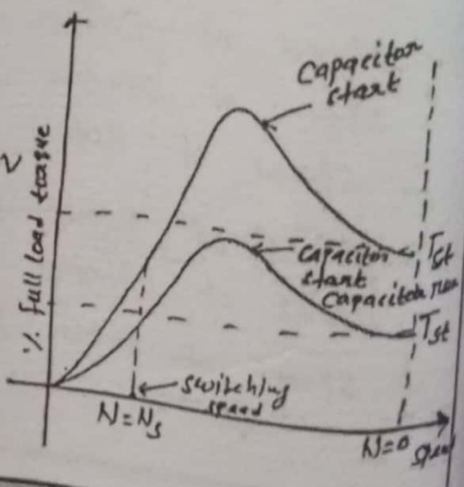
* The auxillary winding has a centrifugal swi[tch] in series with it. So when rotor gain speed upto 70 to 80% of synchronous speed, centrifug[al] switch gets open and starting winding is disconnected.

ii) Capacitor start IM :– It is similar to the resistance split phase. The only difference is there is capacitor in series with Auxillary winding.

* As capacitor draw a leading current. So due to this angle between I_m & I_{st} (α) increases. Hence torque also increases.







Q 24 Explain why synchronous motor is not self starting? How it started? Give the application of synchronous motor.

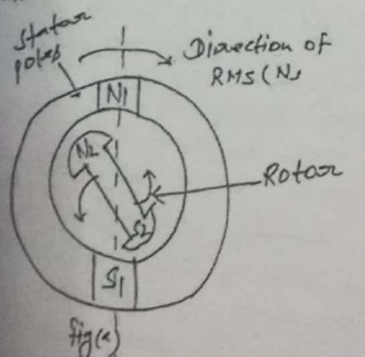
Ans:⇒ WORKING:- Synchronous Motor works on the principle of magnetic locking. When two magnets are brought together, the opposite poles attract each-other and the magnets are magnetically locked.

⇒ Now if one of the magnet is rotated the other magnet also rotates in same direction with the same speed.

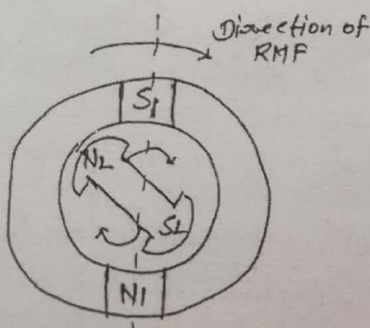
⇒ In synchronous motor 3-ϕ supply is given to 3-ϕ stator winding of stator. So it produces R.M.F (Rotating Pole) which rotates at syn. speed N_s where $\boxed{N_s = \frac{120f}{P}}$

⇒ Now another magnet (electromagnet) is produced by rotor winding. So when DC supply is given to rotor winding, it magnetise the rotor core & produces rotor poles.

⇒ Now if same pole of stator & rotor are brought near each-other, the magnetically locking established b/w them.



fig(a)



fig(b)

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★ Consider a two poles of S.M. having stator poles N_1 & S_1 and poles on rotor is N_2 & S_2

★ Now consider an instant, shown in fig (a). At this instant rotor is stationary & unlike poles will try to attract each-other. So due to this rotor will experience a torque in anticlockwise direction.

★ Now stator poles are rotating very fast (at N_s RPM) so due to inertia of rotor, before rotor hardly rotates in the direction of anticlockwise torque, stator poles changes its position as shown in fig (b)

★ Now again at this instant (fig.b) opposite poles will try to attract each-other and rotor will now experience a clock-wise torque.

★ Due to this the Net torque acting on rotor will be zero & syn. Motor fail to start.

⇒ Methods of starting:-

i) Using pony Motors
ii) Using Damper winding
iii) ~~As~~ a slip-ring I.M.

⇒ Application:-

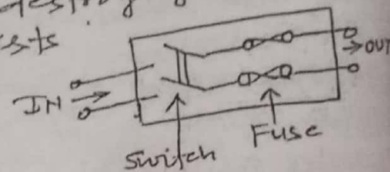
i) Power factor Improvement
ii) Motor-Generator set
iii) synchronous clock
iv) Textile miles, paper mills, rolling mills etc.

UNIT-5

Qno: 25 Write short notes on.
(i) SFU (ii) MCB (iii) MCCB (iv) ELCB (v) Types of wire & cable.

Solution :- (i) SFU (Switch Fuse Unit) :- A Fuse is a protective device which acts quickly in abnormal condition. In abnormal condition, its blows and disconnets the circuit from the supply. Thus, it provides circuit protection by destroying itself.

A unit which consists of the combination of Fuse and switch together is called as Switch Fuse Unit (SFU).



(ii) MCB (Miniature Circuit Breaker) :- A miniature circuit breaker is an electromechanical device which makes and breaks the circuit in normal condition and disconnets the circuit under the normal condition when current exceeds a preset value.

MCB is a high fault capaity current limiting, automatic switching device with thermal and Magnetic operation, to provide protection against overload and short circuit.

Current Rating of MCB is from 0.5A to 63A

(iii) MCCB (Moulded Case Circuit Breaker) :- MCCB is similar to MCB but used when the load current exceeds the capabilities of MCB. It is used for the circuit having current ranges from 63A to 3000 A.

Under normal condition, the contacts are closed but under abnormal condition (overload or short circuit) contacts are opened to interrupt the circuit.

It is working based on thermal mechanism. It has bimetallic contacts which expands when there are changes in temperature.

(iv) ELCB (Earth Leakage circuit Breaker) :- ELCB is used to protect the circuit from the electrical leakage, when someone gets an electric shock, then this circuit breaker cuts of the power at the same time of 0.1 sec for protecting the personal safety against short ckt and overload.

ELCB consists of a small current transformer surrounding live and neutral wire. The secondary winding of CT is connected to Relay circuit which can trip the circuit breaker.

(v) Types of wires :-

(A) Vulcanised India Rubber wire (VIR)

It consists of tinned conductor coated with rubber insulation and is further covered with protective cotton and bitumen compound & finally finished with wax. It is moisture and heat resistant. It is available in single core only.

(B) Cab Tyre Sheathed wire (CTS) :- In this type, ordinary rubber insulated conductors are provided with an additional tough rubber sheath. Also called as Tough rubber sheathed (T.R.S) wire. It provides protection against moisture, chemical, wear & tear. Available in single core, double core & three core

(C) Poly-vinyl chloride wire (PVC) :- Most commonly used wires with PVC insulation. It is tough, non-hygroscopic and moisture proof. It is resistant to corrosion, and chemically inert.

(D) Flexible wire :- It is used very commonly in domestic wiring. It consist of two separately insulated stranded conductors. Insulation is most commonly rubber. Due to its flexible nature, the handling of these wires become very easy.

Types of Cables :- Based on voltage level, the various types of cables are.

(A) **Low Tension Cable** :- used for voltage level upto 6.6kV.

(B) **Medium Tension Cable** :- used for 11kV level and are called Belted cable.

(C) **High Tension Cable** :- used for 22kV and 33kV levels. These are screened type cable.

(D) **Extra High Tension Cable** :- used for voltage level more than 33kV. These are pressure cable. (Oil filled and gas pressure cable).

Based on Core :-

(i) Single Core Cable

(ii) Two Core Cable

(iii) Three Core Cable.

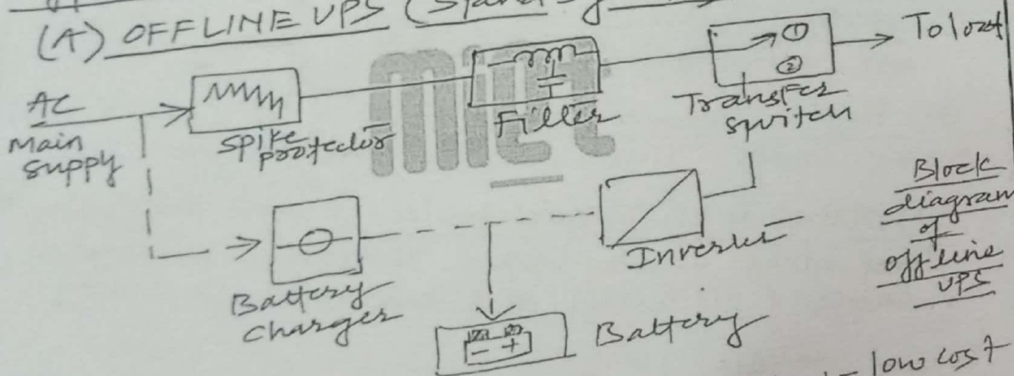
Qno 26.- What is Battery Back-up? What is the difference between on-line and off-line UPS.

Solution :- A Battery backup device is an electronic device that supplies secondary power in the absense of main power. It can also protect electronic hardware from power spikes and fluctuations.

The main Battery Backup device which is commonly used is called Uninterruptible Power supply.

Types of UPS :-

(A) OFFLINE UPS (Stand by UPS)



Block diagram of off-line UPS

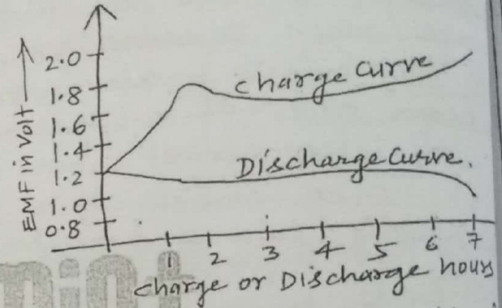
(i) Primary Source : AC Main supply :- low cost
Secondary source : Battery :- Small size.

(ii) Transfer time is ms to μs :- High efficiency

Application :- Modems, office & Home PCs, Small Business centres, Small desktop hubs

Qno:- 27 (A) Draw the Electrical characteristics of Battery.

Solution:- The EMF of a fully charged Nickel Iron Battery is 1.4 volt. The Average discharge voltage is about 1.2V and average charge voltage is about 1.7V per cell.



From the graph, we can see that there is a no lower limit for discharging emf beyond which the output of Battery will be zero.

The emf of a battery is directly proportional to the temp.

(B) An alkaline cell is discharged at a steady current of 4 Ampere for 12 Hours, the average terminal voltage being 1.2V. To Restore it to original state of voltage, a steady current of 3A for 20 hours is Required, the average terminal voltage Being 1.44V. Calculate Ampere hour and watt-hour efficiencies.

Solution:- $I_D = 4A$, $T_D = 12hrs$, $V_d = 1.2V$
$I_C = 3A$, $T_C = 20hrs$, $V_C = 1.44V$

$$\%\eta_{Ah} = \frac{I_D \times T_D}{I_C \times T_C} \times 100 = \frac{4 \times 12}{3 \times 20} \times 100 = 80\%$$

$$\%\eta_{wh} = \frac{I_D \times T_D \times V_D}{I_C \times T_C \times V_C} = \frac{4 \times 12 \times 1.2}{3 \times 20 \times 1.44} = 66.66\%$$