BALASORE SCHOOL OF ENGINEERING

SUBJECT:- ENERGY CONVERSION-II(EET-501)

5TH SEM ELECTRICAL

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CHAPTER- 01

SHORT QUESTIONS AND ANSWER :

1.Q: How can direction of rotation of the 3- ϕ I.M. can be reversed? (2018,w,2(a))

Ans: The direction of rotation of the 3- ϕ I.M. can be reversed by reversing any two terminals of the supply lines.

For example- If supply line is RYB, then if we reversed the rotation of I.M. the terminals should be YRB or RBY.

2. Q: Why are I.M. are called A- Synchronous?(2013)

Ans: Induction motor are called A- Synchronous motor because it does not rotate in Synchronous speed. Its rotor speed is slightly less than the Synchronous speed(N_s) or stator speed.

3.Q: Why rotor slots of a I.M. are not parallels to its shaft but slightly skewed? (2015)

Ans: The rotor slots of an I.M. are slightly skewed to :-

i) reduce the magnetic locking.

ii) to reduce the humming speed.

iii) to increase the starting torque.

4.Q: What is slip? What min. & max. value ?(2013,2014,2015)

Ans: the relative speed difference between the rotating magnetic field (N_s) and rotor speed (N_r) is called slip.

Slip is expressed as:-

$$S = (N_s - N_r) * 100\% / N_s$$

The min. value of slip (S) = 0. (when N_s=N_r)

The max. value of slip (S) = 1. (when N_r=0)

5.Q. What is the measure difference between squirrel cage induction motor and phase hand type induction motor. (2018,w,1(a))

Ans: The motor whose rotor is wound type such type of motor is called slip ring induction motor, whereas the squirrel cage motor, has a squirrel cage type rotor. ... For starting the slip ring motor the rotor resistance starter is used, whereas the slip ring motor does not require any starter.

MEDIUM TYPE QUESTIONS

1.Q: Derive the condition of max. running torque in a 3-ϕ I.M. (2015,2018,w,1(b))

Ans: From the torque equation, it is clear that torque depends on slip at which motor is running. The supply voltage to the motor is usually rated and constant and there exists a fixed ratio between E_1 and E_2. Hence E_2 is also constant. Similarly R_2, X_2 and n_s are constants for the induction motor.

Hence while finding the condition for maximum torque, remember that the only parameter which controls the torque is slip s.

Mathematically for the maximum torque we can write,

$$dT/ds = 0$$

where $T = (k\, s\, E_2^2\, R_2)/(R_2^2 + (s\, X_2)^2)$

While carrying out differential remember that E_2, R_2, X_2 and k are constants. The only variable is slip s. As load on motor changes, its speed changes and hence slip changes. This slip decides the torque produced corresponding to the load demand.

$$T = (k\, s\, E_2^2\, R_2)/(R_2^2 + s^2 X_2^2) \qquad \text{.......Writing } (s\, X_2)^2 = s^2 X_2^2$$

As both numerator and denominator contains s terms, differential T with respect to s using the rule of differentiation for u/v.

$$\therefore \frac{dT}{ds} = \frac{(k\, s\, E_2^2\, R_2)\frac{d}{ds}(R_2^2 + s^2 X_2^2) - (R_2^2 + s^2 X_2^2)\frac{d}{ds}(k\, s\, E_2^2\, R_2)}{(R_2^2 + s^2 X_2^2)^2} = 0$$

$$\therefore \quad k\, s\, E_2^2\, R_2\, (2s\, X_2^2) - (R_2^2 + s^2 X_2^2)(k\, E_2^2\, R_2) = 0$$

$$\therefore \quad 2\, s^2\, k\, X_2^2\, E_2^2\, R_2 - R_2^2\, k\, E_2^2\, R_2 - k\, s^2\, X_2^2\, E_2^2\, R_2 = 0$$

∴ $k s^2 X_2^2 E_2^2 R_2 - R_2^2 k X_2^2 R_2 = 0$

∴ $s^2 X_2^2 - R_2^2 = 0$ Taking $k E_2^2 R_2$ common.

∴ $s^2 = R_2^2/X_2^2$

∴ $s = R_2/X_2$ Neglecting negative slip

This is the slip at which the torque is maximum and is denoted as s_m.

∴ $s_m = R_2/X_2$

It is the ratio of standstill per values values of resistance and reactance of rotor, when the torque produced by the induction motor is at its maximum.

2.Q: Derive the condition of max. starting torque in a 3-ϕ I.M. (2014)

Ans: The torque developed at the instant of starting of a motor is called as starting torque. Starting torque may be greater than running torque in some cases, or it may be lesser.

We know, $T = k_1 E_2 I_2 \cos\phi_2$.

let, R2 = rotor resistance per phase

X2 = standstill rotor reactance

$$Z_2 = \sqrt{(R_2^2 + X_2^2)} \quad = \text{rotor impedence per phase at standstill}$$

then,

$$I_2 = \frac{E_2}{Z_2} = \frac{E_2}{\sqrt{(R_2^2 + X_2^2)}} \quad \text{and} \quad \cos\phi_2 = \frac{R_2}{Z_2} = \frac{R_2}{\sqrt{(R_2^2 + X_2^2)}}$$

Therefore, starting torque can be given as,

$$Tst = k_1 E_2 \frac{E_2}{\sqrt{(R_2^2 + X_2^2)}} \times \frac{R_2}{\sqrt{(R_2^2 + X_2^2)}} = \frac{k_1 E_2^2 R_2}{R_2^2 + X_2^2}$$

The constant k1 = 3 / 2πNs

$$Tst = \frac{3}{2\pi Ns} \frac{E_2^2 R_2}{R_2^2 + X_2^2}$$

Condition For Maximum Starting Torque

If supply voltage V is kept constant, then flux ϕ and E_2 both remains constant. Hence,

$$Tst = k_2 \frac{R_2}{R_2^2 + X_2^2}$$

Hence, it can be proved that maximum starting torque is obtained when rotor resistance is equal to standstill rotor reactance. i.e. $R_2 = X_2$

3.Q: Explain principle of operation of I.M. (2013,2018,w,2(b))

Ans: The I.M. rotates as same as principles of d.c. motor called Lorentz's force. When the rotating magnetic field (N_s) cuts the rotor conductor and as the rotor conductor are short ckted at both ends a current induced in that conductor which has own magnetic field. Due to this a force is created when generates a torque & this torque helps to rotate the rotor in the same direction of N_s . i.e. rotor speed N_r follows the N_s. So there is a relative speed difference between them.

When rotor is at stand still , the speed difference is high but when the rotor starts to rotate, the relative speed difference decreases due to this emf is also decreases. Hence due to decrease the emf the rotor current decreases. There by reducing torque of the rotor. So as the torque of the rotor decreases, the rotor speed slow down & it does not catch up the speed of field flux. This difference is called slip.

4.Q: Explain speed control of I.M. by rotor Rheostatic control method. (2015)

Ans: We know that

$$T \ \alpha \ SE_2^2R_2 / R_2^2 + (SX_2)^2$$

For low slip region $(sx_2)^2 << R_2$ and can neglected. So

$$T \ \alpha \ SR_2 / R_2^2$$

Or $$T \ \alpha \ S / R_2$$

Thus if the rotor resistance is increased, the torque produced decreases. But when the load of the motor is same, motor has to supply same torque. So motor reacts by increasing its slip compensate decrease in torque due to R_2 so due to additional rotor resistance, speed of motor decreases. Thus by increasing rotor resistance R_2 speed below the normal value can be achieved and also starting torque will increase.

But its limitations are:

i) Large speed change are not possible due to large cu. Loss in rotor.
ii) It is only used for slip ring I.M.
iii) Speed above the normal speed can not be obtained.
iv) Due to large power loss , efficiency is low.

LONG TYPE QUESTIONS:

1.Q: Write short notes on speed-torque characteristics of Induction motor.(2014,2018,w,5(b))

Ans: Slip range (S=0 & S=1) in two parts & analyze them independently.

i) low slip region:-

In low slip region, S is very small. Due to this $(SX_2)^2$ is also too small as compared to R_2^2. So it can be neglected.

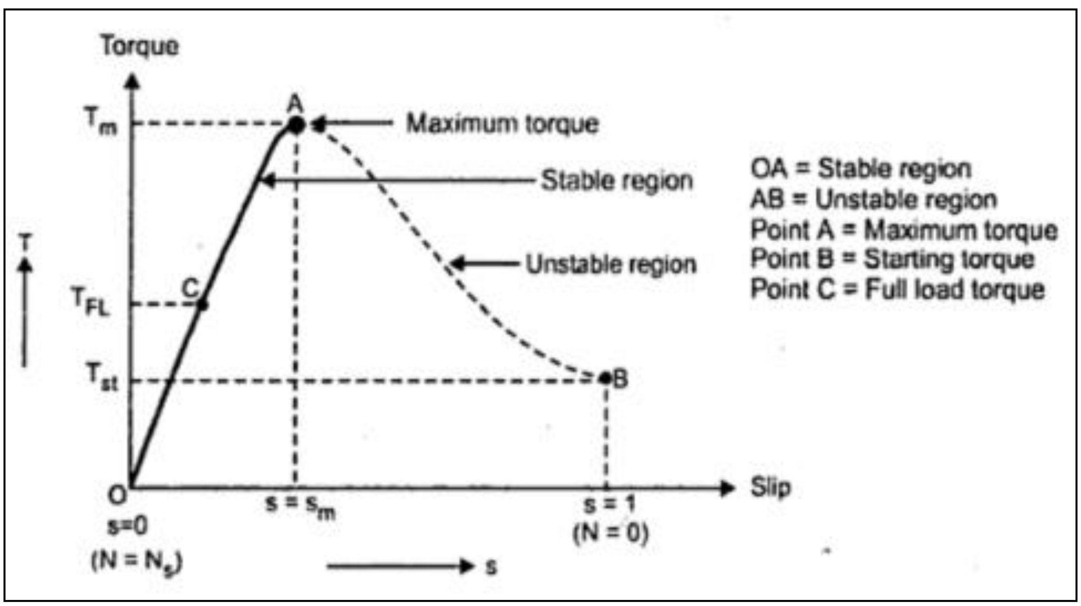
So $T \alpha SR_2 / R_2^2$

$= T \alpha S$ (as R_2 is constant)

Hence in low slip region torque is directly proportional to slip.

So as load increases, speed decreases and slip increases. So torque increases.

Hence the graph is straight line in nature (line OA) which is called stable region.



ii) High sleep region:-

In this region slip is high i.e. slip value is approaching to 1.

Here we can assumed that R_2^2 is very small as compared to $(SX_2)^2$.

So $T \alpha SR_2 /(SX_2)^2$

$$T \ \alpha \ SR_2 / S^2X_2^2$$

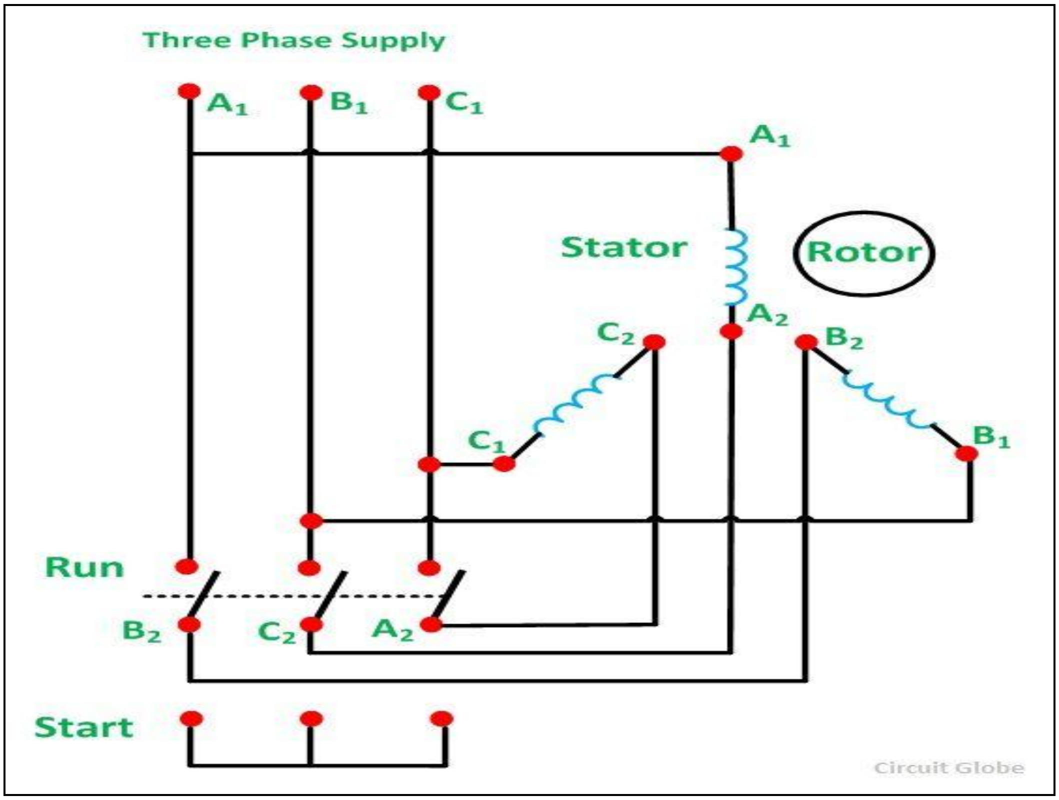
$$T \ \alpha \ 1/S$$

(As R_2 & X_2 are constant)

So in high region torque is inversely proportional to slip. Hence its nature is like rectangular hyperbola (line AB). This region is also called unstable region.

2.Q: Write the short notes on starting of squiral case motor by Star-delta starter. (2013,2015)

Ans: This is the cheapest starter of all and hence used very commonly for I.M. It uses Triple Pole Double through (TPDT) switch. The switch connects the starter winding in star at start.



Hence perphase voltage get reduced by the factor $1/\sqrt{3}$. Due to this reduced voltage starting current is limited.

When is thrown to other side the winding get connected in delta. So it gets normal ratted voltage. The winding are connected in delta when motor gathers sufficient speed. The cheapest of all and maintenance free operation are two important advantages of this starter.

3.Q: Briefly discuss speed control of induction motor. (2013,2014)

Ans:- A 3-phase I.M. is practically a constant speed motor like a d.c. shunt motor. But in case of 3-ϕ I.M. is very difficult to achieve smooth speed control.

We know that

$$N_r = N_s (1-S).$$

From this expression, it can be seen that the speed of I.M. can be changed either by changing synchronous speed(N_s) or by changing slip(S).

Similarly

$$T \ \alpha \ SE_2^2R_2 / R_2^2 + (SX_2)^2$$

So as parameter like R_2, E_2 are changed, then keep the torque constant for constant load condition.

Thus the speed of the I.M. can be controlled by basically two methods.

i) From starter side
ii) From rotor side.

From starter side , it includes following method.

i) Supply frequency control called v/f control.
ii) Supply voltage control.
iii) Controlling number of sector poles.
iv) Adding Rheostats in starter ckt.

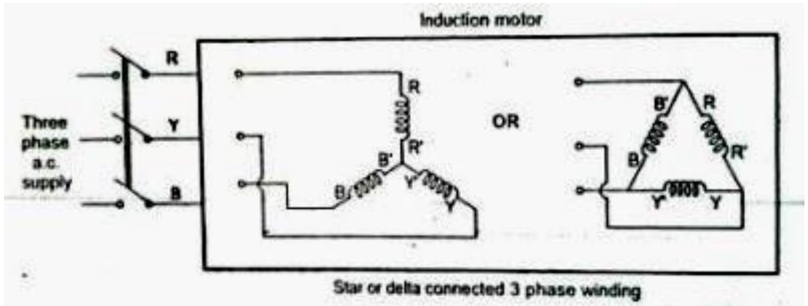
From rotor side, it includes:

i) Adding external resistance in rotor ckt.
ii) Cascade control
iii) Injecting slip frequency voltage into rotor ckt.

4. Q: Explain how 3-phase supply produced a rotating magnetic field.(2018,w,1(c))

Ans:- The production of Rotating magnetic field in 3 phase supply is very interesting. When a 3-phase winding is energized from a 3-phase supply, a rotating magnetic field is produced. This field is such that its poles do no remain in a fixed position on the stator but go on shifting their positions around the stator. For this reason, it is called a rotating field. It can be shown that magnitude of this rotating field is constant and is equal to 1.5 fm where fm is the maximumflux due to any phase.

A three phase induction motor consists of three phase winding as its stationary part called stator. The three phase stator winding is connected in star or delta. The three phase windings are displaced from each other by 120°. The windings are supplied by a balanced three phase ac supply.



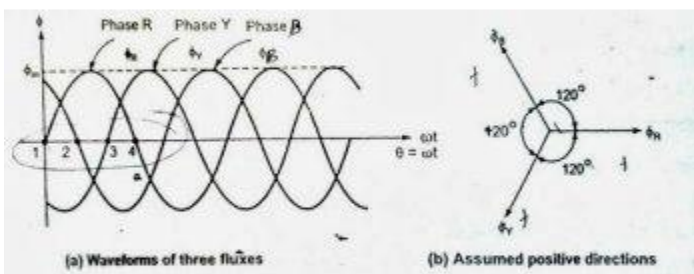
The three phase currents flow simultaneously through the windings and are displaced from each other by 120° electrical. Each alternating .phase current produces its own flux which is sinusoidal. So all three fluxes are sinusoidal and are separated from each other by 120°. If the phase sequence of the windings is R-Y-B, then mathematical equations for the instantaneous values of the three fluxes ΦR , ΦY ,ΦB can be written as,

$\Phi R = \Phi m \sin(\omega t)$

$\Phi Y = \Phi m \sin(\omega t - 120)$

$\Phi B = \Phi m \sin(\omega t - 240)$

As windings are identical and supply is balanced, the magnitude of each flux is Φm .



Case 1 : ωt = 0

$\Phi R = \Phi m \sin(0) = 0$

$\Phi Y = \Phi m \sin(0 - 120) = -0.866\ \Phi m$

$\Phi B = \Phi m \sin(0 - 240) = +0.866\ \Phi m$

Case 2 : ωt = 60

$\Phi R = \Phi m \sin(60) = +0.866\ \Phi m$

$\Phi Y = \Phi m \sin(- 60) = -0.866\ \Phi m$

$\Phi B = \Phi m \sin(- 180) = 0$

Case 3 : ωt = 120

ΦR = Φmsin(120) = +0.866 Φm

ΦY = Φmsin(0) = 0

ΦB = Φmsin(- 120) = -0.866 Φm

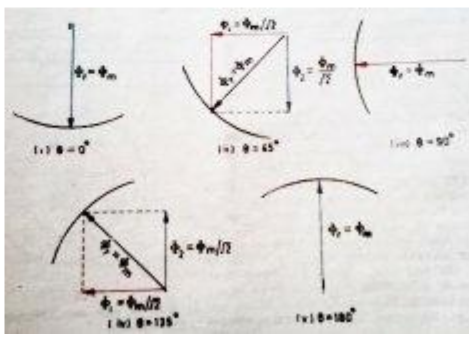
Case 4 : ωt = 180

ΦR = Φmsin(180) = 0

ΦY = Φmsin(60) = +.866 Φm

ΦB = Φmsin(- 60) = -0.866 Φm

By comparing the electrical and phasor diagrams we can find the the flux rotates one complete 360 degree on the 180 degree displacement of flux.



5.Q: For a 3-phase slip ring I.M., the max. torque is 2.5 times the full load torque and the starting torque is 1.5 times the full load torque. Determine the percentage reduction in rotor circuit resistance to get a full load slip of 3%. Neglect starter impedance. (2014)

Ans:- Given that $T_{max} = 2.5T_f$

& $T_{st} = 1.5T_f$

$T_{st} / T_{max} = 1.5/2.5 = 3/5$

Now $T_{st} / T_f = 3/5 = 2a / 1+a^2$

Or $3a^2 - 10a + 3 = 0$

Or $a = 1/3$

Now $a = R_2 / X_2$ or $R_2 = X_2 /3$

When full load slip is 0.03

$T_f / T_{st} = 2aS / a^2 + S^2$

Or $2/2.5 = 2a * 0.03 / a^2 + 0.03^2$

Or $a^2 - 0.05a + 0.009 = 0$

Or a= 0.1437

If $R_2^{'}$ is new rotor ckt resistance then

$R_2^{'} = 0.1437X_2$

So percentage reduction in rotor ckt resistance is

$((x_2/3) - 0.1437*(X_2) / (x_2/3))*100 = 56.8\%$

6.Q: A 20kw, 4-pole, 50hz, 3-ϕ I.M. has friction & windage loss of 3% of the input. The full load speed of the motor is 1440 r.p.m. Find for full load.a) the rotor copper loss b)the rotor input c)shaft torque d) Gross electromagnetic torque.(2014)

Ans:-

Motor output, P_{out}=20kw=20000w

Friction & windage loss, P_w=3% of 20kw= 600w.

Rotor gross output, P_m= 20000+600= 20600w.

The synchronous speed. $N_s = \frac{120f}{P} = \frac{120\times50}{4}$ =1500r.p.m.

$\%slip = \frac{Ns-Nr}{Ns} = \frac{1500-1400}{1500} = 0.04 = 4\%$

a) Rotor cu. Loss / Rotor gross output = S / 1-S
   Or rotor cu. Loss = (0.04 / (1-0.04)) * 20,600 = 858.3 w

b) Rotor input P_2 = Rotor cu. Loss / S
   = 858.3 / 0.04 = 21,458.3 w

c) Shaft torque, $T_{sh} = 9.55\ P_{out} / N$
   = 9.55*20,000 /1440 =132.63 N-m

d) Gross electromagnetic torque $T_g = 9.55*P_M / N$
   = 9.55*20,600/1440 = 136.61 N-m

CHAPTER- 02

SHORT QUESTIONS AND ANSWER :

1.Q: What is the advantages of open type slot in starter in alternator.(2015)

Ans: The advantages of open type slot are :

i) The winding can be easily placed into the slot of the armature.
ii) Tooth loss decreases.

2.Q: Calculate the pitch factor for the windings which has 36 slots, 4 poles and coil span is 1 to 7.(2018,w,5(a))

Ans: P=4,S=36, slot angle=180*P/S = 180*4/36 = 20^0

Coil span is 1 to 7=7-1=6

β =6*20^0=120^0

α = 180- β= 180 – 120 =60^0

Cos $\alpha/2$ = Cos $60^0/2$ = Cos 30^0 = 0.866

3.Q: What are the condition of parallel operation of alternator. (2018,3(a))

Ans:

i) The terminal voltage of incoming machine must be same as that of bus-bar voltage.
ii) The frequency must be same as that of incoming machine with bus-bar.
iii) The phase of alternator voltage must be identical with phase of bus-bar voltage.

4.Q:- Which type of alternator is used in thermal power plant? (2013)

Ans:- Non-Salient pole type alternator is used in thermal Power plant.

5.Q:- What is the voltage regulation of alternator? (2014)

Ans:- the voltage regulation of an alternator is defined as the charge in terminal voltage from no-load to full-load, divided by full load voltage.

$$\% \text{ Regulation} = \frac{E_0 - V}{V} \times 100$$

6.**Q. What is Hunting? (2018,w,4(a))**

Ans:- If the driving torque applied to an alternator is pulsating such as that produced by a diesel engine, the alternator rotor may be pulled periodically ahead of or behind its normal position as it rotates. This oscillating action is called **hunting**.

MEDIUM TYPE QUESTIONS

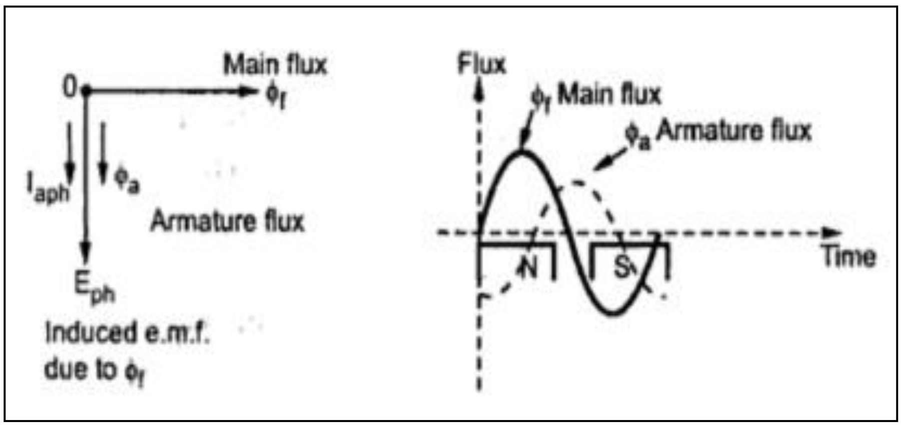
1.Q:- What is armature reaction of alternator. Explain with phase or diagram the effect of generated voltage when load is i) resistive ii) Inductive iii) Capacitive. (2018,w,6,(c))

Ans:-

i) **Unity P.F. load:- (Resistive load)**

Consider a purely resistive load connected to the alternator, having unity power factor. i.e. E_{ph} and I_{ph} are in phase.

If ϕ_f is the main flux produced by the field wog responsible for producing E_{ph} than E_{ph} lags ϕ_f by 90°



Now current through armature I_a produces armature flux ϕ_a. So ϕ_a and I_a are always in phases in same direction.

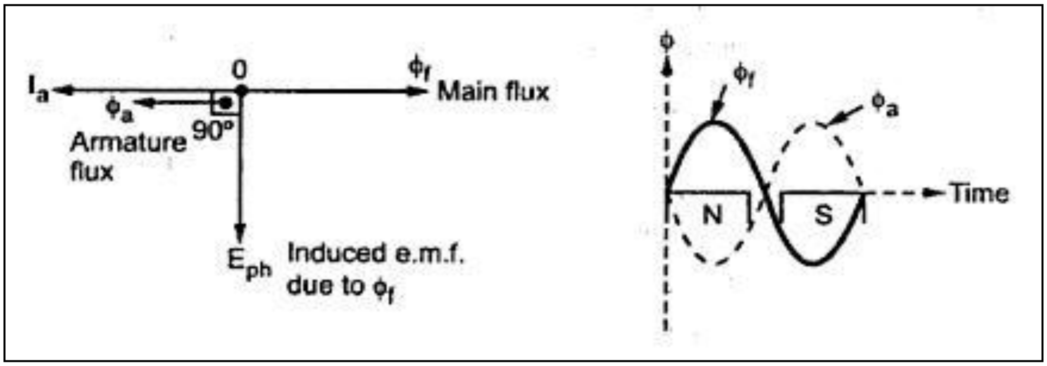
It is seen that there exist a phase difference of 90° between ϕ_a and ϕ_f. from the wave from it is seen that the two fluxes opposes each other on the left half's and assist each other at right half of each pole. Hence arrange flux is constant but its flux distribution gets distorted.

"Such distortion effect on armature reaction under unity p.f. is called cross magnetizing effect."

Due to this small voltage drop will occur at the terminals of alternator.

II) **Zero lagging P.F. :- (Inductive load)**

Consider a pure Inductive load connected to the alternator having zero having zero lagging p.f. This indicates that I_a is lags by E_{ph} by 90°.

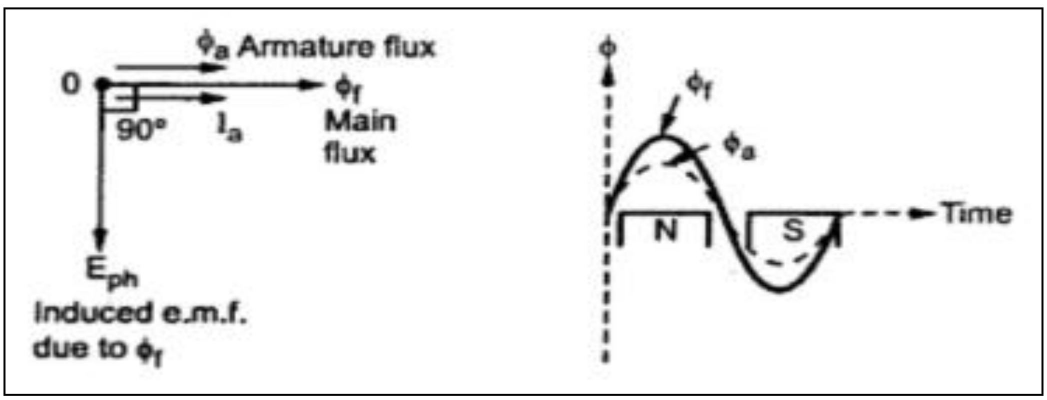


It is seen from phasor diagram that ϕ_f and ϕ_a are exactly in opposite direction to each other.

" So armature flux tries to cancel the main flux, such an effect of armature reaction is called de-magnetizing effect."

As this effect causes reduction in the main flux, the terminal voltage drops. This drop is higher than unity p.f.

III) **Zero leading P.F.:- (Capacitive load)**



Consider a pure capacitive load having zero loading p.f. connected to alternator. This means that $I_{a\ ph}$ is leads E_{ph} by 90°.

It can be seen from the phasor diagram and wave from that the armature flux and the main flux are in the same direction. i.e. they are helping each other .This results in to the addition in main flux.

" Such an effect of armature reaction due to which armature flux assists field flux is called magnetizing effect of armature reaction."

2.Q:- Derive the emf eq^n of alternators.(2013,2014,2015)

Ans:- Let Z= no. of armature conductors in series phase= 2T.

ϕ = flux per pole

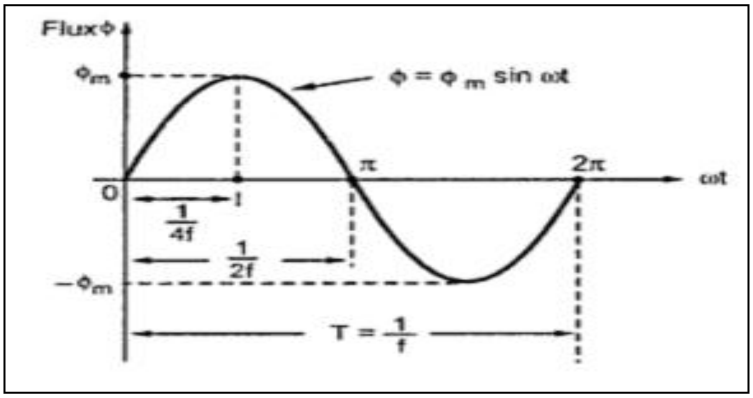
K_p = pitch factor

K_d = distribution factor.

f = frequency in Hz.

E = rms value of voltage.

N = speed in rpm.



$d\phi=\phi_m$, $dt = T/4 = \frac{1}{4f}$.

According to Faraday's laws of induction, the average induced in one conductor: - e = $\frac{d\phi}{dt} = \frac{\phi m}{1/_{4f}}$

= $4f\phi_m$.

Rms value of induced emf = form factor X e

= $1.11\times 4f\phi_m$ volt.

For short pitched distributed winding:-

E = $4.44\ K_pK_df\phi_m$ volt.

$E_{line}= \sqrt{3}\times 4.44\ K_pK_df\phi_m$

3.Q. Derive the expression for distribution factor of an alternator.(2018,w,4(b))

Ans: **Definition**

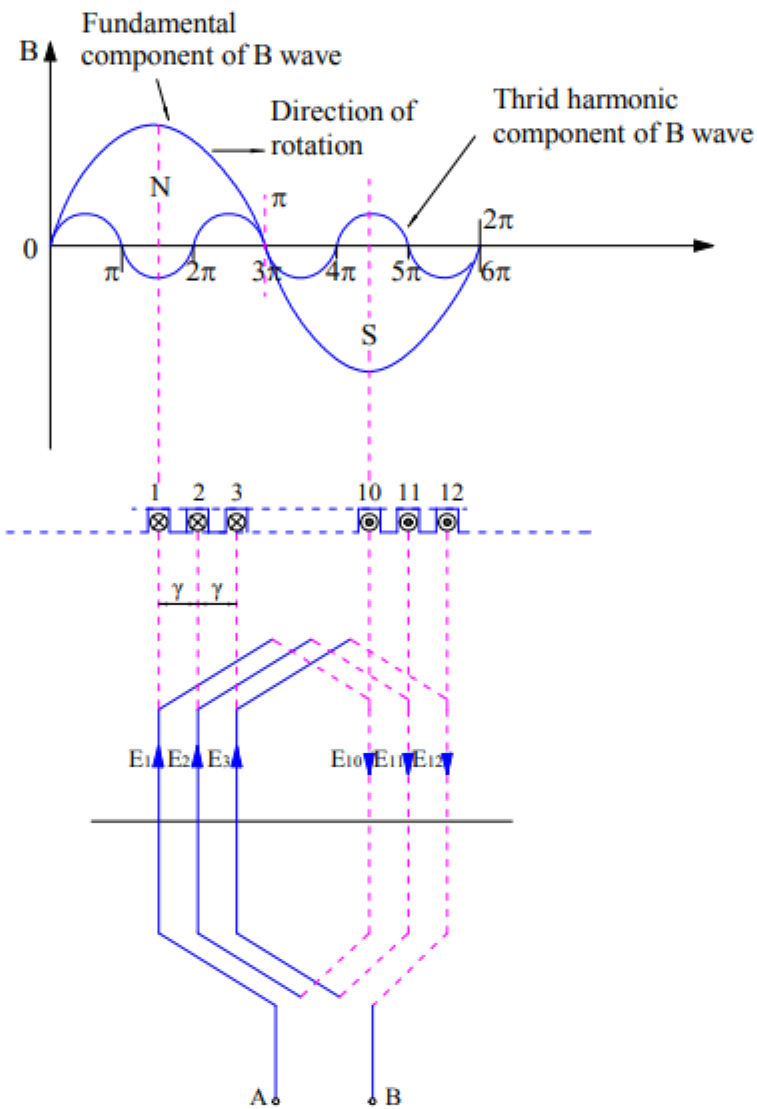
Distribution factor is defined as the ratio of phasor sum of coil emfs to the arithmetic sum of coil emfs. It is also known as Belt or Breadth factor and denoted by k_d.

Calculation of Distribution Factor

To get a general expression or formula of distribution factor, let us assume a 2 pole, 3 phase electrical machine having a total of 18 slots in its stator. These slots are distributed along the periphery of stator in 2 pole pitches. Therefore the angle between any two consecutive slots will be equal to 20 degree (2×180 / 18 = 20). This angle between two consecutive slots is called ***Angular Slot Pitch***. It is in electrical degree not in mechanical degree.

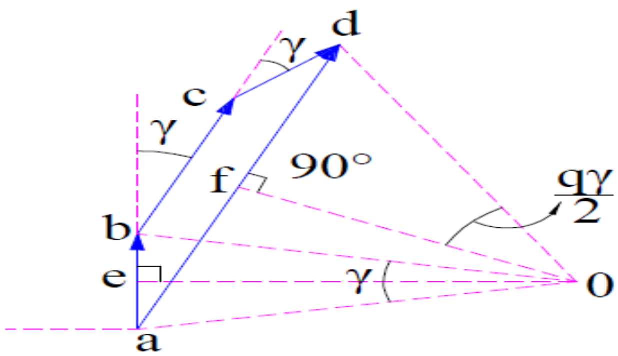
Angular Slot Pitch = (Number of Poles x 180) / Number of Slots

Thus angular slot pitch for our example is 20 degree. The number of slots per pole per phase will be 3 [(18/2)/3 = 3]. This means that a particular phase will consists of three coils distributed in three slots under a single pole. This is shown in figure below.



In the above figure it can be seen that, coils are distributed in slot number 1,2,3 and 10,11,12. It can also be observed that, coil sides are connected in series in such a way that emf induced in coil side at 1 and 10 are additive. This means, if E_1 and E_{10} are the emf induced in respective coil sides then the total emf induced will be E_1+E_{10}. Similarly, if the emf induced in coil sides 2 and 11 are E_2 & E_{11}, then the total emf in coil 2-11 is given as arithmetic sum of E_2 and E_{11}.

Thus the total emf at the coil terminal A & B is the phasor sum of (E_1+E_{10}), (E_2+E_{11}) and (E_3+E_{12}). Let us assume (E_1+E_{10}) as reference phasor and draw the phasor diagram of the above three emf to get the total emf available at terminal AB.



In the above phasor, ab represents (E_1+E_{10}). Since the slots are displaced from each other by angular slot pitch of γ (in our example, it is 20 degree), this means the emf induced in coil 2-11 will be displace by an angle of γ from reference phasor ab. This is shown by 'bc' in above phasor. Similarly, 'cd' represents the emf induced in coil 3-12 and is displaced by reference phasor by and angle of 2γ.

Thus the total emf across terminals AB of coil will be the phasor sum of ab, bd and cd which is equal to 'ad'. Let us now calculate this phasor sum.

Since ab, bc and cd are lying in stator slot, therefore their perpendicular bisector must meet at the centre of the circle. Let us now draw perpendicular bisector oe and of on ab and ad respectively as shown in above figure. In general, the angle aob should be equal to angular slot pitch γ, angle aod equal to qγ and angle aof equal to (qγ/2) where q is number of slots per pole per phase.

In right angled triangle aoe,

$\sin(\gamma/2) = ae / oe$

$ae = oe\sin(\gamma/2)$

Thus, $ab = 2oe\sin(\gamma/2)$ as oe is perpendicular bisector of ab.

Therefore, if the coil were concentrated then the emf across coil terminal AB would have been arithmetic sum of emf. This is given as

Emf per coil = Number of slots per pole per phase x $2oe\sin(\gamma/2)$

$= 2q(oe)\sin(\gamma/2)$

Now, in right angled triangle aof,

Sin(qγ/2) = af / oa

af = (oa)Sin(qγ/2)

Hence the resultant emf ad equal to the phasor sum of ab, bc and cd is given as

ad = 2(oa)Sin(qγ/2)

Therefore as per the definition of distribution factor,

Kd = Phasor Sum of Coil emf / Arithmetic sum of coil emf

= ad / q ab

= [2(oa)Sin(qγ/2)] / [2qoeSin(γ/2)]

= **Sin(qγ/2) / qSin(γ/2)**

Thus the formula for distribution factor is given as below.

$$\text{Distribution Factor } K_d = \sin(q\gamma/2) \,/\, q\sin(\gamma/2)$$

where q is number of slots per pole per phase and γ is angular slot pitch.

3.Q. What do you mean by voltage regulation?How do you find the regulation of alternator by synchronous impedance method.(2018,w,4(b))

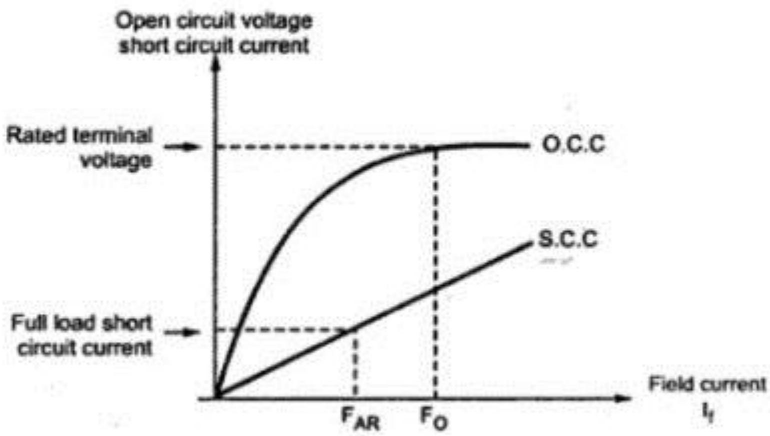
Ans: Voltage Regulation :- The voltage regulation of an alternator is defined as the change in its terminal voltage when full load is removed, keeping field excitation and speed constant, divided by the rated terminal voltage. The value of the regulation not only depends on the load current but also on the power factor of the load.

$$\text{Percentage Voltage Regulation} = \left(\frac{|E_0| - |V|}{|V|}\right)$$

The Synchronous Impedance Method or Emf Method is based on the concept of replacing the effect of armature reaction by an imaginary reactance. The method requires following data to calculate the regulation.

1. **The open -circuit characteristic (O.C.C) :**

- The O.C.C is a plot of the armature terminal voltage as a function of field current with a symmetrical three phase short-circuit applied across the armature terminals with the machine running at rated speed.
- At any value of field current, if E is the open circuit voltage and Isc is the short circuit current then for this value of excitation
  - Zs = E/Sic
- At higher values of field current, saturation increases and the synchronous impedance decreases.
- The value of Zs calculated for the unsaturated region.
- The O.C.C is called the unsaturated value of the synchronous impedance.



2. **The short-circuit characteristic (S.C.C)**

- The S.C.C is a plot of short-circuit armature current versus the field current.
- The current range of the instrument should be about 25-50 % more than the full load current of the alternator.
- Starting with zero field current, increase the field current gradually and cautiously till rated current flows in the armature.
- The speed of the set in this test also is tom be maintained at the rated speed of the alternator.

3. **Resistance of the armature winding.**

- Measure the D.C. resistance of he armature circuit of the alternator.
- The effective a.c resistance may be taken to be 1.2 times the D.C. resistance.

Regulation Calculation

- From O.C.C. and S.C.C., Z_s can be determined for any load condition.
- The armature resistance per phase can be measured by different methods.

- One of the method is applying d.c. known voltage across the two terminals and measuring current. So value of R_a per phase is known.

$$Xs = \sqrt{Zs^2 - Ra^2}$$

So synchronous reactance per phase can be determined.

- No load induced e.m.f. per phase, E_{ph} can be determined by the mathematical expression derived earlier.

$$Eph = [\sqrt{I(V\cos\varphi + IRa)^2 + I(V\sin\varphi + IXs)^2}]$$

where V_{ph} = Phase value of rated voltage
I_a = Phase value of current depending on the load condition
$\cos\Phi$ = p.f. of load

- Positive sign for lagging power factor while negative sign for leading power factor, R_a and X_s values are known from the various tests performed.

The regulation then can be determined by using formula,

$$\text{Percentage Voltage Regulation} = \left(\frac{|E_0| - |V|}{|V|}\right)$$

LONG TYPE QUESTIONS

1.Q:- Write short circuit and open circuit test of an alternator ? (2013)

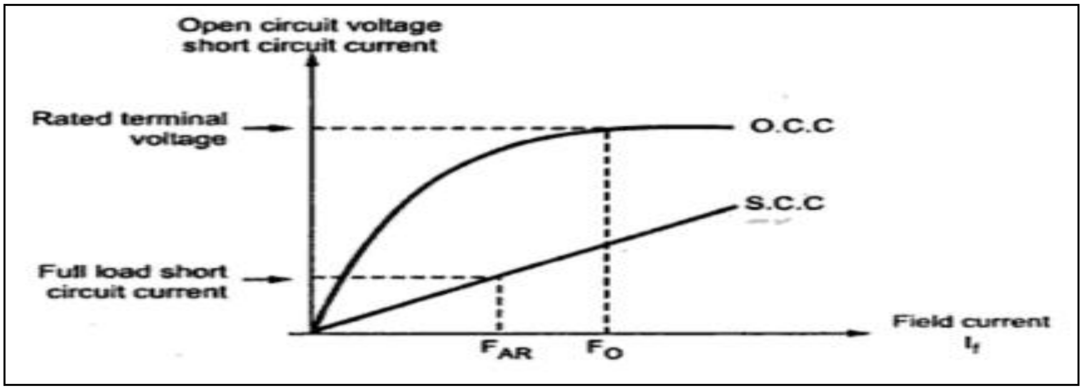
Ans:-

Open ckt test:-

The procedure for open ckt test is as follows:

i) Short the prime mover and adjust the speed to synchronous speed.
ii) Keeping rheostat in the field ckt max. switch on the d.c. supply.
iii) The TPST switch in the armature ckt is kept open.
iv) With the help of rheostat, the field current is varied from its minimum value to rated value. Due to this flux increases, thus induced e.m.f. increases and armature reading gives the field current.

From this two reading of various value, graph of $(V_{oc})_{ph.}$



Short ckt test :-

After completing open ckt test

i) The field rheostat is brought to max. Position, reducing field current to a minimum value.

ii) Close the TPST switch. As the ammeter has negligible resistance, the armature gets short ckted.

iii) Then the field excitation gradually increased till full load current is obtained through armature winding. This can be observed on ammeter.

iv) Now for different value of I_f and $I_{sc,}$ we can plot the graph of S.C.C.

2.Q:- Explain the parallel operation of 3-phase alternator by dark and bright lamp method. (2013)

Ans:-

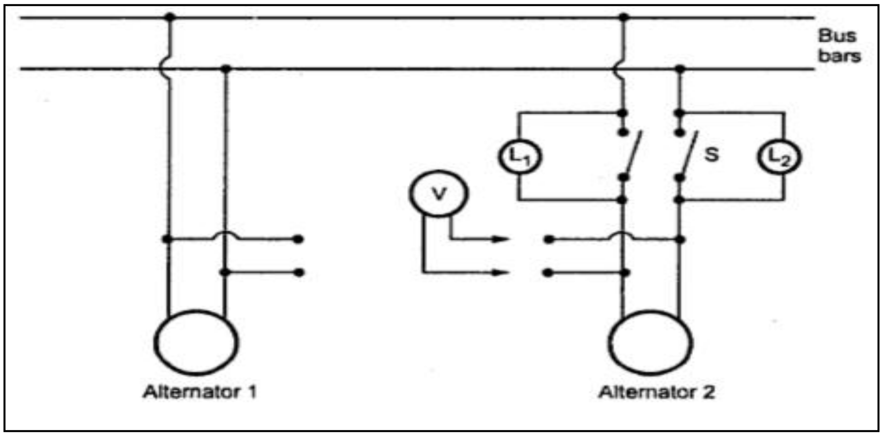
The parallel operation can be done by two ways.

I) Dark lamp method.

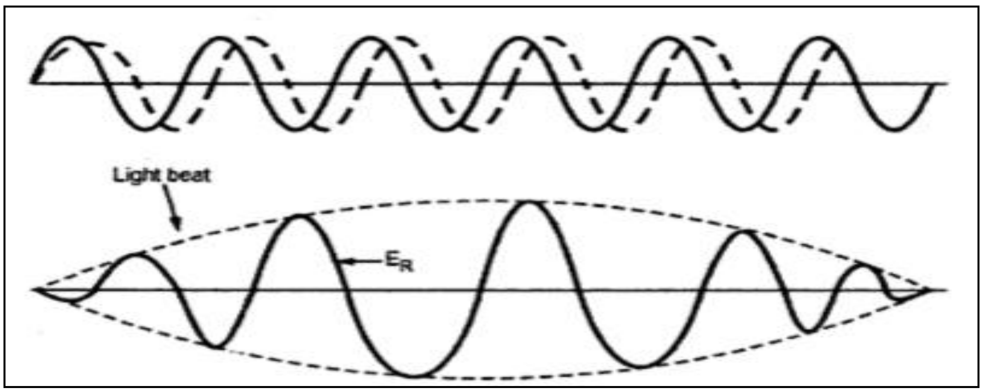
II) Bright lamp method.

I) Dark lamp method:-

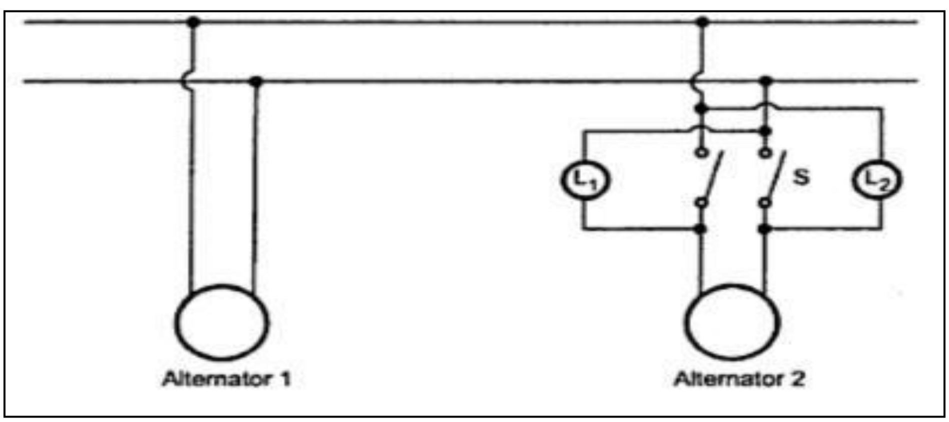
In this method, the lamps are arranged as shown above figure. The alternator to be synchronized, which consist of two lamps connected across the switch terminal of same phase.



The lamps are connected in such a way that the polarity and frequency of two m/c can be checked. When the frequency is exactly same and voltage is just phase opposition to each other, so no resultant emf. Under this condition lamp will not glow and at that moment, the switch is closed for parallel operation.



Bright lamp method:-



Since it is very difficult to judge the correct instant of zero voltage in lamps dark method. So it is used for synchronization of two alternator. This is more sharp and accurate method of synchronization because the lamps are much more sensitive to change in voltage at their maximum brightness than when they are dark.

3.Q:- Write briefly parallel operation of 3-phase alternator? (2015)

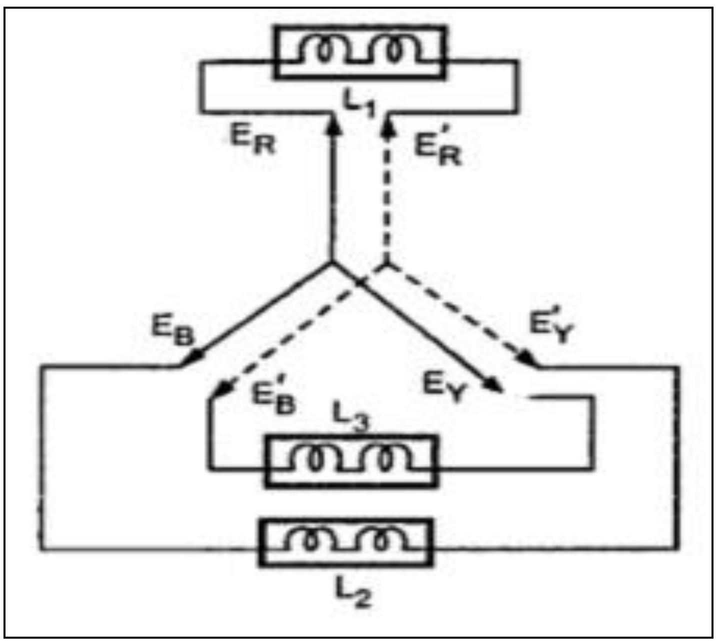
Ans :-

Parallel operation of 3-phase alternator:-

Consider two alternator A & B to be synchronized. The alternator A is already running at synchronous speed and is connected to bus-bar of constant voltage and frequency. The alternator "B" is connect to bus-bar and it's process of synchronization can be explained below.

Step – 1: start the prime mover the m/c. Adjust its speed to a synchronous speed of m/c- B.

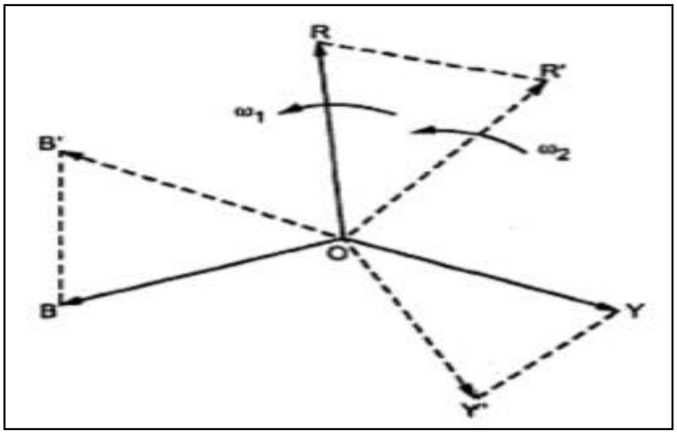
Step -2: By adjusting the excitation to field by the help of rheostat. The induced emf of 'B' is equal to the induced emf of 'A'.



Step -3: By verifying remaining condition, three lamps are used (L_1,L_2 & L_3) as shown above.

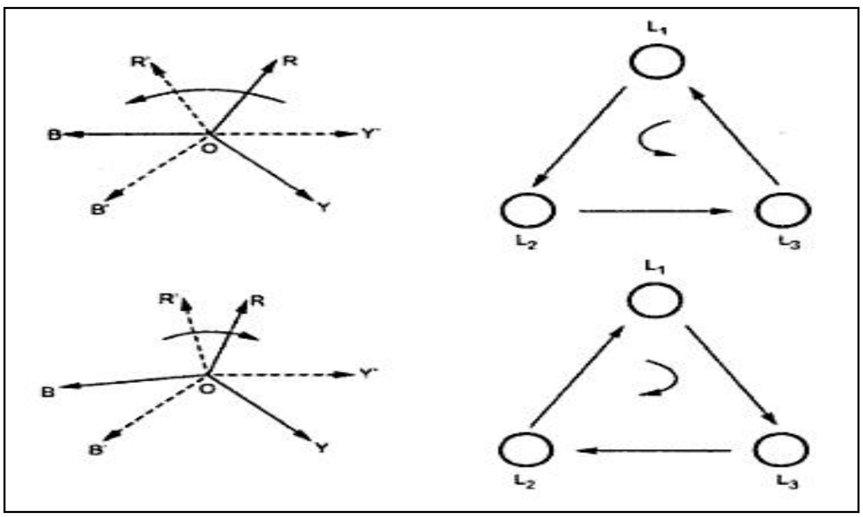
Let the three bus-bar voltage are represented by phasor OR , OY & OB rotating at a angular speed of W_1 rad/sec. And the coming m/c voltage are represented by OR',OY', OB', rotating at W_2 rad/sec.

The phasor sum E_{rr}, joining the tips R & R' is voltage across lamp pair L_1. Similarly $E_{YB'}$ and $E_{BY'}$ are voltage across lamp L_2 and L_3 respectively.



If there difference between two frequencies due to different in speed, the lamp will become dark and bright in a sequence. This sequence tells whether incoming m/c frequency is less or greater than m/c-A.

The sequence L_1, L_2, L_3 tells that m/c-B is faster, but the sequence L_3, L_2, L_1 tells that m/c-B is slower than m/c-A.



So the prime mover speed can be adjust accordingly to match the frequency.

So in this method when lamp L_1 is dark and other two lamps L_2 & L_3 are equally bright, at that moment, synchronizations done. So this method is called "Bright and Dark lamp" method.

4.Q:- A 3-ϕ,10 pole, Y- connected alternator runs at 600 rpm. It has 120stator slots with 8 conductors of each phase are connected in series. Determine the phase and line emf, if the flux per pole is 56 mwb. Assume full pitch coil.(2014)

Ans :- We know that

$f = PN/120 = 10*600/120 = 50hz$

since K_c is not given, it would be taken as one.

n = 120/10 = 12

β = 180°/12 = 15°

m = 120/10*3 = 4

K_d = sin4*(15°/2) / 4sin(15°/2) = 0.5 /0.52 = 0.95

Z = 120*8/3 = 320

T = 320/2 = 160/ph

E_{ph} = 4.44*1* .95*50*56*10^{-3}*160 = 1889.6v

Line voltage E_L = √3 * E_{ph} = 3272.8v

5.Q:- In a 50kva, star connected, 440v,3-phase 50 Hz alternator, the effective armature resistance is 0.25Ơ Ω/phase. The synchronous reactance is 3.2 Ω/phase & leakage reactance is 0.5 Ω/phase. Determine at ratted load and unity p.f. (2014)

a) Internal emf E_a.

b) No-load emf E_0.

c) Percentage regulation on full load.

d) voltage of synchronous reactance which replace armature reaction.

Ans:-

a) V = 440/√3 = 254v
F.L. out put current at u.p.f. is
50,000 / √3*440 = 65.6A
Resistive drop = 65.6*0.25 = 16.4v = IR_a
Leakage reactance drop = IX_L = 65.6 * 0.5 = 32.8v
So $E_a = \sqrt{(V+IR_a)^2+(IX_L)^2} = \sqrt{(254+16.4)^2+(32.8)^2}$ = 272
So line value = √3*272 = 471v

b) $E_o = \sqrt{(V+IR_a)^2+(IX_S)^2} = \sqrt{(254+16.4)^2+(65.6*3.2)^2}$=342v
So line value = √3* 342= 592v

c) % regulation 'up' = (E_o – V)/V *100 = 342-254/254 *100 = 34.65%

d) $X_a = X_s – X_L$ = 3.2 – 0.5 =2.7 ohm

CHAPTER- 03

SHORT QUESTIONS AND ANSWER :

1.Q: What is load angle 'α' in case of synchronous motor ?(2015)

Ans :- When a s.m. is given load than the rotor pole falls behind its corresponding opposite stator pole. This is called load angle 'α'.

2.Q:- Mention some specific application of synchronous motor. (2014)

Ans :- Voltage regulator, Synchronous condensers, constant speed drives etc.

3.Q:- What factors determines the number of poles of a s.m. (2013)

Ans :- The factors to determines the number of poles are

i) The stator & rotor poles should be same number.

ii) The speed of the synchronous motor.

LONG QUESTIONS

1.Q:- Explain how the power factor becomes loading when 3-ϕ synchronous motor operates at over excited conditions.

Or

Explain with vector diagram how a synchronous motor can be operated as a synchronous condenser.

Ans :- An over-excited synchronous motor running at no-load is called synchronous condenser.

All the industrial loads are inductive in nature. So the draw more current at low p.f. It leads to poor efficiency & voltage regulation.

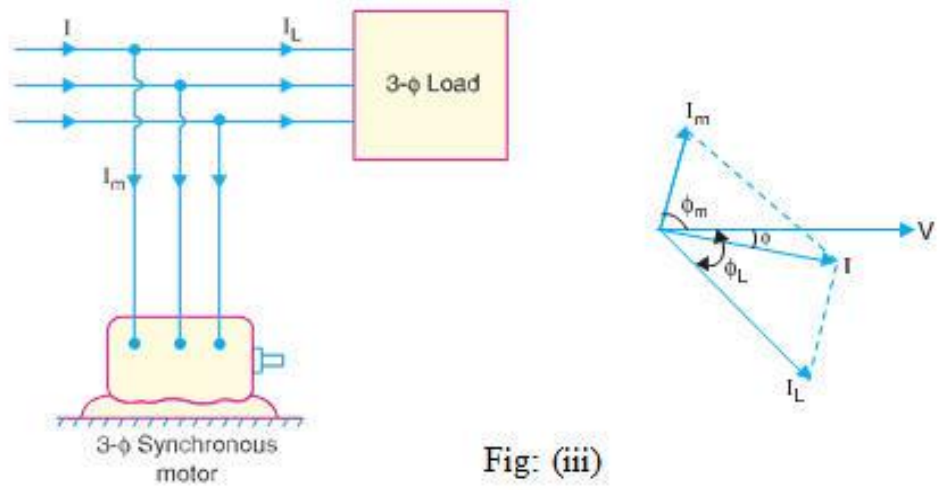


Fig: (iii)

An over-excited synchronous motor at no load when connected in parallel to the inductive load on the system will draw line current at improved p.f.

As shown in the vector diagram, I_m is the motor current at leading p.f. along with it, the load current I_L will draw resultant current I. The p.f. angle Iϕ is less than ϕ_L. So p.f. is improved and I decreases than I_L. So, losses voltage drop is decreased.

Advantages:

I) Step less control of power factor.
II) High thermal stability to short circuit currents.
III) Faults can be removed easily.

Disadvantages:

I) There are considerable losses in motor.
II) The maintenance cost is high.
III) It produces noise.
IV) For starting synchronous motor, auxiliary arrangements are required.

2.Q:- Explain effect of changing excitation on constant load.(2013,2015,2018)

Ans :-

Effect of varying Excitation with constant load.

We have seen that with constant excitation with load changes current drawn by the motor increases.

But if excitation i.e. field current is changed keeping load constant, s.m. reacts by changing its power factor of operation.

At start, consider normal excitation motor drawing certain current I_a & the power factor is logging. Now when excitation is change, so it E_b also changes but the power input is constant as load constant.

Now $P_{in} = \sqrt{3}V_L I_L \cos\phi = \sqrt{3}V_{ph} I_{ph} \cos\phi$

Most of the time voltage applied motor is constant. Hence for constant power input as V_{ph} is constant, $I_{ph}\cos\phi$ remain constant.

i) UNDER EXCITATION:-

The motor is said to be under excited, if field excitation is such a way that $E_b < V$. Under such condition, the current I_a lags. Behind V, so that power factor is lagging. As shown in the figure(1). Since $E_b < V$, the net voltage E_r decreases & turn clockwise angle $'\theta'$ between E_r & I_a is constant, therefore phasor I_a also turns clockwise. Consequently, the motor has a lagging p.f.

ii) NORMAL EXITATION:-

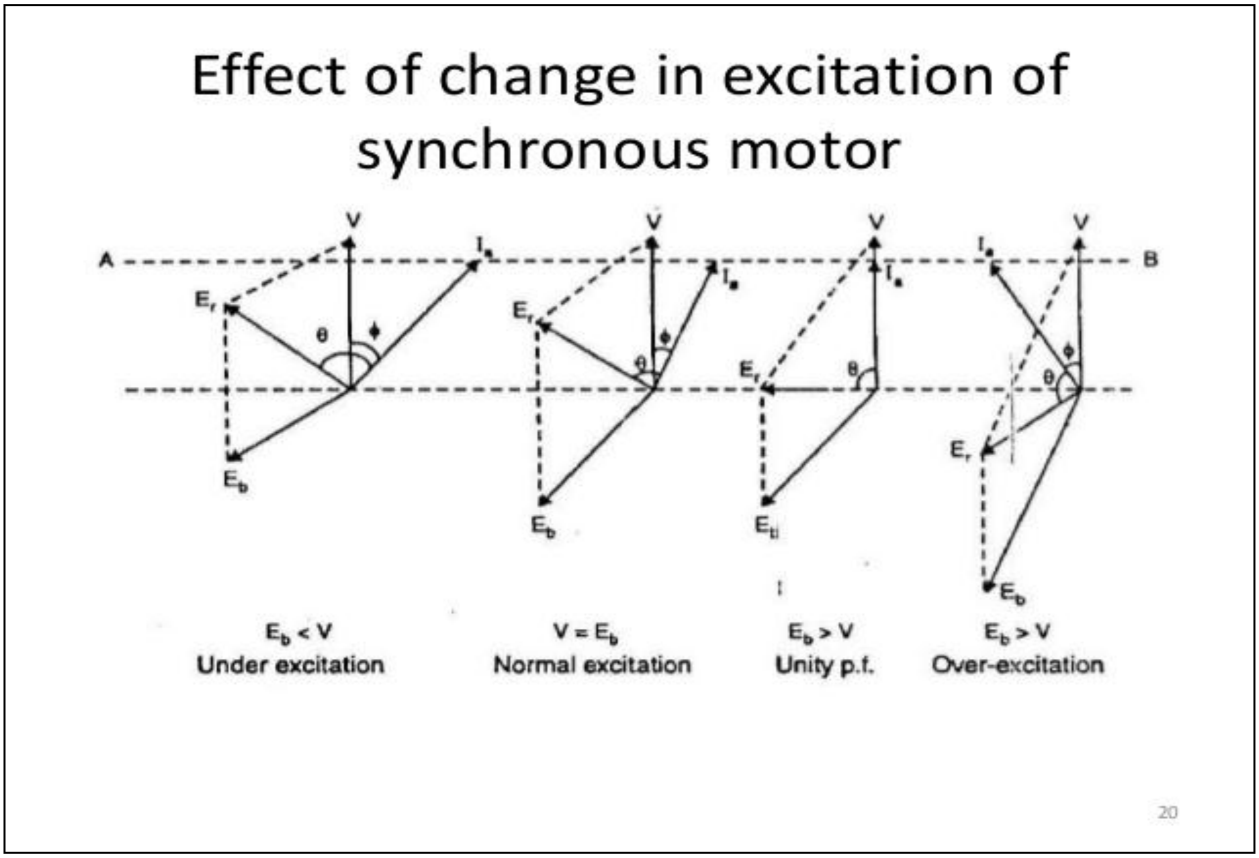
The motor is said to be normally excited, if the field excitation in such a way that E_b as shown in the figure-2. Note that the effect of increasing excitation is turn the phasor E_r and hence I_a in the anti clockwise direction. i.e. phasor I_a comes closer to V. Therefore p.f. increasing through still lagging. Since input power is unchanged the stator current I_a must decrease with increase in p.f.

Suppose the field excitation is increased until the current I_a in phase with the applied voltage 'V', making the p.f. of the s.m. unity as shown in the fig-3for a given load at unity p.f., the resultant E_r & I_a is minimum.

iii) OVER EXCITATION:-

The motor is said to be over excited, if field excitation is such a way that $E_b > V$. Under such a condition I_a leads V and the motor power factor is leading as shown in fig-4. Note that E_r and hence I_a further turn anticlockwise from normal excitation position.

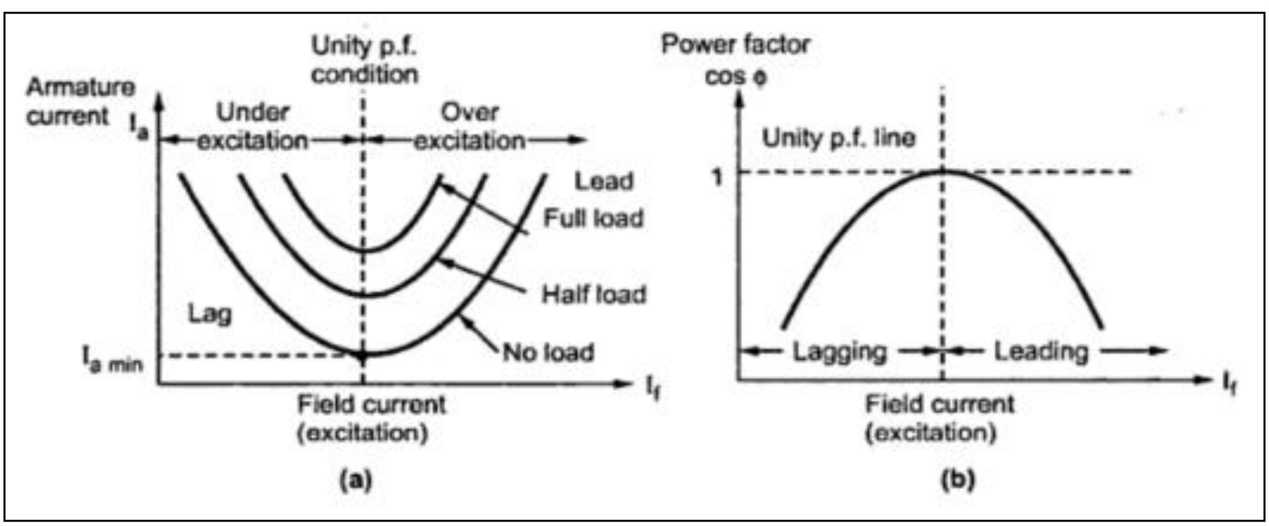
From the above discussion, it is conclude that if the excitation is increases with constant load, the p.f. also increases. Note that armature current I_a is minimum at unity p.f. and increases as the p.f. becomes poor, either leading or lagging.



3.Q:- Explain V-curve of a synchronous motor.(2012,2014,2018,w,6(a))

Ans :-

We know that if excitation is varied from very low (under excitation) value than to very high (over excitation) value than I_a decreases up to unity power factor and then again increases. But initially current Is lagging and then it is leading. This can be plotted as shown between I_a & I_f.



The shape of this plot looks like an English alphabet 'V'. Such curve is called 'v- curve'.

As against this, if the power factor (cosϕ) plotted against field current (I_f), than the shape of the graph looks like an inverted 'V'. Such curve obtained by plotting p.f. against I_f. This graph is called inverted 'V' curve.

4.Q:- A 3-ϕ, 6600v, 50 Hz star connected synchronous motor takes 50 A current. The resistance & synchronous reactance per phase are 1 Ω & 20 Ω respectively. Find the power supplied to the motor and induced emf for a power factor of a) 0.9 lagging b) 0.9 leading. (2014)

Ans :- a) p.f = 0.8 lag

Power input = √3*6600*50*0.8=457,248w

Supply voltage /ph = 6600/√3 = 3810v

$\emptyset = \cos^{-1}(0.8) = 36°52'$

$\Theta = \tan^{-1}(X_s/R_a) = (20/1) = 87°8'$

$Z_s = \surd 20^2 + 1^2 = 20$ ohm

Impedance drop = $I_a Z_s$ = 50*20=1000v/ph

So $E_b^2 = 3810^2 + 1000^2 - 2*3810*1000*\cos(87°8' - 36°52')$

Or E_b = 3263 v/ph

So line value = 3263*√3 = 5651v

ii)power input would remain same

$\emptyset = 36°52'$

Now $(\Theta + \emptyset) = 124°$

Cos124° = -cos56°

$E_b^2 = 3810^2 + 1000^2 - 2*3810*1000*-\cos 56°$

So E_b = 4447v/ph

Line induced emf = √3*4447=7,700v

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CHAPTER- 04

SHORT QUESTIONS AND ANSWER :

1.Q:- Why 1-ϕ I.M. is not self starting? (2015)

Ans :- At starting, as the torque on the rotor is equal & opposite and resultant torque is zero. So 1-ϕ I.M. is not self starting.

2.Q:- How the direction of rotation of 1-ϕ I.M. can be reversed? (2013)

Ans :- The direction can be reversed by interchanging either main or auxiliary winding.

3.Q:- When a d.c. series motor is connected to single phase A.C. supply, what will happen? (2015)

Ans :- When a d.c. series motor is connected to single phase A.C. supply, then it will be rotate at its same speed, but now it is called universal motor.

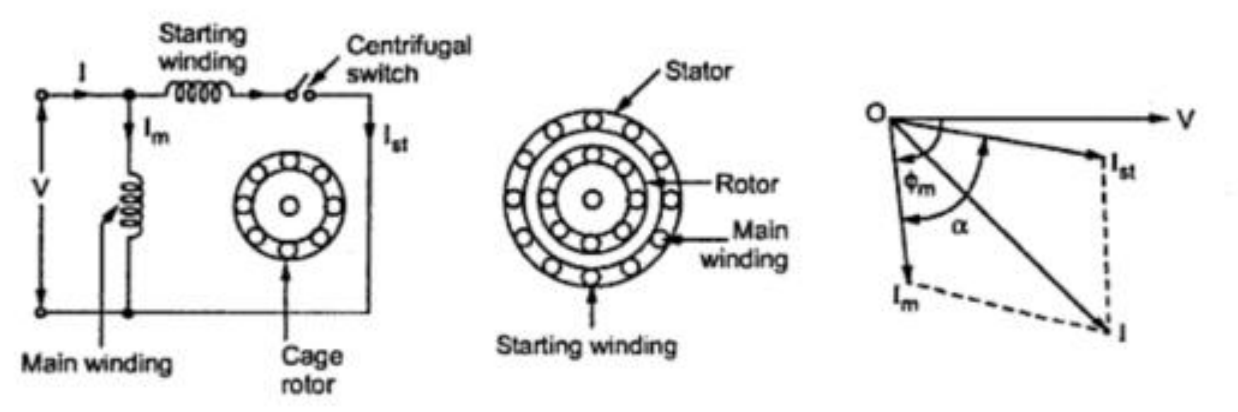
LONG QUESTIONS

1.Q:- Explain principle of split –phase I.M. with diagram.2017

Ans :-

Construction :-

The stator of a split-phase I.M. is provided with an auxiliary winding or starting winding 's' in addition to main winding (M). The starting winding 's' is located 90° electrical from the main winding and operating at starting. The starting winding has high resistance.



(a) Circuit diagram (b) Representation (c) Phasor diagram

Operation :-

When two starter winding are energies from a single phase supply, the main winding carries current I_m while the starting winding carries current I_s.

Since main winding is made highly inductive, while starting winding highly resistive, the current I_m & I_s have a reasonable phase angle 'α'(25° to 30°). Consequently, a weak revolving field to that a 2-phase machine is produced which starts the motor.

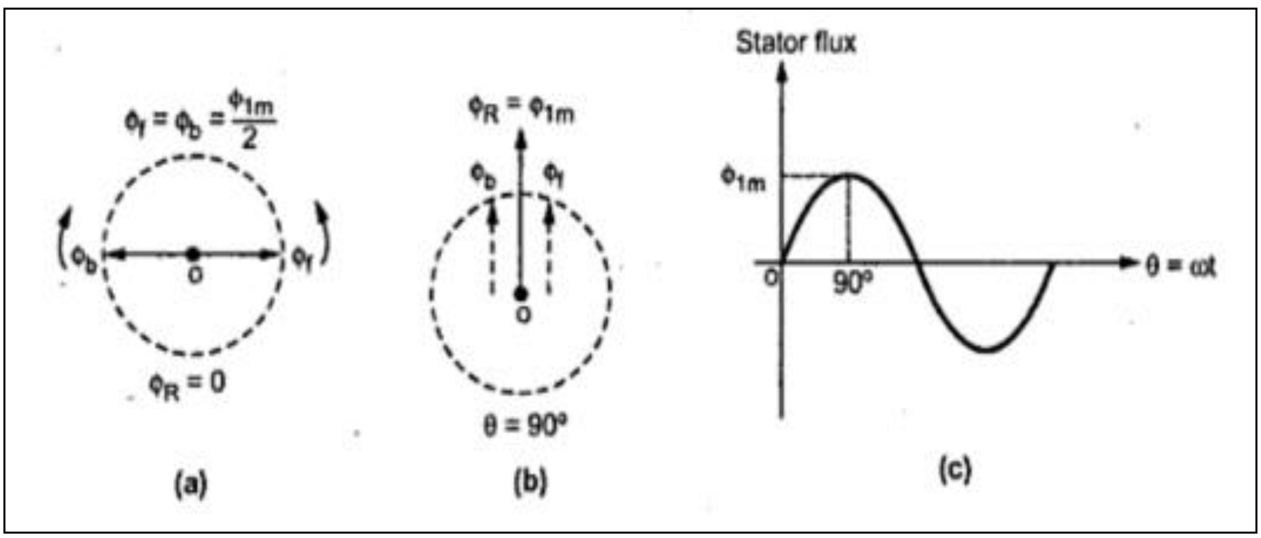
When motor reaches 75% of synchronous speed, the centrifugal switch open the ckt. The motor then operates as a single phase I.M. and continue to accelerate till it reaches the normal speed.

2.Q:- Explain the double-field revolving theory of a 1-ϕ induction motor. (2013,2014,2015,2018,w,7(i))

Ans :- It states that the stationary pulsating magnetic field can be resolved in to two rotating magnetic field each of equal magnitude & rotating in opposite direction.

Explanation:-

The two rotating flux at same speed rotating in opposite direction. So the resultant flux is alternating in nature. At starting, as the torque on the rotor is equal and opposite, resultant torque is zero. So, a 1-ϕ induction motor is not self-starting.



.

In running condition, if the rotor is rotated by some external means, torque in the direction of rotation increases due to reduced slip & for another rotating field, it decreases due to increasing slip. So, the motion with a 1-ϕ supply.

3.Q:- Write short on Shaded pole motor.(2013,2018,w,7(ii))

Ans :-

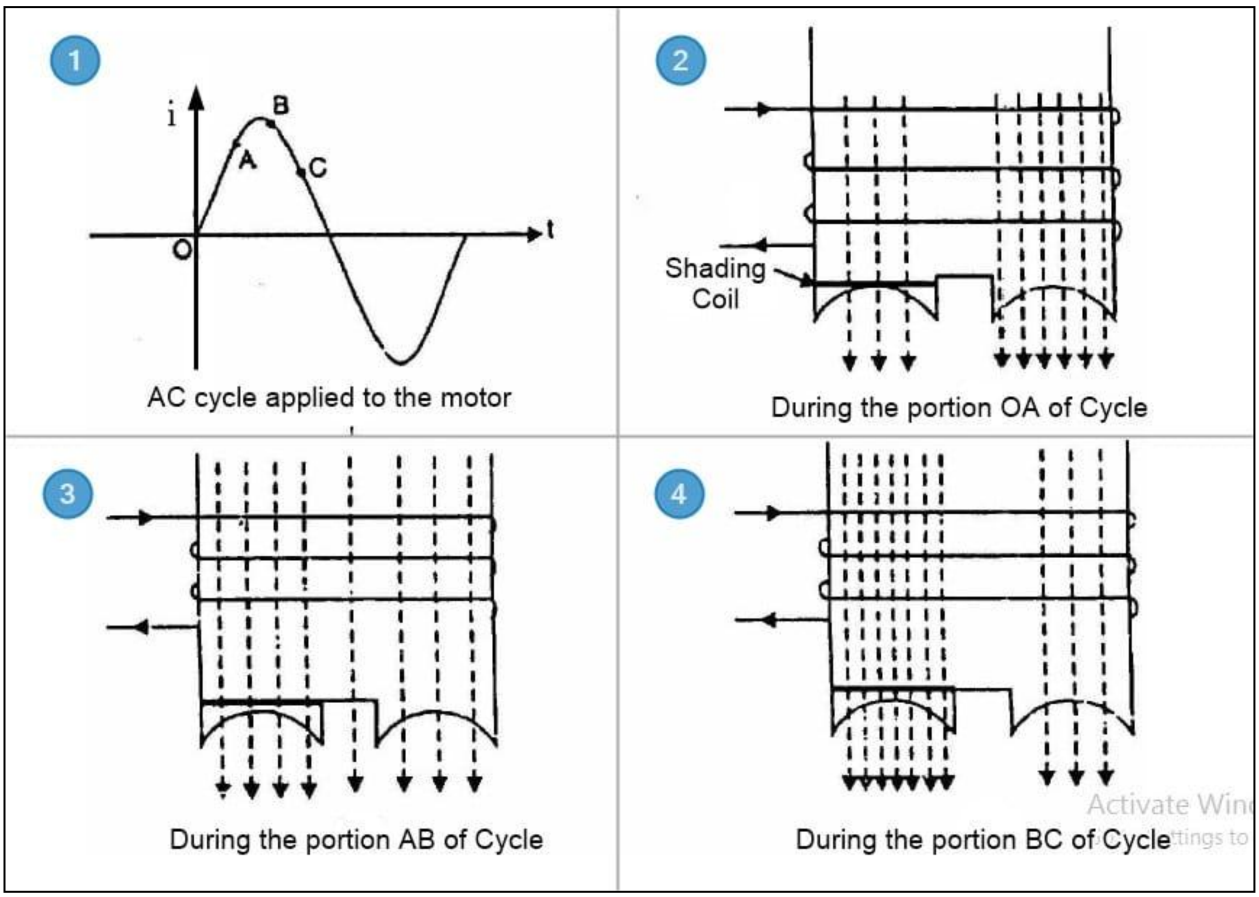
SHADED POLE MOTOR:

These motors have salient poles on the stator squirrel cage type rotor. There are four poles of alternate polarity. The laminated poles are cut 1/3rd distance from one edge. The small part is placed with a short circuited cu coil known as standing coil. This part is shaded part & the other as unshaded part.

The movement of flux from unshaded part to shaded part as follows:

i) During OA, the supplied flux in shaded part will increase and induced flux shaded part will decrease the total flux in the shaded part. So, resultant flux of the pole is at the centre of unshaded part.

ii) From A to B, the flux among the whole pole is nearly constant. So , the resultant flux is at the centre of the pole.



iii) From B to C ,the flux in unshaded part is weaker than the shaded. So resultant flux appears to move from unshaded to shaded part which induce current in the rotor. And the motor starts to rotate.

Application :- Small fans, toys, hair dryers etc.

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CHAPTER- 05

SHORT QUESTIONS AND ANSWER :

1.Q:- Write the application & universal motor.(2014)

Ans :- The application of universal motors are

i) High speed vacuum cleaner.
ii) Electric shavers.
iii) Drills.
iv) Sewing machine.

LONG QUESTIONS

1.Q:- Write the short notes on universal motor.(2012,2018,7(ii))

Or

Explain single phase series motor.(2013)

Ans:-

Universal Motor or single phase series motor

A d.c. series motor will rotate in the same direction regardless of the polarity of the supply. A d.c. series motor also operate on A.C. supply, then it is called A.C.

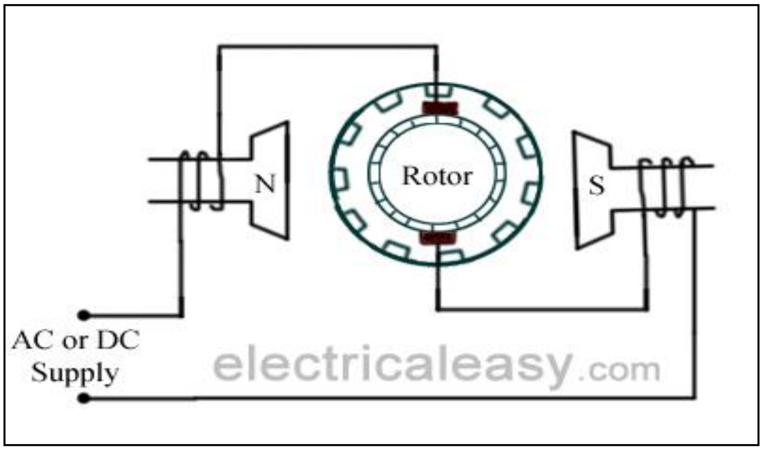
series motor.

But some changes will be required. These are:

i) The entire magnetic ckt is laminated in order to reduce the eddy current loss. Hence A.C. series motor are more expensive.
ii) The series field winding uses as few turns as possible to reduce the reactance of the field winding. This reduces the voltage drop across field.
iii) A high field flux is obtained by using a low reluctance magnetic ckt.
iv) To reduce the sparking at commutator a high resistance leads are connected to the commutator segment.

Construction :-

The construction of A.C. series motor is very much similar to d.c. series motor except the above changes. Such motor can operate both A.C. & d.c. and resulting torque. Speed characteristics about the same. Hence such motor is also called universal motor.



Operation :-

When motor is connected to A.C. supply, the same alternating current flow through field & armature winding. The field winding produces an alternating flux that reacts with the current flowing in the armature to produce a torque. It may be noted that no rotating flux is produced in this type of machine. The principal of operator is same as d.c. series motor.

Characteristics:-

i) The speed increases to a high value with a decrease In load.
ii) It has high starting torque.
iii) At full load, p.f. is about 90%.

Application :-

i) High speed vacuum cleaner
ii) Sewing machine
iii) Electric shavers
iv) Drills

CHAPTER- 06

LONG QUESTIONS AND ANSWER :

1.Q:- Write the short notes on Permanente magnet stepper motor.(2014)

Ans :-

Permanent Magnet Stepper Motor

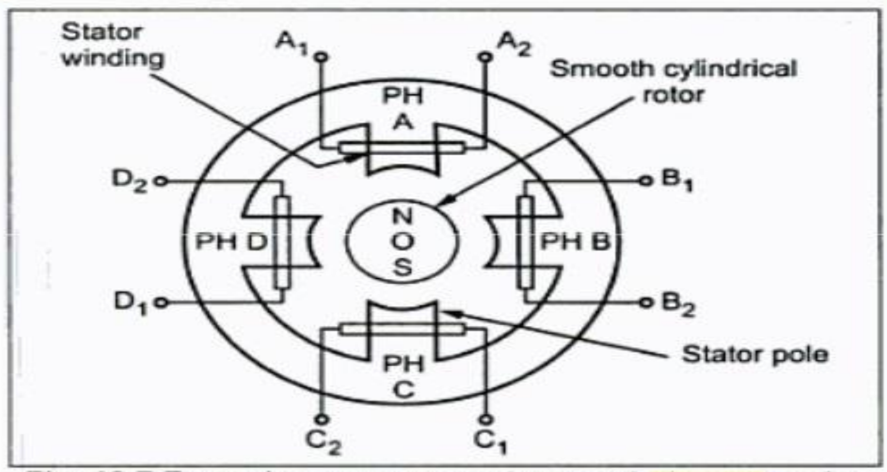


Fig. 10.7 Four phase permanent magnet stepper motor

Construction :-

The stator of a PM stepper motor is composed of steel lamination and carries stator winding. The stator winding is energized from a d.c. source to create two or more stator pole. The rotor of the motor is a Permanente magnet, made of high- retentivity steel alloy. The rotor has even no. of pole.

Operation:-

- When only phase- A winding is excited by a constant ct.(fig-i), stator tooth '1' become south pole & tooth -3 become north pole. This makes the north pole & south p[ole of rotor align with stator as shown in (fig-i). The rotor will remain locked in this position as long phase-A is energized.
- If phase –A is de-energized, & phase –B is energized as shown in fig- ii, stator tooth become south pole. As a result, north pole of rotor align with south pole of stator. Thus the rotor is displaced 90° in the anticlockwise direction.

- If phase-B is de-energized & phase-A is excited with reverse current as shown in fig-iii i.e. opposite to case-1. The rotor will further rotate 90° in anticlockwise direction. Now the north pole of PM motor align with the stator tooth B.

This is the way in which PM stepper motor rotate.

2.Q:- Write the short notes of Repulsion motor.(2015)

Ans :-

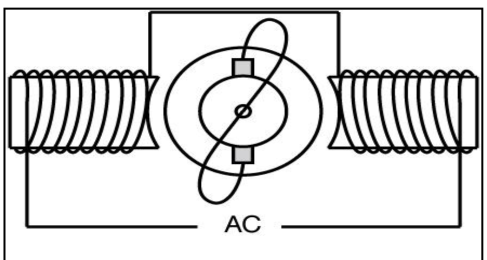
REPULSION MOTOR:-

Repulsion motor are 1-ϕ commutator motor and are following three types.

- **i) Plain repulsion motor.**
- **ii) Repulsion start Induction motor.**
- **iii) Repulsion Induction motor.**

i) Plain Repulsion motor :-

A repulsion motor is similar to A.C. series motor except that the brushes are not connected to supply but are short circuited and the field structure are non-salient pole type.



repulsion motor

The major difficulties with an ordinary single-phase I.M. is low with starting torque. By using a commutator motor with brushes short ckted, it is possible to vary the starting torque by changing the brush axis.

Principle of operation:-

Now consider two pole repulsion motor with brushes placed at right angle to the main field pole(i.e. stator)

When a 1-ϕ A.C. is fed to stator winding, an alternating field will be produced. Let at this particular moment, the alternating ct. is passing through its positive half & increasing in magnitude. So it will set up a magnetic flux of increasing nature which acts from north to south. This increasing flux will produce an emf in the armature winding & set up a flux in opposite direction to stator, according to lenz's law. As both the fluxes are opposite to each other. As both the fluxes are opposite to each other and equal in magnitude, so no torque will develop.If now the brushes are placed midway between the field poles. Which made for the same moment of time as in the previous case, a clockwise ct. will flow through the brushes in the upper half of armature winding and anti-clockwise in lower half of the winding. This current will produce equal & opposite torque, so rotor will not rotate.

Now suppose, the brushes are placed at a particular angle 'α' to the field axis. At this position the main field flux & armature induced flux is in same direction. So net torque will be in one direction & motor will rotate.

Since the rotor of this motor possesses high resistance due to d.c. armature winding, its starting current is low. However it high starting torque & therefore started on load. Therefore it is used in lifts, cranes etc.

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CHAPTER- 07

SHORT QUESTIONS AND ANSWER :

1.Q:- Why transformer are ratted in KVA ?(2014)

Ans :- Transformer cu. Loss is depend on current and iron loss is depend on voltage but not the angle between current & voltage. i.e angle between them. That's why the transform is ratted in KVA.

MEDIUM QUESTIONS

1.Q:- what is parallel operation? Why it is needed? State the necessary condition of parallel operation.(2014)

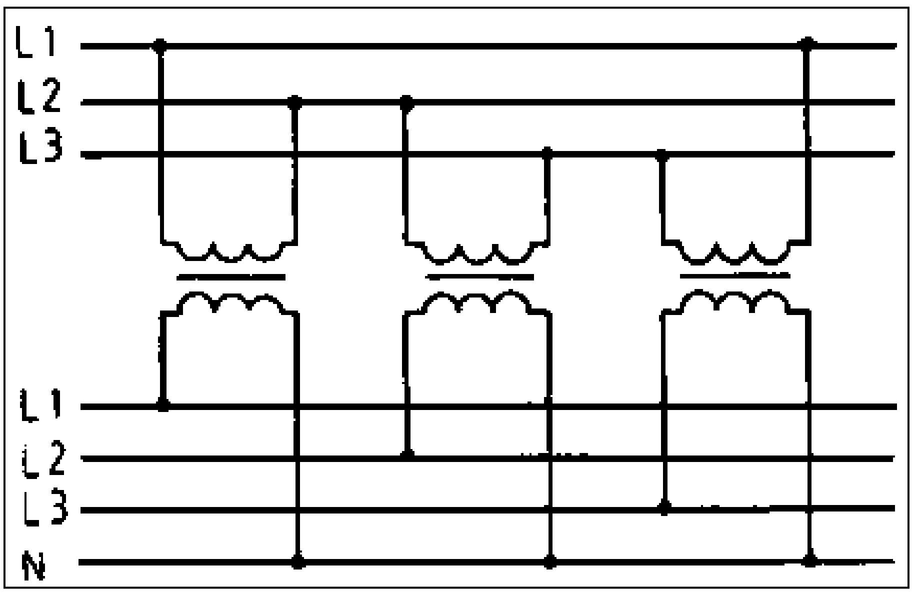
Ans:-

By parallel operation we mean two or more transformers are connected to the same supply bus bars on the primary side and to a common bus bar/load on the secondary side. Such requirement is frequently encountered in practice.

1. To maximize electrical power system efficiency:
2. To maximize electrical power system availability
3. To maximize power system reliability
4. To maximize electrical power system flexibility

The reasons that necessitate parallel operation are as follows.

1. The line voltage ratio of two transformers must be equal.
2. The per unit impedance of each transformer should be equal and they should have same ratio of equivalent leakage reactance to the equal resistance(X/R).
3. The transformers should have same secondary winding polarity.
4. The Transformers should have same phase sequence (Three phase transformer)



5. The transformers should have the zero relative phase replacement between the secondary line voltages.(Three phase transformers)

LONG QUESTIONS

1.Q. Write the short notes of maintenance of transformer.(2014,2018,7(iii))

Ans:-

There are many different maintenance action, to be performed on a power transformer. Some of them in yearly basis, some of them are monthly basis, some other are quarterly, some are half-yearly basis. These are mainly transformer maintenance action, which to be performed in 3 to 4 years interval.

Monthly Basis Maintenance of Transformer

Let us first discuss about the action to be taken on power transformer in monthly basis.

1. The oil level in oil cap under silica gel breather must be checked in one month interval. If it is found the transformer oil inside the cup comes below the specified level, oil to be top up as per specified level. **2.** Breathing holes in silica gel breather should also be checked monthly and properly cleaned if required, for proper breathing action.

3. If the transformer has oil filled bushing the oil level of transformer oil inside the bushing must be visually checked in the oil gage attached to those bushing. This action also to be done monthly basis. If it is required, the oil to be filled in the bushing up to correct level. Oil filling to be done under shutdown condition.

Daily Basis Maintenance and Checking

There are three main things which to be checked on a power transformer in daily basis and they are :

1. Reading of MOG (Magnetic Oil Gage) of main tank and conservator tank.

2. Color of silica gel in breather.

3. Leakage of oil from any point of a transformer. In case of unsatisfactory oil level in the MOG, oil to be filled in transformer and also the transformer tank to be checked for oil leakage. If oil leakage is found take required action to plug the leakage. If silica gel becomes pinkish, it should be replaced.

Yearly Basis Transformer Maintenance Schedule

1. The auto, remote, manual function of cooling system that means, oil pumps, air fans, and other items engaged in cooling system of transformer, along with their control circuit to be checked in the interval of one year. In the case of trouble, investigate control circuit and physical condition of pumps and fans.

2. All the bushings of the transformer to be cleaned by soft cotton cloths yearly. During cleaning the bushing should be checked for cracking.

3. Oil condition of OLTC to be examined in every year. For that, oil sample to be taken from drain valve of divertor tank, and this collected oil sample to be tested for dielectric strength

(BDV) and moisture content (PPM). If BDV is low and PPM for moisture is found high compared to recommended values, the oil inside the OLTC to be replaced or filtered.

4. Mechanical inspection of Buchholz relays to be carried out on yearly basis.

5. All marshalling boxes to be cleaned from inside at least once in a year. All illumination, space heaters, to be checked whether they are functioning properly or not. If not, required maintenance action to be taken. All the terminal connections of control and relay wiring to be checked an tighten at least once in a year.

6. All the relays, alarms and control switches along with their circuit, in R&C panel (Relay and Control Panel) and RTCC (Remote Tap Changer Control Panel) to be cleaned by appropriate cleaning agent.

7. The pockets for OTI, WTI (Oil Temperature Indicator & Winding Temperature Indicator) on the transformer top cover to be checked and if required oil to be replenished.

8. The proper function of Pressure Release Device and Buchholz relay must be checked annually. For that, trip contacts and alarm contacts of the said devices are shorted by a small piece of wire, and observe whether the concerned relays in remote panel are properly working or not.

9. Insulation resistance and polarization index of transformer must be checked with battery operated megger of 5 KV range.

2.Q: Explain how voltage can be increased or decreased in a transformer by use of tap changer.(2012,2013)

Ans:-

The electrical equipments are normally designed to operate satisfactory at normal voltage level. But due to growth of utilization of electricity there is a variation of voltage at load end. The tap changer are used in transformer to keep the voltage level with in specific limit by changing numbers of turns.

Tapings are provided at high voltage side. because

1. As no. of turns on high voltage side is large smooth & fine voltage control is obtain.
2. Low voltage side placed nearer to the core. So it is easier to tap high voltage side which is outside of the core.

There are two types of tap changers

i) No load or OFF load tap changers

ii) On load tap changers.

i)No-load (off-load or off-circuit) tap changing

The cheapest method of changing the turn ratio of a transformer is the use of off-circuit tap changer. As the name indicates, it is required to de energize the transformer before changing the tap. A simple no-load tap changer is shown in Fig. 3.68. It has eight studs marked one to eight. The winding is tapped at eight points. The face plate carrying the suitable studs can be mounted at a convenient place on the transformer such as upper yoke or located near the tapped positions on the windings. The movable contact arm A may be rotated by hand wheel mounted externally on the tank.

If the winding is tapped at 2% intervals, then as the rotatable arm A is moved over to studs 1, 2; 2, 3;   6, 7; 7, 8 the winding in circuit reduces progressively by it from 100% with arm at studs (1, 2) to 88% at studs (7, 8).

The stop *F* which fixes the final position of the arm A prevents further anticlockwise rotation so that stud 1 and 8 cannot be bridged by the arm. Adjustment of tap setting is carried out with transformer de energized. For example, for 94% tap.

the arm is brought in position to bridge studs 4 and 5. The transformer can then be switched on.

To prevent unauthorized operation of an off-circuit tap changer, a mechanical lock is provided. Further, to prevent inadvertent operation, an electromagnetic latching device or micro switch is provided to open the circuit breaker so as to de energize the transformer as soon as the tap changer handle is moved; well before the contact of the arm with the stud (with which it was in contact) opens.

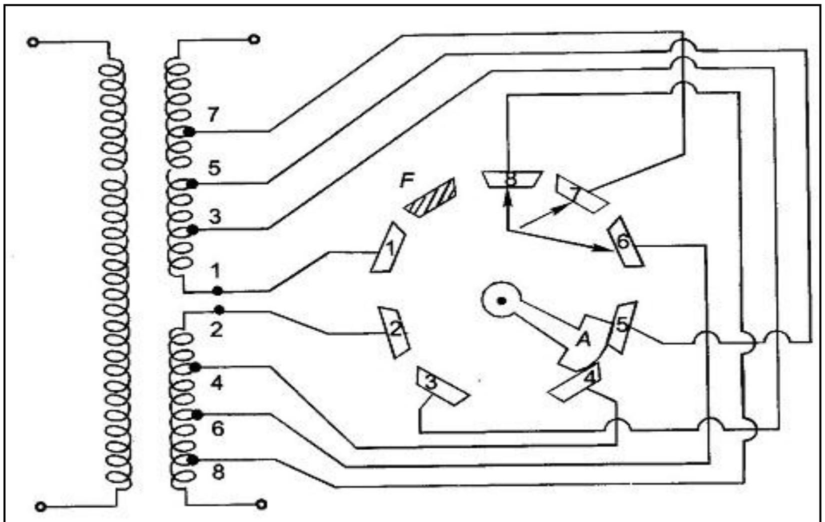
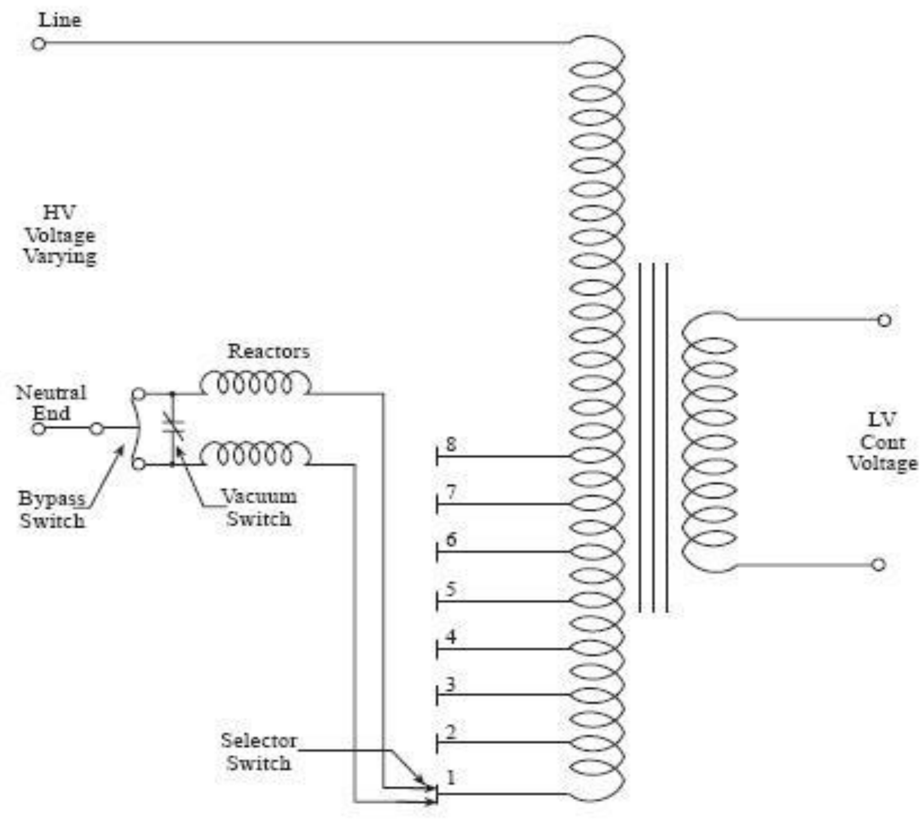


Fig. 3.68 *No-load tap changer*

ii) On–load Tap Changing



On-Load Tap Changer

- The above shown figure is an on load tap changers. it is used for daily or short period voltage regulation. the care should be taken that no part of the tapped winding should get short ckted.
- A center tapped reactor is used to limit the short ckt current during the tap changing operation. The main ckt should not be open.
- In normal operation switch ‘S’ is closed. If switch ‘1’ is closed, 2,3,4,&5 being open & entire winding is in the ckt.
- If switch ‘S’ is opened, now the total current flows through the upper half of the reactor.
- Switch ‘2’ is closed : winding between tap-1,2 is connected to the reactor.
- Switch ‘1’ is open : entire current flows through lower half of reactor.
- Switch ‘S’ is closed : the total current now flows through the upper & lower half of the reactor.

3.Q: The grouping of a 3-phase transformer are star-star, delta-delta, star-delta, delta-star. Show their connection diagram.(2014)

Ans :-

i)Star- star connection

This connection used for small high voltage transformer. Small high voltage means small in size but it can withstand high voltage. Because in star connection $V_L = \sqrt{3}V_{PH}$. so if V_L =1000v then V_{PH}=577.35v. so per winding numbers of turns is minimum & require less insulation.

ii) delta- delta connection

this connection is used for large low voltage transformer. large low voltage means large in size & low voltage transformer. Because here

$V_L = V_{PH.}$ So it requires more number of turns & very high insulation.

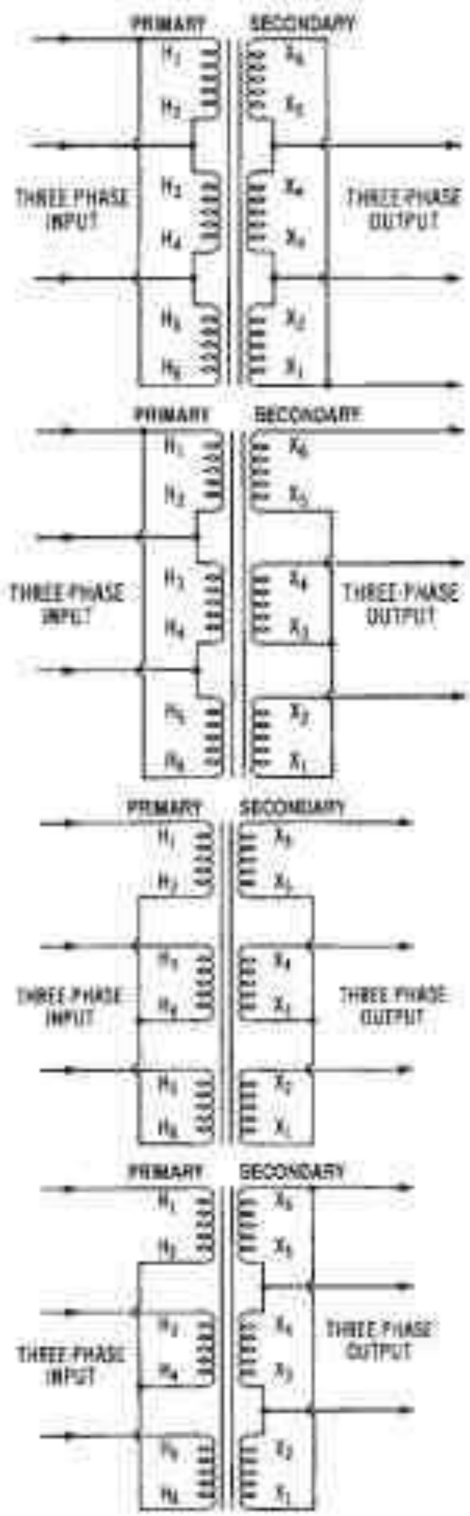
iii)star –delta connection.

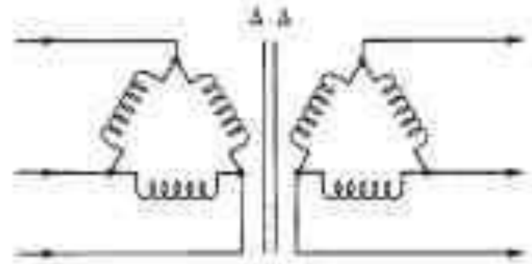
This connection is commonly used for stepping down voltage from high level to medium or low level because secondary side is delta connected

So it is used for stepping down voltage purpose.

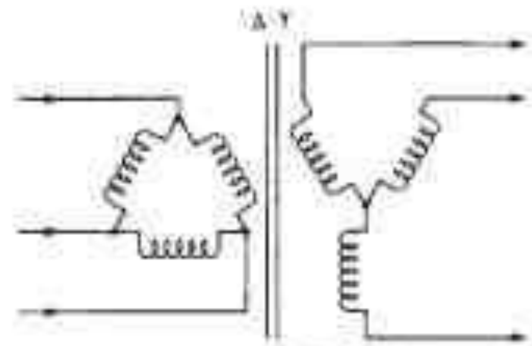
iii)delta – star connection.

This type of connection is used for stepping up the voltage to a high level. for example these are used in the beginning of the H.V. transmission line. so that the insulation is stressed to about 57.74% of line voltage at secondary.

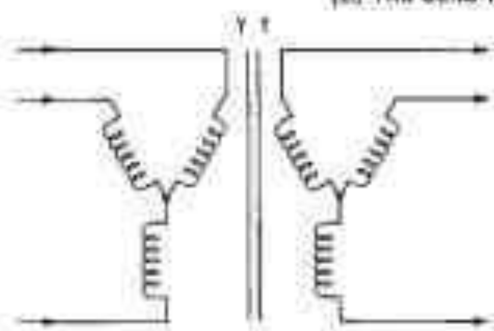




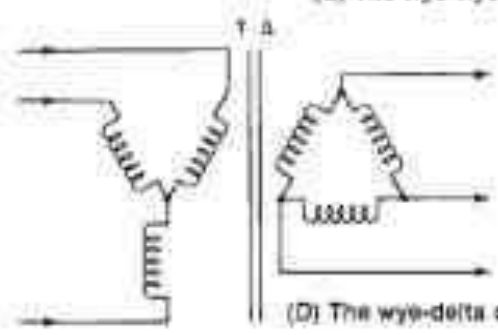
(A) The delta-delta connection.



(B) The delta-wye connection.



(C) The wye-wye connection.



(D) The wye-delta connection.