Friday

Module - IV

Date 24/05/24

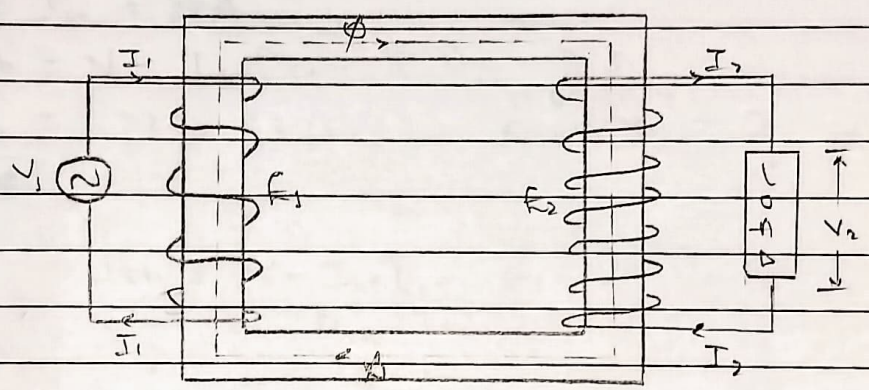
Saathi

1) TRANSFORMER

* **Defination:** It is a static or stationary device which transfer electrical power from one coil circuit to other coil circuit, without changing the frequency.

⇒ It works on the principal of Mutual Induction between two coils.

* **Working principal of single phase Transformer**



* A physical basis of transformer is mutual induction between two coils linked by a common magnetic flux. In its simplest form, it consists of two inductive coils which are electrically separated but magnetically linked through a path of low reluctance as shown. The two coil posses high mutual inductance.

* The coils are wound on a thin sheet steel laminations assembled to provide continuous

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magnetic path called core. The coil to which A.C supply is connected is called primary winding & the other coil from which electrical energy is taken is called secondary winding.

* When Alternating voltage is connected on the 1° winding, current starts to flow in 1° winding, which sets up an Alternating flux in the laminated core. This flux which links with 1° winding induces an emf called self induced emf. Since the core offers a path of low reluctance, the flux passes through the core & links the 2° winding. ∴ change in flux in the 1° winding linking with the 2° winding induces an emf called Mutually induced emf.

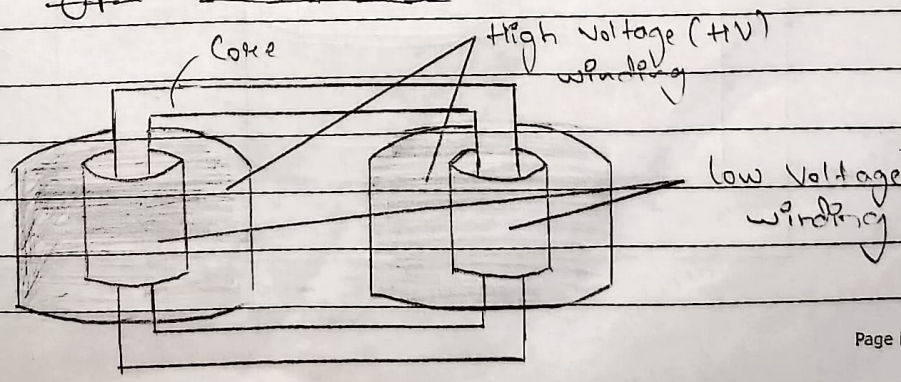
→ The eqn for 1° & 2° induced emf given by

$$E_1 = N_1 \frac{d\phi}{dt}$$

$$E_2 = N_2 \frac{d\phi}{dt}$$

* Types of Transformer based on Construction:-

(i) Core type transformer:



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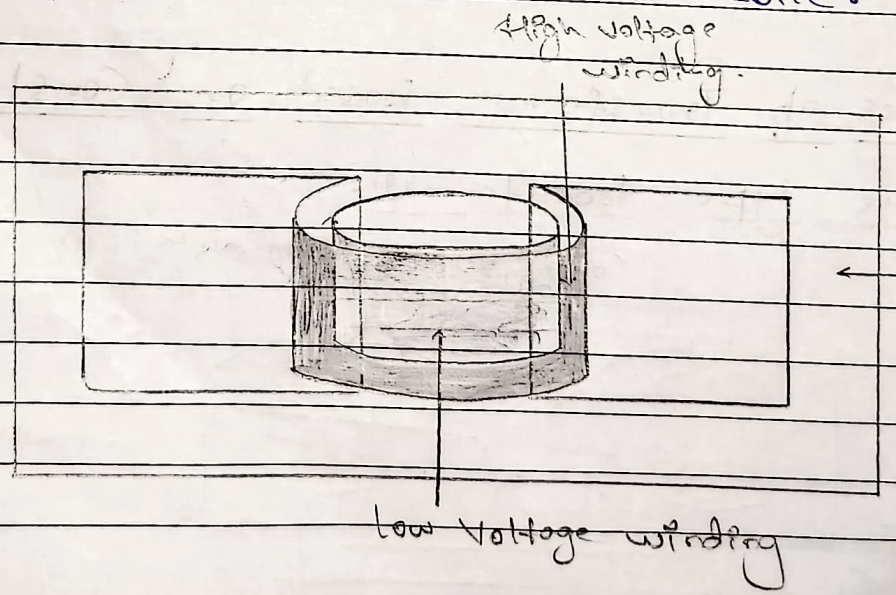
* In the core type transformer, considerable part of the core is surrounded by windings. The coils used are form wound and are of cylindrical the general form of these coils may be be also in circular or rectangular form.

* In small size transformer, simple rectangular core is used with cylindrical coils. But for large transformer or round circular cylindrical coils are used which are so wound as to fit over circuiform core structure/section.

* Since low voltage winding requires less insulation, it is always wound first in the core.

(ii) Shell type transformer :

* A shell type transformer may have simple rectangular form as shown in fig. In this case also the low voltage winding is first wound on the core.



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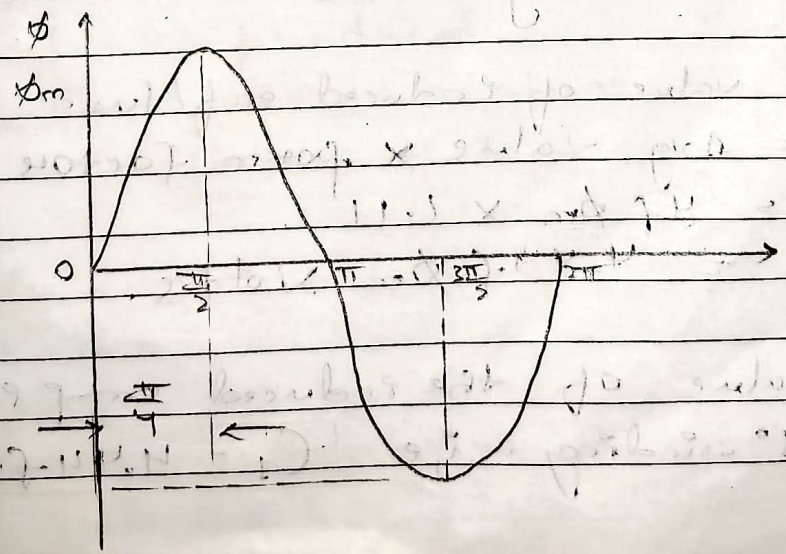
* In this type of transformer, considerable part of winding is surrounded by core. In this core also the coils are firmly wound but are multilayered disk type usually wound in form of pancakes. The different layers of such multilayered disk are insulated from each other by papers.

* EMF equation of Single Phase Transformer

* let N_1 → no. of turns in primary winding.
  N_2 → no. of turns in secondary winding.
  f → frequency of supply voltage in Hz.
  ϕ_m → Max value of flux in the core in wb.
  E_1 → RMS value of induced emf in the 1° winding.
  E_2 → RMS value of the induced emf in the 2° winding.

let us consider one cycle of the alternating flux as shown below.



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Referring to that fig, the core flux increases from 0 to Max value ϕ_m in $\frac{T}{4}$ seconds.

$\therefore$ Average rate of change of flux

$$= \frac{\phi_m - 0}{\frac{T}{4}} \qquad \left[\because T = \frac{1}{f}\right]$$

$$= \frac{\phi_m}{\frac{1}{4f}}$$

$\therefore$ Average rate of change of flux $= 4f\phi_m$

Now, the rate of change of flux per turn is the induced emf, according to Faraday's law of EMI.

Avg induced emf/turn $= 4f\phi_m$ Volts.

Since Alternating quantities are defined by the RMS value, which can be calculated by considering form factor (K_f).

$$K_f \text{ i.e } \frac{\text{RMS value}}{\text{Avg value}} \Rightarrow 1.11$$

$\therefore$ RMS value of induced emf/turn

$= \text{Avg value} \times \text{form factor}$

$= 4f\phi_m \times 1.11$

$= 4.44 f\phi_m$ Volts.

RMS value of the induced emf in the complete 1° winding. i.e $\boxed{E_1 = 4.44 f\phi_m \times N_1}$

$$\boxed{E_2 = 4.44 f \phi_m \times N_2}$$

* **Transformation ratio (K)**
* It is defined as the ratio of 2° induced emf to the 1° induced emf in the transformer.

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{V_2}{V_1}$$

For Ideal transformer:

$$O/P\ VA = I/P\ VA$$

$$V_2 I_2 = V_1 I_1$$

$$\boxed{\frac{V_2}{V_1} = \frac{I_1}{I_2} = K.}$$

* **losses in transformer:-**

1. Iron or Core losses [Wi]
   - (a) Hysteresis losses [Wh]
   - (b) Eddy Current losses [We]
2. Copper or Winding loss [Wcu]

(1) **Iron or core losses [Wi]:-**

(a) **Hysteresis losses [Wh]:** It is caused because of continous reverse magnetic polarity of heat produced.

* **Solution:** Silicon Steel are used to construct core.

$$\boxed{W_h = \eta . B_{max}^{1.6} V.f \text{ watts.}}$$

(b) **Eddy Current losses (We):-** The dφ linking to the coil and also the core produces unwanted circulating current i.e eddy current due to this the core gets heated.

* **Solution:** Make core with thin sheet of laminations.

$$\boxed{W_e = P . B_{max}^2 f^2 t^2 \text{ watt}}$$

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② Copper losses :- It is also called as Variable losses. It refers to the energy lost due to the resistance of Cu windings when electric current flows through them. This loss manifests as heat. This loss is proportional to the square of current passing through the windings and is also called I^2R loss, where I represents current and R represents resistance of wires.

* Solution : Use windings which offers the low resistance.

$$\boxed{W_{Cu} = I_1^2 R_1 + I_2^2 R_2}$$

(V. Imp) → Iron losses are called Constant losses. because ϕ, f are constant.

→ Copper losses are called variable losses.

1 HP = 735.5 W
1 HP = 0.735 KW

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* Efficiency of Transformer :-

$$\% \eta = \frac{O/P \text{ power}}{I/P \text{ power}} \times 100$$

Total losses = I/P − O/P

$$W_i + W_{cu} = I/P - O/P$$

Iron loss, Cu loss

$$O/P = I/P - W_i - W_{cu}$$

$$I/P = O/P + W_i + W_{cu}$$

$$\% \eta = \frac{I/P - W_i - W_{cu}}{I/P} \times 100$$

$$\% \eta = \left[1 - \frac{(W_i + W_{cu})}{I/P}\right] \times 100$$

$$\% \eta = \frac{O/P}{O/P + W_i + W_{cu}} \times 100$$

* For determining the efficiency for any desire load, we define the load factor (x)

$$x = \frac{\text{Actual load}}{\text{Full load}}$$

→ As the rating of the transformer is usually given in VA or KVA but the efficiency is determined by considering the output or input in terms of watts or KW.

→ ∴ The general expression for efficiency of the transformer in terms of output is given as

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$$\cos\phi = \frac{KW}{KVA}$$

$$\therefore KVA \times \cos\phi = KW$$

$$\boxed{\%\eta = \frac{x \times O/P\ KVA \times \cos\phi}{(x \times O/P\ KVA \times \cos\phi) + W_i + x^2 W_{cu}}}$$

Numericals :

(1) The no load ratio of 50Hz single phase transformer is 6000/250V. Calculate the no. of turns on each winding if the maximum flux in the core is 60mwb

Soln

Given: $V_1 = E_1 = 6000V$ $\phi_m = 60mwb$

$V_2 = E_2 = 250V$ $= 60 \times 10^{-3} wb$

$f = 50Hz$ To find $N_1, N_2 = ?$

$$E_1 = 4.44 f \phi_m N_1$$

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

$$N_1 = 450.45 \approx 450$$ no. of turns should be in decimal

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

$$N_2 = 19$$

(2) A 200KVA, 3300/240V, 50Hz single phase transformer has 80 turns on 2° winding. Assuming an ideal transformer determine (i) the no. of 1° turns, (ii) max value of flux in core (iii) 1° & 2° currents on full load.

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Given: $N_2 = 80$ $V_1 = 3300\,V = E_1$

O/P KVA = 200 KVA $V_2 = E_2 = 250\,V$

$= 200 \times 10^3$ VA $f = 50\,Hz$

I_1 & I_2 = ? $\frac{N_2}{N_1} = \frac{E_2}{E_1}$

$N_1 = 1100$

$E_1 = 4.44 f \phi_m N_1$

$\phi_m = 0.013$

$\phi_m = 13.5\,mwb$

O/P VA $= V_2 . I_2$

$200 \times 10^3 = 240 I_2$

$I_2 = \frac{200 \times 10^3}{240}$

$I_2 = 833.33A$.

$V_2 I_2 = V_1 I_1$

$\therefore I_1 = \frac{V_2 I_2}{V_1}$

$I_1 = 60.6A$.

(3) A 100KVA single phase transformer has full load Cu loss of 1.5 KW and Iron loss of 1 KW. Determine the efficiency of transformer on (i) 1/4th of full load, 0.9 power factor

(ii) 50% of full load, 0.95 power factor

(iii) 3/4th of full load, u.p.f (unity power factor)

(iv) full load, 0.8 power factor.

(v) 1.25 times of full load, 0.75 power factor.

→ For full load cu loss we use W_{cu}

→ For 2/3, 1/4 etc cu loss we use $x^2 W_{cu}$.

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(3) Soln

Given: O/P ~~KVA~~ = 100 KVA
$= 100 \times 10^3$ VA.

$W_i = 1$ KW ⇒ 1000 W

$W_{cu} = 1.5$ KW ⇒ 1500 W

To calculate,
(i) % η, $\frac{1}{4}$th FL, 0.9 φ = ?
(ii) % η 50% FL, 0.95 φ = ?
(iii) % η 3/4th FL, upf = ?
(iv) 1.25 FL, 0.75 pf = ?

(i) efficiency at 1/4th of F.L, 0.9 φ f.

→ $x = 1/4 \Rightarrow 0.25$

$\cos\phi = 0.9$

$$\% \eta = \frac{x \times O/P\ KVA \times \cos\phi}{(x \times O/P\ KVA \times \cos\phi) + W_i + x^2 W_{cu}} \times 100$$

$\% \eta_{1/4\ FL} = 95.37\%$

(ii) efficiency at 50% of F.L, 0.95 φ f.

$x = 50\% \Rightarrow 0.5$

$\cos\phi = 0.95$

$$\% \eta_{50\%FL} = \frac{0.5 \times 100000 \times 0.95}{(0.5 \times 100000 \times 0.95) + 1000 + [(0.5)^2 \times 1500]} \times 100$$

$\% \eta_{50\%FL} = 97.18\%$

(iii) efficiency at 3/4th FL, 1 power fact.

$x = .75$, $\cos\phi = 1$

$\% \eta_{3/4\ FL} = 97.6\%$

(iv) efficiency at 1.25 FL, 0.75 pf.

$\% \eta_{1.25FL} = 96.31$

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(4) A 100 kg single transformer has efficiency of 96.96% at 0.8 power factor on full load and 97.18% efficiency at 0.9 power factor on 50% of full load, determine the efficiency of the transformer at 85% of full load at unity power factor.

Sol: O/P = 100 KVA

= 100×10^3 VA.

$\% \eta_{F.L} = 96.96\%$ at $\cos\phi = 0.8$

$= 0.9696$

$\% \eta_{50\% F.L} = 97.18\%$ at $\cos\phi = 0.95$

$= 0.9718$

To calculate, $\% \eta_{85\%} = ?$ at u.p.f

(i) Full load efficiency at ~~0.9696~~ 0.8 power factor

$x = 1$

$$\% \eta_{F.L} = \frac{x \times O/P\ KVA \times \cos\phi}{(x \times O/P \times VA \times \cos\phi) + W_i + x^2 W_{cu}}$$

$$96 = 0.9696 = \frac{1 \times 100 \times 0.8}{(1 \times 100 \times 0.8) + W_i + (1)^2 W_{cu}} \times 100$$

$$80 + W_i + W_{cu} = \frac{80}{0.9696} \Rightarrow 82.5$$

$\therefore W_i + W_{cu} = 2.5$ KW — (1)

(ii) $$\% \eta_{HL} = 95 = \frac{0.5 \times 100 \times 0.95}{(0.5 \times 100 \times 0.95) + W_i + W_{cu}} \times 100$$

$W_i + 0.25 W_{cu} = \cancel{96.1605 - 47.5}$ 1.37 KW — (2)

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$$W_i + W_{cu} = 2.5\ KW$$

$$W_i + 0.25\ W_{cu} = 1.37\ KW$$

$$0.75\ W_{cu} = 1.13\ KW$$

$$\therefore W_{cu} = 1.5\ KW$$

$$W_i = 1\ KW$$

(iii) efficiency at 85% full load at u.p.f.

$$\% \eta_{80\%} = \frac{0.85 \times 100 \times 1}{(0.85 \times 100 \times 1) + 1 + (0.85)^2 1.5} \times 100$$

$$\% \eta_{80\%} = 97.6$$

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2) Three phase Induction Motor

→ Advantages :-

* It has a very simple, extremely rugged and almost unbreakable construction.
* It has sufficiently high efficiency compare to other motors.
* It requires minimum of maintainance.
* It's cost is less and it is very reliable.
* It has a reasonable good power factor.
* It is a self starting a motor and doesn't need any starting mechanism to start the motor.

→ Disadvantages :-

* It speed decreases somewhat with increase in load
* It's speed can't be vary without sacrifying its efficiency

Construction of Three phase Induction Motor.

1. Stator
2. Rotor
   - (i) Squirrel cage rotor
   - (ii) Slipring rotor.

1. Stator :-

Same as that of an alternator or synchronous generator. It is made up of no. of stamping which are slotted to receive the winding.

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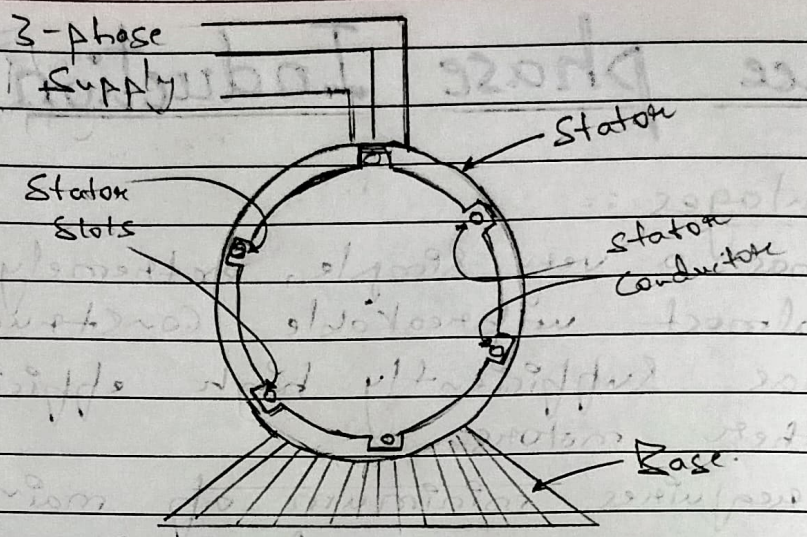
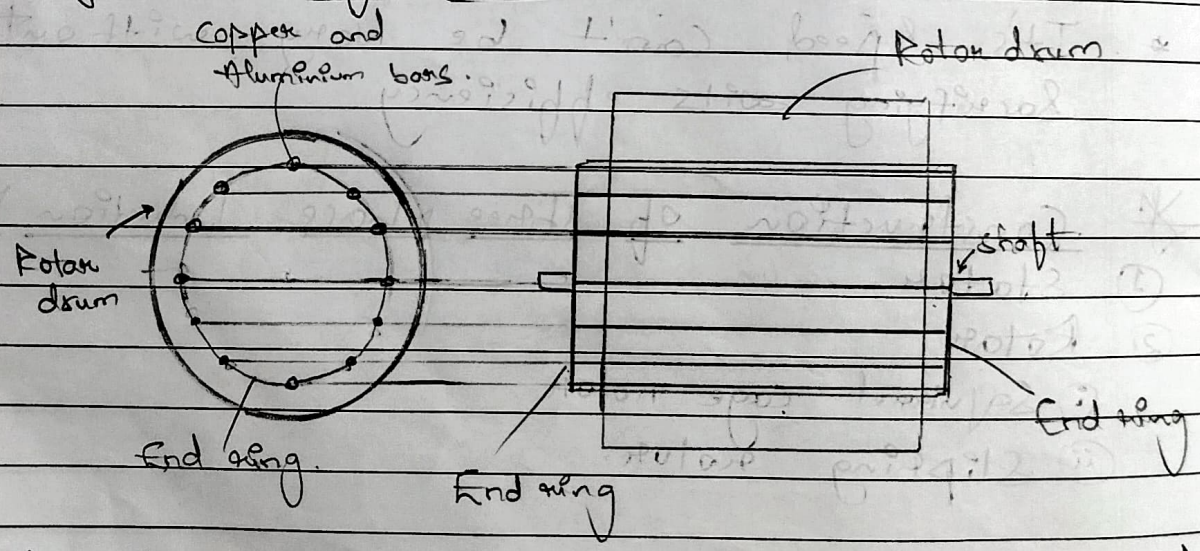


The Stator carries 3-phase winding & it is fed from 3-phase supply as shown in fig. It is wound for definate no. of poles, The exact no. of poles is determined by the requirement of speed.

(2) **Rotor** :-

(i) Squirrel Cage rotor



Almost 90% of Induction motor are squirrel cage type because this type of rotor has the simplest, most rugged and almost unbreakable construction. The rotor consists of a cylindrical laminated core with

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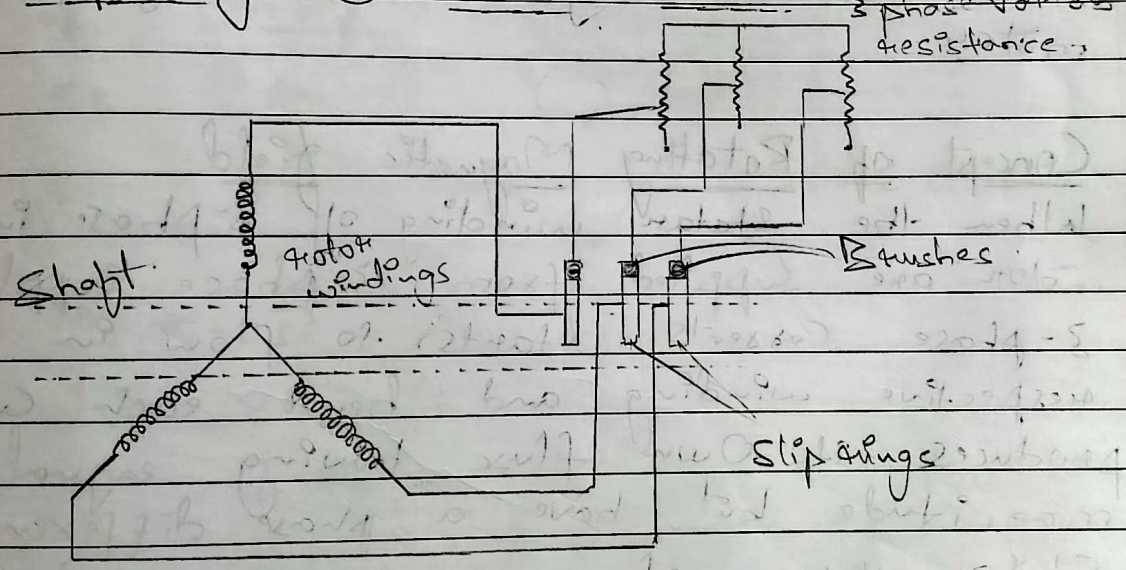
parallel slots for carrying rotor conductors, which are not wires but consist of heavy bars of Cu & Al. One bar is placed in each slot and are inserted from one end to other end. The rotor bars are electrically welded two heavy short circuiting end ring. It should be noted that the rotor bars are permanently short circuited on themselves. Hence it is not possible to add or remove the external resistance in rotor circuit. Such type of rotor are usually constant speed rotor.

(ii) Slipring (or) wound rotor.



This type of motor is provided with 3-phase double layer & distributed winding consist of coil as used in alternator. The rotor is always wound for 3-phase even when the stator is wound for 2-phase. The 3-phase rotor windings are connected in star internally. The other 3-terminals are brought out & connected to

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3 insulated slip ring mounted on the shaft with brushes resting on them. These brushes are externally connected to 3-phase star connected rheostat as shown in fig. This arrangement makes it possible to add resistance in motor circuit during starting. When running under normal condition the slip rings are automatically short circuit by means of a metal colon which pushed along the shaft. The brushes are automatically lifted on slip ring to reduce ~~from the brushes to~~ the friction losses due to wear & tear. Hence it is seen that under normal running condition, the slip ring motor is short circuited just like squirrel cage motor.

* Concept of Rotating Magnetic field.

* When the stator winding of 3-phase induction motor are supplied from 3-phase supply, 3-phase currents starts to flow in respective winding and hence each current produces its own flux having equal magnitude but have a phase difference of 120°
* Such three flux are represented in form of equation, waveform and phasor diagram to their respective +ve direction.

$$\phi_R = \phi_m \sin \omega t \quad \text{— (1)}$$

$$\phi_Y = \phi_m \sin(\omega t - 120°) \quad \text{— (2)}$$

$$\phi_B = \phi_m \sin(\omega t - 240°) \quad \text{— (3)}$$

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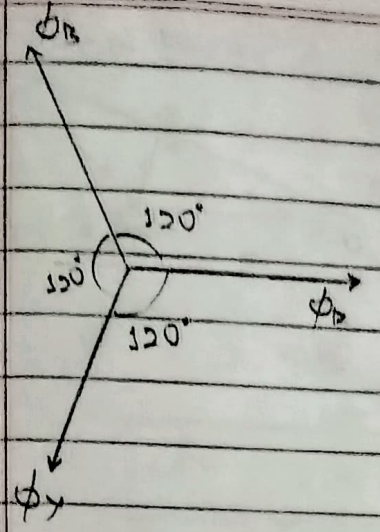
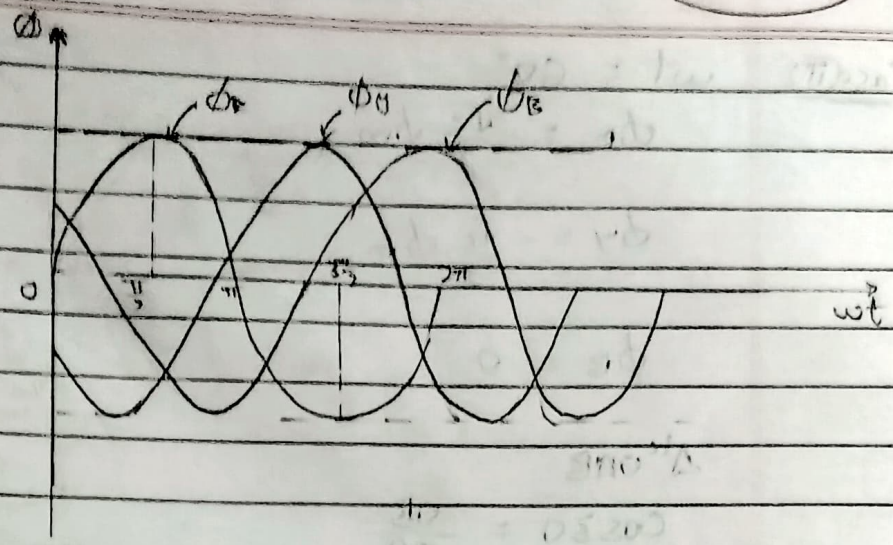




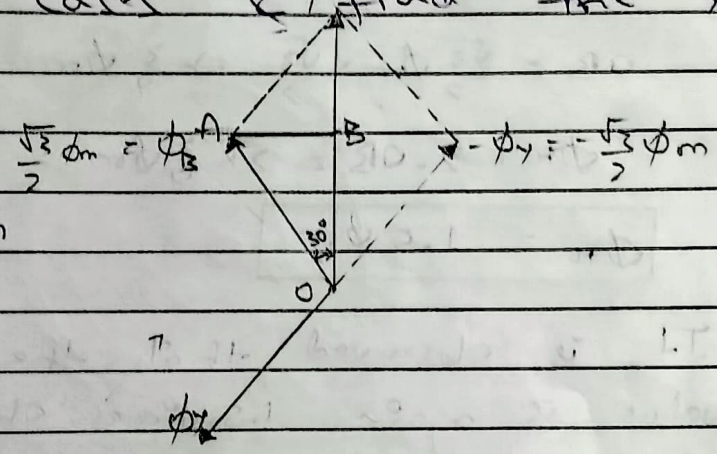
* At any instant the resultant flux ϕ_R is the vector sum of 3 flux. let's consider the following 4 cases & find the ϕ resultant.

Case (i) $\omega t = 0$

$\phi_R = 0$

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

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



Δ^{le} OAB,

$\cos 30 = \frac{OB}{OA}$

$OB = OA \cos 30$

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

$OB = \frac{\sqrt{3}}{2}\phi_m \times \frac{\sqrt{3}}{2}$

$OB = \frac{3}{4}\phi_m$

$\phi_R = 2.OB \Rightarrow 2 \times \frac{3}{4}\phi_m$

$\boxed{\phi_R = 1.5\phi_m}$

The resultant flux is 1.5 times of ϕ_m

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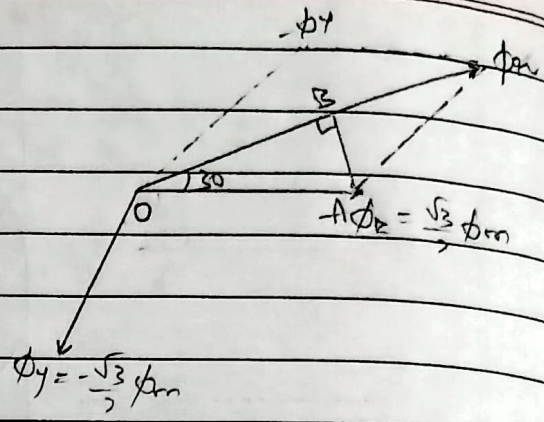
Case (ii) $\omega t = 60^\circ$

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

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

$\phi_B = 0$



Δ^{le} OAB

$\cos 30 = \frac{OB}{OA}$

$OB = OA\cos 30$

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

$OB = \frac{\sqrt{3}}{2}\phi_m \times \frac{\sqrt{3}}{2} \Rightarrow \frac{3}{4}\phi_m$

$\phi_R = 2 \cdot OB = 2 \times \frac{3}{4}\phi_m$

$\boxed{\phi_R = 1.5\phi_m}$

It is observed that the resultant flux value is again 1.5 times of ϕ_m which is same as that of the instant $\omega t = 0$, but it is observed that the resultant flux has rotated in clockwise direction by 60°.

Case (iii) $\omega t = 120^\circ$

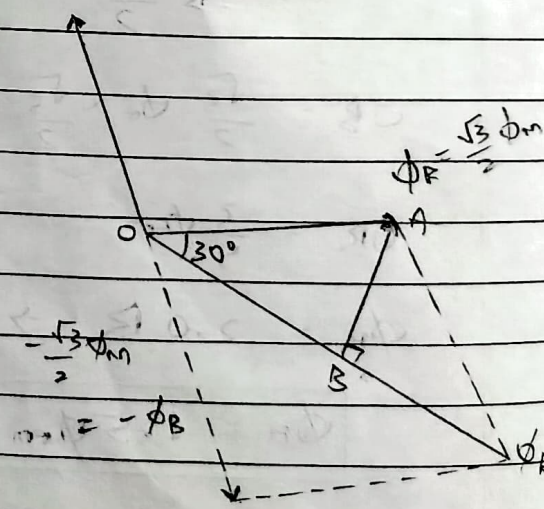
$\phi_R = \frac{\sqrt{3}}{2}\phi_m$

$\phi_Y = 0$

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

ΔOAB, $\cos 30 = \frac{OB}{OA}$

$OB = OA\cos 30.$



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$$OB = \frac{\sqrt{3}}{2}\phi_m \times \frac{\sqrt{3}}{2}$$

$$OB = \frac{3}{4}\phi_m$$

$$\phi_R = 2.OB \Rightarrow 2 \times \frac{3}{4}\phi_m$$

$$\boxed{\phi_R = 1.5\,\phi_m}$$

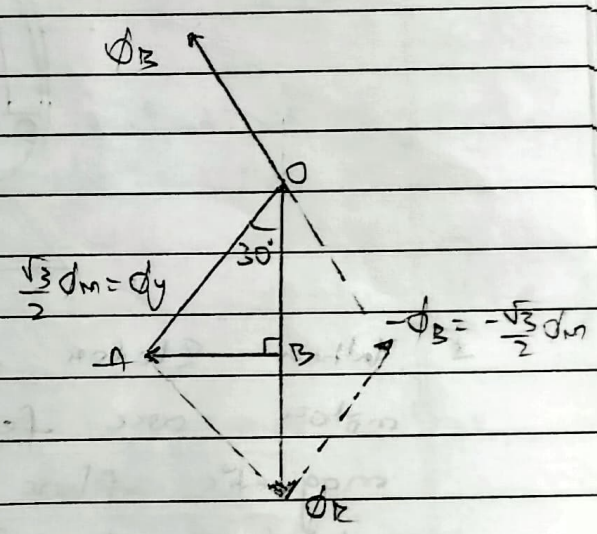
Here also the resultant flux is $1.5\phi_m$ but it's observed that the resultant flux rotated by angle of $60°$ in the clockwise direction.

Case (iv) $\omega t = 180°$

$\phi_R = 0$

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

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



$$\cos 30 = \frac{OB}{OA}$$

$$\therefore OB = \frac{3}{4}\phi_m$$

$$\therefore \phi_R = 2.OB$$

$$\boxed{\phi_R = 1.5\phi_m}$$

The resultant flux is again $1.5\phi_m$ but it's observed that the resultant flux as rotated by another $60°$ in the clockwise direction.

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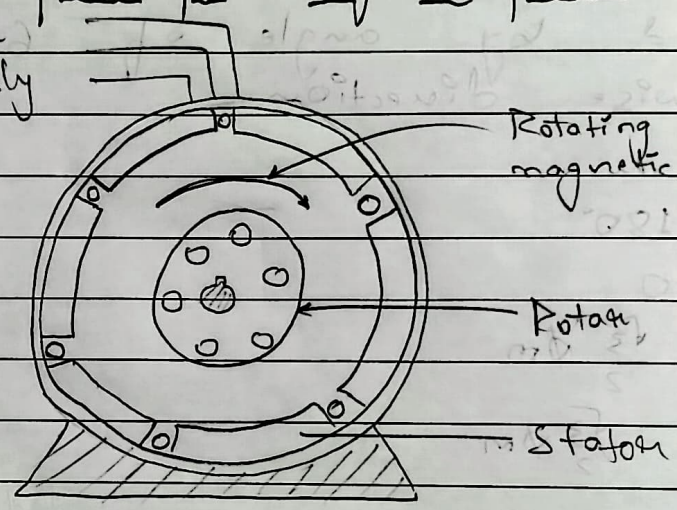
⇒ **Conclusion :-**

* Hence we can conclude that, when the stator windings of 3 phase induction motor are supplied from 3-phase supply, a resultant flux ϕ_m is developed whose magnitude is equal to 1.5 ϕ_m ~~but~~ which is constant but it is revolving around the stator at sp called synchronous speed (N_s)

* Working principle of 3 phase Induction Motor



* When stator windings of three phase induction motor are fed from 3-phase supply, a magnetic flux of constant magnitude but rotating at synchronous speed (N_s) is set up.
* This flux passes through the air gap, sweeps pass the rotor surface and links or cuts the rotor conductors which are at stationary.
* Due to the relative speed b/w the rotating stator flux & stationary rotor conductor an emf is induced in the rotor conductors acc to Faradays laws of EMI.

* The mangnitude of Induced EMF in the rotor conductors is max because the relative speed is max. The frequency of the EMF induced in the rotor is same as the supply frequency.
* Since the rotor conductors formed a closed circuit, current starts to flow in the rotor conductors ~~which is given by~~ direction of which given by lenz law i.e the direction of current such that it opposes the cause that produce it.
* In this case the cause produce rotor current is relative speed between rotating ~~speed~~ ~~rotor~~ stator flux & stationary rotor conductor.
* Hence to reduce the relative speed, the rotor starts to rotate in the same direction as that of rotating flux and tries to catch up with the rotating flux.
* This is how the induction motor the rotor in put into rotation.

* **Slip** : In practise the rotor will never succeed in catching up the speed of rotating flux. The difference in speed between synchronous speed (N_s) and actual speed of rotor (N) is known as slip, usually express as percentage of synchronous speed.

$$\% \text{ Slip} = \left(\frac{N_s - N}{N_s}\right) \times 100$$

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* $$\boxed{N_s = \frac{120f}{P}}$$

$f \rightarrow$ frequency $\qquad P \rightarrow$ poles.

* $$\boxed{f = \frac{N_s \cdot P}{120}}$$

let f_r (or) f' be the frequency of rotor or current
It depends upon relative speed

$$f' \text{ (or) } f_r = \frac{(N_s - N)P}{120}$$

$$\frac{f_r}{f} = \frac{\frac{(N_s - N)\cancel{P}}{\cancel{120}}}{\frac{N_s \cancel{P}}{\cancel{120}}} \Rightarrow \frac{N_s - N}{N_s}$$

* $$\therefore \boxed{f_r = S \cdot f}$$

* $$S = \frac{N_s - N}{N_s}$$

$$SN_s = N_s - N$$

$$N = N_s - SN_s$$

$$\boxed{N = N_s(1 - S)}$$

* Numericals :-

(1) A 6 pole 3-phase Induction Motor is supplied from 50 Hz supply has an emf in the rotor of a frequency 2.5 Hz. Determine the slip and speed of the Induction Motor.

(1) Soln Given: $P = 6$

$f = 50$ Hz

$f_r = 2.5$ Hz

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$f_r = S.f$

$\therefore S = \frac{f_r}{f} \Rightarrow S = 0.05$

$\% S = 5\%$

$N = N_s(1-S)$

$N_s = \frac{120f}{P}$

$N_s = 1000 rpm$

$N = 950 rpm$

(2) A 3phase induction motor is wound for 4 pole and is supply from

Determine (i) Synchronous speed.

(ii) Speed of motor when slip is 4%.

(iii) The rotor current frequency when speed of motor is 1350 rpm

Soln (2)

$P = 4, f = 50 Hz, N_s = ?$ To find, Speed, N at slip 4%.

$S = 4\% = 0.04$ f_r at 1350 rpm

(i) $f_r = S.f$

$S = \frac{f_r}{f}$

$S = 0.05$

$\% S = 5\%$

(ii) $N = N_s(1-S)$

$N_s = \frac{120f}{P}$

$N_s = 1500 rpm$

$N = 1440 rpm$

(iii) For $N = 1350 rpm$

$\% slip = \frac{N_s - N}{N_s} \times 100 \Rightarrow \frac{1500-1350}{1500} \times 100$

$\% slip = 10\% \Rightarrow slip = 0.1$

$f_r = 0.1 \times 50 \Rightarrow f_r = 5 Hz$

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(3) A 3-phase 4 pole Induction motor is running at slip of 2% on no load & a slip of 4% on full load. Determine the change in speed from no load to full load. If it is supply from a 3-phase 50 Hz supply.

(3) Soln

Given : $P = 4$ $S_0 = 2\% \Rightarrow 0.02$

$f_s = 50Hz$ $S_{FL} = 4\% \Rightarrow 0.04$

To Find the change in speed from no load to full load.

Changes in speed $= N_0 - N_{FL}$

$N_0 = N_s(1 - S_0)$

$N_s = \frac{120f}{P}$

$N_s = 1500$ rpm

$N_0 = 1470$ rpm

$N_{FL} = N_s(1 - S_{FL})$

$N_{FL} = 1500(1 - 0.04)$

$= 1500 \times 0.96 \Rightarrow 1440$ rpm

Change in speed $N_0 - N_{FL} = 1470 - 1440 \Rightarrow 30$ rpm

(4) A 12 pole, 3 phase Alternator driven at a speed of 500 rpm, supply power to an 8 pole, 3 phase induction motor. If the speed of motor at full load is 3%. Calculate the full load speed of the motor, rotor current frequency. The relative speed or slip speed and the rotor current frequency when the motor is stand still.

Sol:

Given:

Alternator:

$P_a = 12$

$N_{sa} = 500$ rpm

To find,

$N = ?$ (full load speed), $f_r = ?$

f_r at $N = 0$

$$N_{sa} = \frac{120 f}{P_a}$$

3ϕ Induction motor

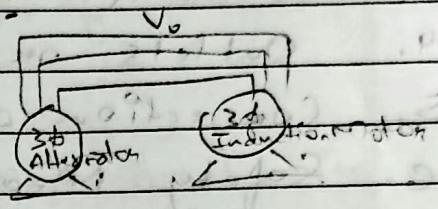
$P = 8$

% slip = 3%

slip = 0.03

relative speed / slip speed

$(N_s - N) = ?$



→ The supplied frequency from alternator is defined as

$$f = \frac{N_{sa} \times P_a}{120}$$

$f = 50$ Hz

$$N_s = \frac{120 f}{P}$$

$N_s = 750$ rpm

$N = N_s(1 - S)$

$N = 750(1 - 0.03)$

$N = 727.5$

$f_r = S.f \Rightarrow 1.5$ Hz

Relative speed or slip speed $= (N_s - N)$

$= 750 - 727.5$

$= 22.5$ rpm

When motor is stationary, the speed $n = 0$

The speed is maximum i.e $S = 1$

$\% S = 100\%$

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Module - V

Chapter - 1

Saathi

1) Domestic Wiring :-

* Requirement of Wiring :-

=> The basic requirement of electrical wiring are :-

1. Design of wiring diagram
2. Electrical boards
3. Conduits.
4. Outlets or load points
5. Connection of wiring (Series or parallel)
6. Safety measures.

* Types of Wiring :-

1. Joint box (or) Tee wiring.
2. Loop in system wiring
3. Clead wiring.
4. Pattern wiring (Wooden).
5. Casing and Caping.
6. Conduit wiring.

* Casing and Caping Wiring System :-

→ This is one of the simplest form of electrical wiring system. This is a little bit old or conventional wiring system. Nowadays, the often use this wiring system in PVC insulated wire's (or) cables that are placed in a plastic casing and covered with cap. The casing is of rectangular cross section and its color is usually white or grey. The casing and caps are available in standard sizes in the market.

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Advantages :-

1) It is the cheapest wiring system compared to concealed wiring system.

2) It is strong and long casting.

3) Replacement and alteration of defective wires is easy.

4) It provides protection against mechanical damage.

5) It is safe from oil, steel, smoke and rain.

6) No risk of electric shock due to covered wires (OR) cables in casing and capping

Disadvantages:

1) It requires skilled workmanship, ∴ the labour cost is high.

2) It can be used only on surface and cannot be concealed in plaster.

3) Internal condensation of moisture may damage the insulation.

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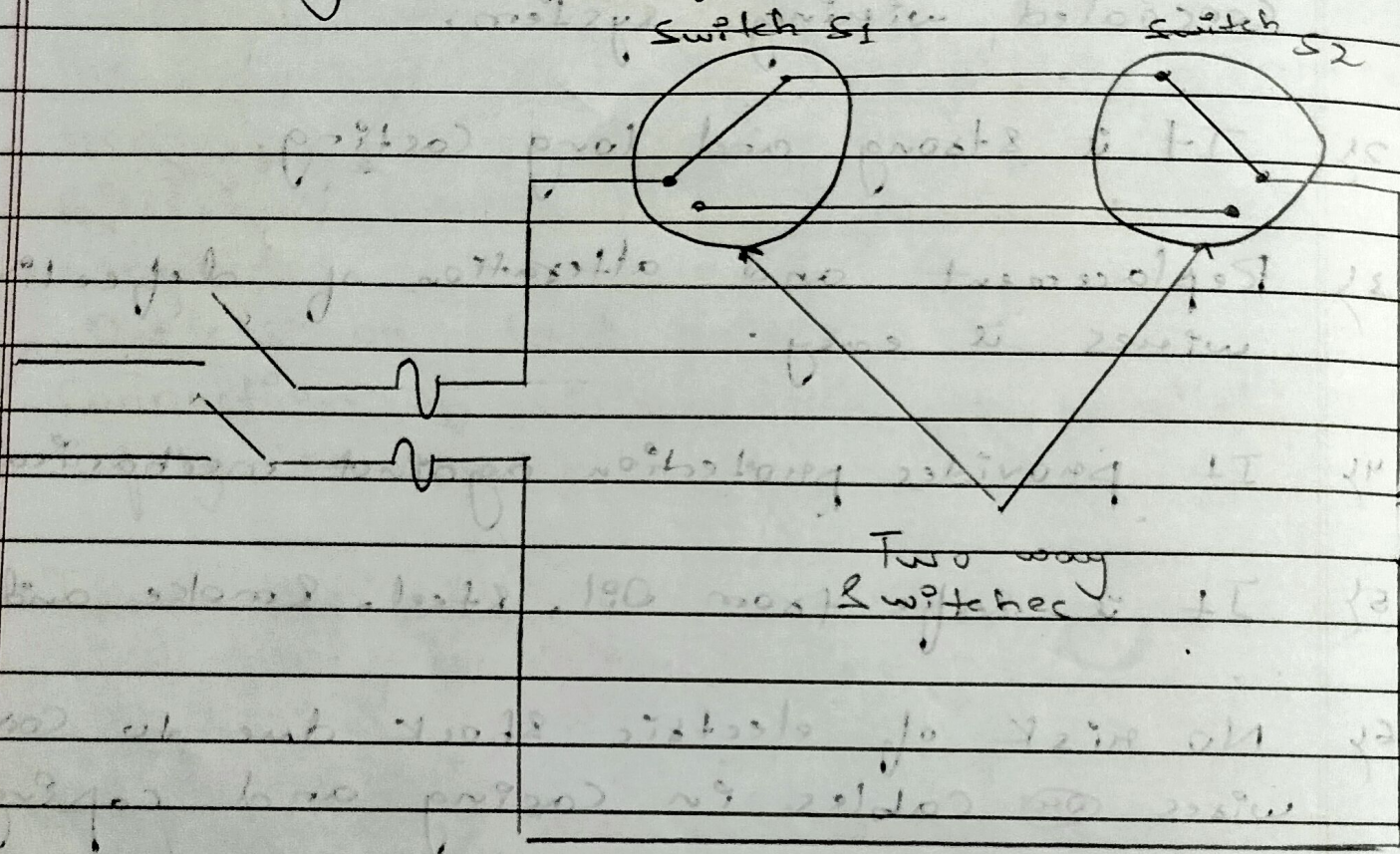
* Two way and Three way Control of load.

① Two way control of load (lamp):



position of Switch S_1	position of Switch S_2	Lamp Status
A	C	ON
B	D	ON
A	D	OFF
B	C	OFF.

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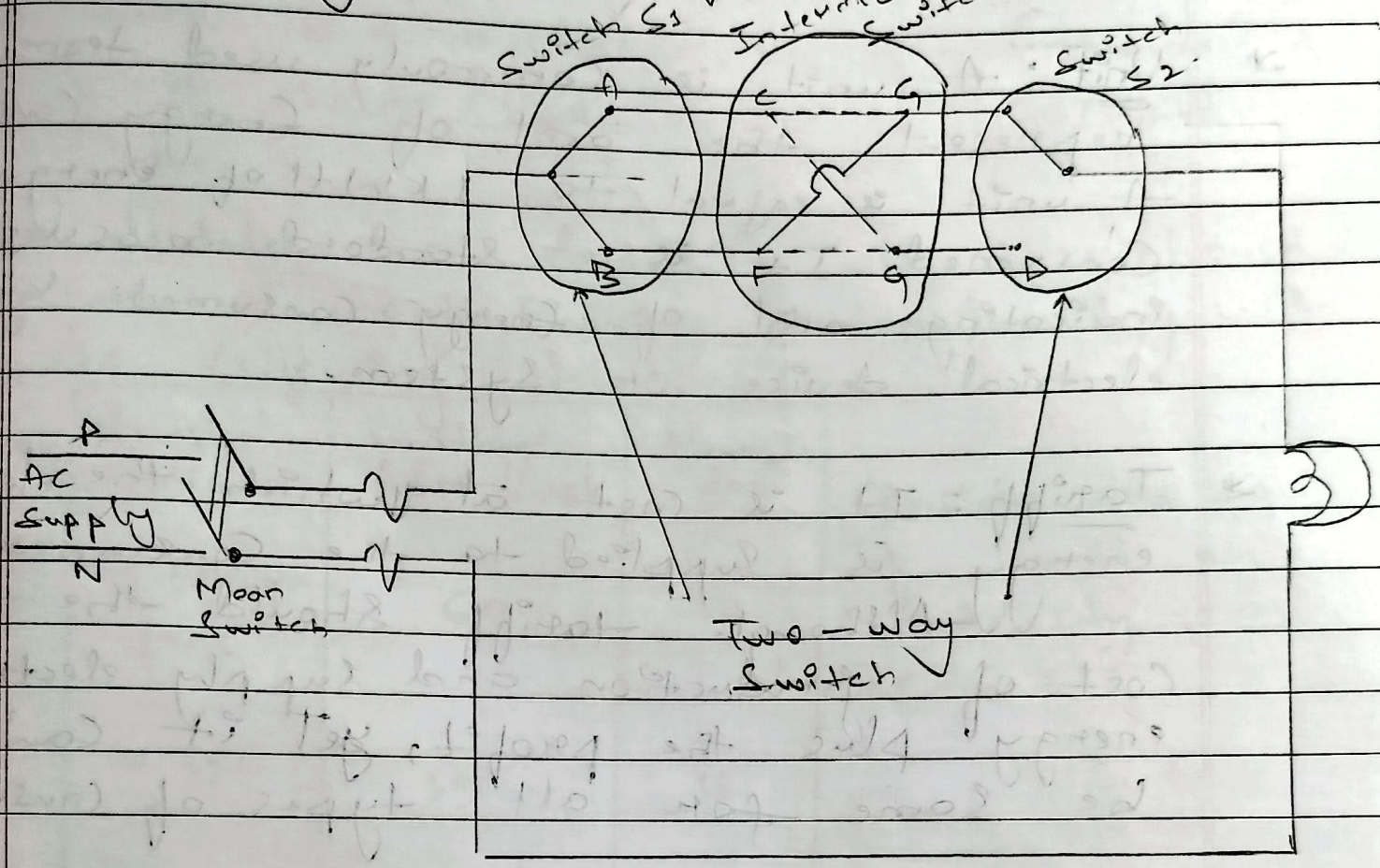
② Three-way Control of load (lamp)



Position of switch S_1	position of switch S_2	position of intermediate switch	Lamp status.
A	C	Straight	ON
B	D	Connection	ON
A	D	EG	OFF
B	C	FH	OFF
A	C	cross	OFF
B	D	Connection	OFF
A	D	EH	ON
B	C	FG	ON

Module - V

Date 20/06/24 chapter - 2

Saathi

Electricity Bill :-

* **Unit** : A unit is commonly used term to represent the amt of energy consumed. A unit is equal to 1 KWH of energy consumed. It is a standard measure indicating amt of energy consumed by an electrical device or system.

* **Tariff** : It is cost at which the electrical energy is supplied to the consumer.
  Although tariff should the total cost of production and supply electrical energy plus the profit, yet it can't be same for all types of consumer.

→ **Two-part tariff** : When the rate of electrical energy is charged on the basis of maximum demand of consumer and units consumed, it's called a two-part tariff.
  In this tariff the total charge to be made from consumer is split into two components ie fixed charges and running charges. The fixed charges depends upon the max demand of the consumer while the running charges depends upon no. of units consumed by the consumer. Thus a consumer is charge at certain amt per KW of maximum demand plus certain amt of KWH of energy consumed.

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∴ Total charges = Rs. $[(b \times KW) + (c \times KWH)]$

where b is a charge / kw of max demand & c is charge / kwh of energy consumed.

Q1 Calculate the electricity bill of a household for a month (having 30 days) using with the following details.

electrical appliance	wattage (unit watt)	Hours/day
6 Ceiling fans	60	10
4 CFL bulb	15	15
6 LED bulb	10	5
1 computer	100	4
Television set 1	250	8
1 Mixer Grinder	450	0.25
1 air conditioner	1500	10
1, 1.5 Hp motor	1100	0.5

Consider the cost of 1 unit of electricity as Rs. 6

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Ans: (1)

electrical appliance	wattage	Hours/day	Total kWh per day	Total kWh/day
Ceiling fan: 6	60	10	6×60×10 3.6×10 (3600)	3.6
CFL bulb: 4	50	15	900	0.9
LED bulb: 6	10	5	300	0.3
Computer 1	100	4	400	0.4
T.V: 1	250	8	2000	2
Mixer: 1	450	0.25	112.5	0.1125
A.C: 1	1500	10	15000	15
1.5 HP Motor: 1	1100	0.5	550	0.55
			Total KWh/day of all appliances	= 22.8625

∴ The total power consumed in a month (30 days) = 22.8625 × 30
= 685.2415

∴ The electricity bill = Total energy consumed in a month × cost of one unit
= Rs. 4115

Power rating for household appliances :-

Appliances	wattage
Ceiling fans	60 - 80 W
fluorescent lamp	50-60 W
CFL bulb	10-30 W
Incandescent lamp	40-100 W
LED	10-15 W
A.C	1500-2000 W
TV	150-200 W
Motor (1Hp-1.5Hp)	740 - 1100 W
Desk top Comp	200 W
laptop	100 W
Printer	100 W
Iron box	1000-1500 W
Geyser	1500-2000 W
Refrigerator	400 - 500 W
Mixer	500-900 W

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Q(1) Calculate the E. bill of a household for a month (30-days) using the following details.

Appliance	Numbers	wattage	Hours	Total kWh/day
Incandescent bulb	3	40W	6	720 => 0.72
Tubelight	4	50W	8	1600 => 1.6
TV	1	120W	6	720 => 0.72
Ceiling fan	6	60W	10	3600 => 3.6
CFL	4	15W	8	480 => 0.48

Consider the cost of 1 unit of electricity as Rs. 7

Ans: Total kWh/day of all appliances = 7.12×30 month

= 213.6

∴ Electricity bill = ₹ 1495.2