<UNIT-3>

<Three phase A.C. Circuit>

Que.1> Write down Merits & Demerits of poly phase system over Single phase system.

Ans.1> (i) In a single phase system power delivered is pulsating even when Current and Voltage are in phase. the power is zero twice in a Cycle. In case of heavy motor this Cause Vibration. this problem is resolved in three phase System

(ii) The rating of given machine Increases with the Increase in no of phase.

(iii) Single phase Motor (Induction) has no starting torque but three phase Induction Motor has starting torque.

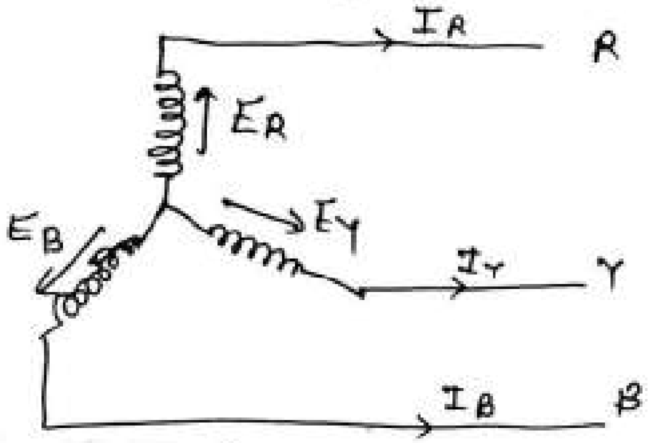
(iv) Power factor of single phase Motor is lower than that of poly phase motor of same rating.

(V) Three phase system requires 3/4th weight of copper of that required in single phase system to transmit the Same amount of power at given voltage over Same Distance

(vi) Rotating Magnetic field can be setup by poly phase system only.

Que.2> Prove that for a star Connected System the line Voltage = $\sqrt{3}$ Phase Voltage. ($V_L = \sqrt{3} V_P$).

Ans.>



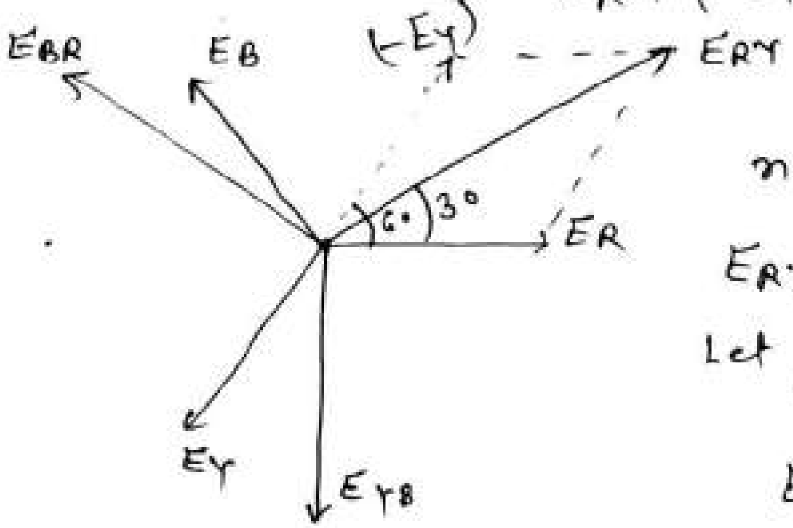
* Voltage b/w any two line is known as line voltage.

⇒ here the Phase Sequence is R, Y, B

Line Voltages are E_{RY}, E_{YB}, E_{BR}

now $E_{RY} = E_R - E_Y$

$= E_R + (-E_Y)$



now from phasor Diagram

$$E_{RY} = \sqrt{E_R^2 + E_Y^2 + 2E_R E_Y \cos 60}$$

Let $E_R = E_Y = E_B$ = Phase Voltage (E_P)

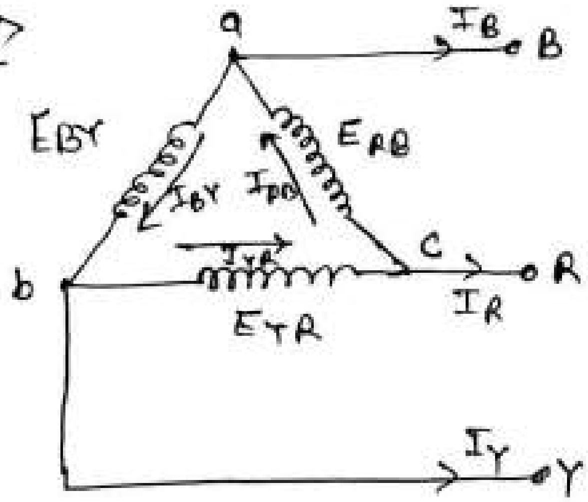
$E_{RY} = E_L$ (Line Voltage)

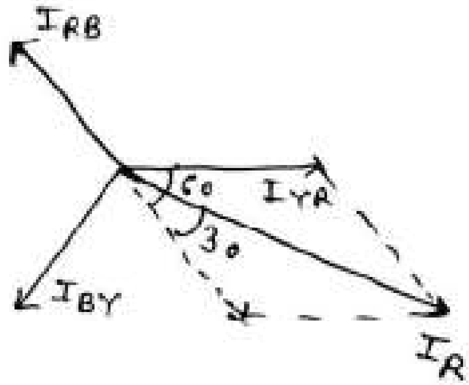
$$E_{RY} = \sqrt{E_P^2 + E_P^2 + 2E_P^2 \cos 60}$$

$$\boxed{E_L = \sqrt{3}\, E_P}$$

Que.3> For Delta Connected System Prove that $I_L = \sqrt{3}\, I_P$.

Ans.>





from the figure we can say

line Voltage = Phase voltage

$$\boxed{E_L = E_P}$$

Now apply KCL at Node C →

$I_R = I_{YR} - I_{RB}$

$I_R = I_{YR} + (-I_{RB})$

the angle b/w I_{YR} & $-I_{RB}$ is 60°

So

$I_R = \sqrt{I_{YR}^2 + I_{RB}^2 + 2 I_{YR} I_{RB} \cos 60}$

now $I_{YR} = I_{RB} = I_{BY} = I_p$ (Phase Voltage)

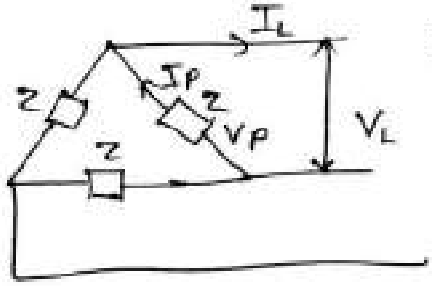
$I_R = \sqrt{I_p^2 + I_p^2 + 2 I_p^2 \cos 60}$

$I_R = \sqrt{3}\, I_p$

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

Ques. 4 > A balance Delta connected load of $(12 + j9)\,\Omega$/phase is connected to 3 phase 400V supply. Find (i) line current (ii) Power factor (iii) Power consume (iv) Reactive Power

Ans. > $R = 12\,\Omega$ $X_L = 9\,\Omega$



$I_L = \sqrt{3}\, I_p$

$V_p = V_L$

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

$= 15\,\Omega$

$\cos\phi = R/Z = 12/15$

$\phi = 36.87°$

(i) Phase current $I_p = \frac{V_p}{Z} = \frac{400}{15} = 26.67$ A

$I_L = \sqrt{3}\, I_p$ $I_L = 46.2$ A

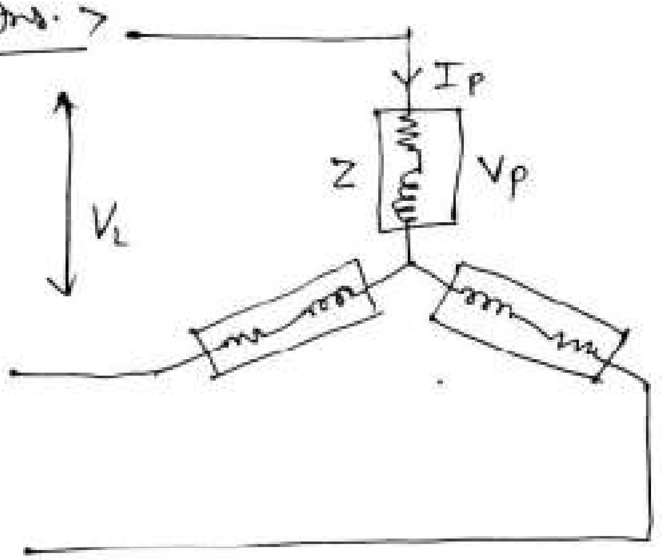
(ii) $\cos\phi = 12/15 = 0.8$ (lagging)

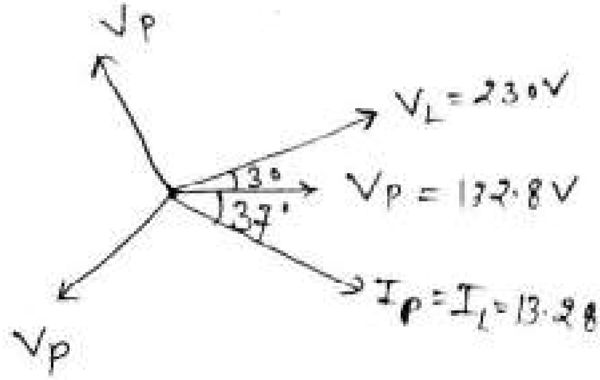
(iii) $P = 3 V_p I_p \cos\phi = 25600$ W

(iv) $P_R = 3 V_p I_p \sin\phi = 3 \times 400 \times 26.67 \times 0.6 = 19200$ W

Que. 5> A balance star Connected load of $(8+j6)\,\Omega$ per phase is Connected to 3 phase, 230V, 50Hz. Supply. find the line current, power factor, Volt ampere reactive. Draw the phasor Diagram for ckt.

Ans. >





now given → $V_L = 230V$ $Z = \sqrt{8^2+6^2} = 10\,\Omega$

$Z = 8+j6\,\Omega$ $V_P = V_L/\sqrt{3} = 132.8\,V$

now

$$I_P = \frac{V_P}{Z} = \frac{132.8}{10} = 13.28\,A$$

(i) $I_L = I_P = 13.28\,A$

(ii) $\cos\phi = R/Z = 0.8$ and $\phi = 36.87$

(iii) $P = 3V_P I_P \cos\phi = 3 \times 132.8 \times 13.28 \times 0.8 = 4.232\,kW$

(IV) $P_R = 3 V_P I_P \sin\phi = 3 \times 132.8 \times 13.28 \times 0.6 = 3.179\,kVAR$

Que. 6> A 3ϕ balance load draw 10kW Power from a 400V, 3phase, supply at 0.8 lagging power factor. determine (i) line current (ii)

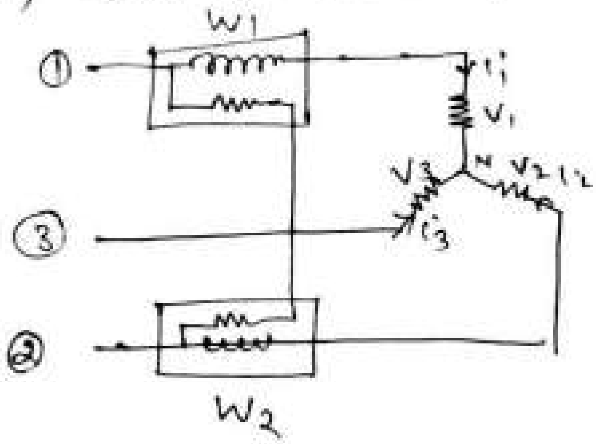
Ans.> $P = 10kW$ $V_L = 400V$ $\cos\phi = 0.8$

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

$\boxed{I_L = 18.04A}$ Ans

Qu.7> Prove that Power can be measured by two wattmeter method for Star & Delta Connected System.

(i) Star Connected System>



Total Power in ckt is given by

$$P = V_1 i_1 + V_2 i_2 + V_3 i_3 \quad \text{---(i)}$$

apply KCL at node N

$$i_1 + i_2 + i_3 = 0$$
$$i_3 = (-i_1 - i_2)$$

Put the value of i_3 in eq. (i)

$$P = V_1 i_1 + V_2 i_2 - V_3(i_1 + i_2)$$
$$P = i_1 (V_1 - V_3) + i_2 (V_2 - V_3) \quad \text{———(ii)}$$

* Now for Wattmeter reading.

(W_1) → the current coil having current i_1 & Pressure coil voltage is $V_{13} = (V_1 - V_3)$ so Wattmeter reading is

$$W_1 = i_1 (V_1 - V_3)$$

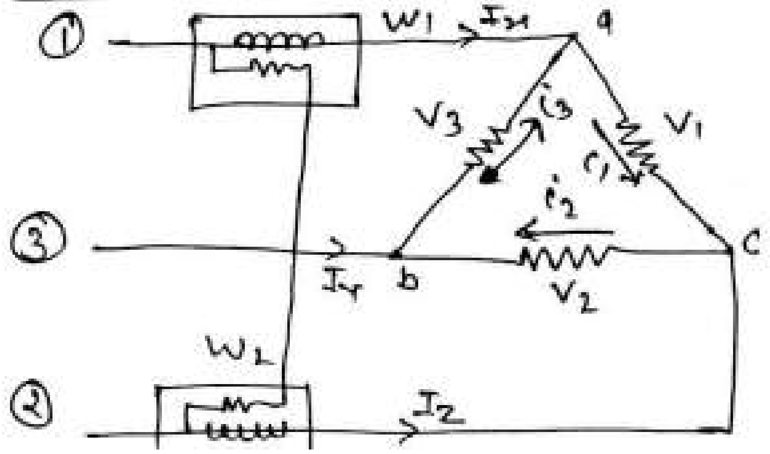
Similarly $W_2 = i_2 (V_2 - V_3)$

by eq. (ii) total Power is now

$$\boxed{P = W_1 + W_2}$$

So total Power can be measured by two wattmeter Method

(ii) Delta Connected System>



Total Power in Delta Connected System is

$$P = V_1 i_1 + V_2 i_2 + V_3 i_3 \quad \text{---(i)}$$

apply KVL in loop abcb →

$$V_1 + V_2 + V_3 = 0$$
$$V_1 = -(V_2 + V_3)$$

Put the value of V_1 in eq. (1')

$$P = V_1 i'_1 + V_2 i'_2 + V_3 i'_3$$

$$= -(V_2+V_3) i'_1 + V_2 i'_2 + V_3 i'_3$$

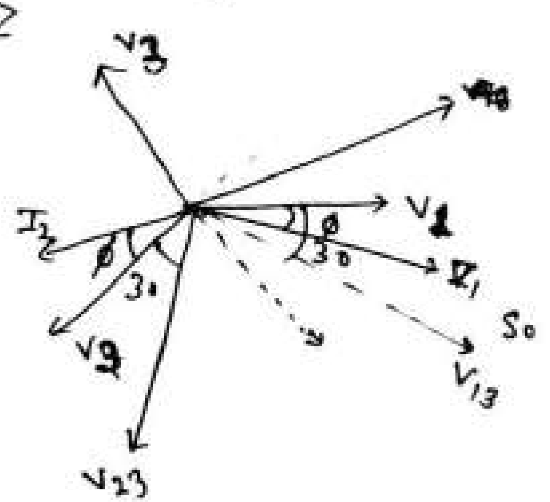
$$P = -V_3(i'_1 - i'_3) + V_2(i'_2 - i'_1)$$

Compairing with wattmeter reading →

$$\boxed{P = W_1 + W_2}$$

Que. 8> Derive the Expression for power factor by wattmeter reading.

Ans.>



Wattmeter readings are

$$W_1 = i_1 (V_1 - V_3)$$

$$W_2 = i'_2 (V_2 - V_3)$$

for Inductive load →

$$W_1 = V_L I_L \cos(30 - \phi)$$

$$W_2 = V_L I_L \cos(30 + \phi)$$

now $W_1 + W_2 = V_L I_L \cos(30 - \phi) + V_L I_L \cos(30 + \phi)$

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

$$W_1 - W_2 = V_L I_L \cos(30 - \phi) - V_L I_L \cos(30 - \phi)$$

$$= V_L I_L [2 \sin 30 \sin\phi]$$

$$= V_L I_L \sin\phi$$

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{1}{\sqrt{3}} \tan\phi$$

$$\tan\phi = \sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)$$

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