BEE QUESTION PAPER SOLUTION

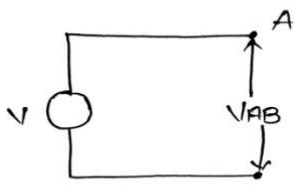
MAY 2018(CBCGS)

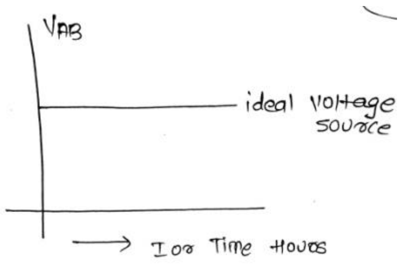
Q1] a) What is the difference ideal source and actual source? Illustrate the concept using the V-I characteristics of voltage and current source. (4)

Solution:-

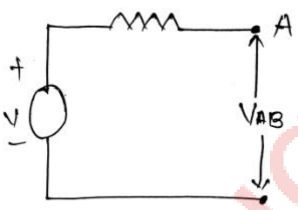
A voltage source is a two terminal device whose voltage at any instant of time is constant and is independent of the current drawn from it.

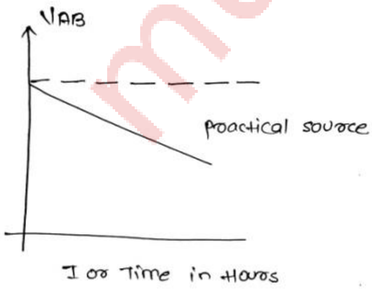
Ideal voltage source have zero internal resistance practically an ideal voltage source cannot be obtained.





Source having some amount of internal resistance are known as practical voltage source due to this internal resistance voltage drop takes place and it causes the terminal voltage to reduce.





Q1] b) In a balanced three phase circuit the power factor is 0.866. what will be the ratio of two wattmeter reading if the power is measured using two wattmeter **(4)**

Solution:-

Pf = 0.866

$\cos\varphi = 0.866$

$\varphi = \cos^{-1} 0.866$

$\varphi = 30.00$

$\tan\varphi = \tan(30.00) = 0.57735$

$\tan\varphi = \sqrt{3}\frac{(W_1-W_2)}{(W_1+W_2)}$

$\frac{0.57735}{\sqrt{3}} = \frac{(W_1-W_2)}{(W_1+W_2)}$

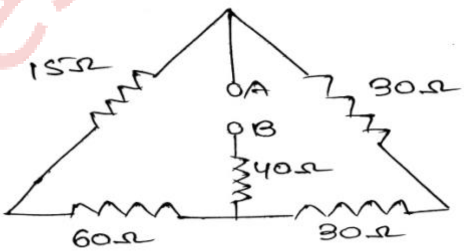
$0.333((W_1 + W_2) = (W_1 - W_2)$

$0.333W_2 + W_2 = W_1 - 0.333W_1$

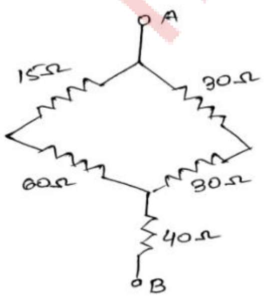
$\frac{W_1}{W_2} = \frac{1.333}{0.667}$

$\frac{W_1}{W_2} = 1.9985$

Q1] c)calculate R_{AB} **(4)**



Solution:-

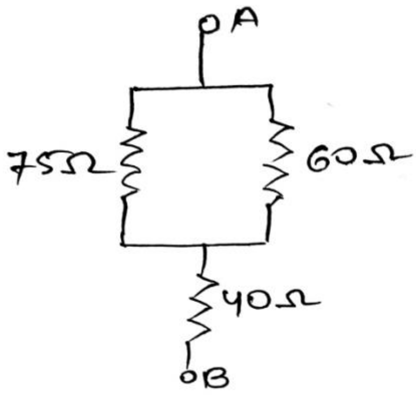


15+60 = 75Ω ………….(resistors are in series)

30+30 = 60Ω ……………..(resistors are in series)

Now, resistor 75Ω and 60Ω are in parallel,

75 || 60 = 33.33Ω



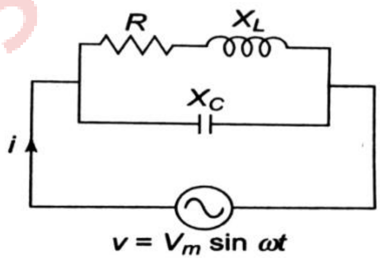
Now 33.33Ω and 40Ω are in series.

33.33 + 40 = 73.33Ω

R = 73.33Ω

Q1] d) Derive the equation for resonance frequency for a parallel circuit in which a capacitor is connected in parallel with a coil having resistance R and inductive reactance X_L. What is the resonance frequency if inductor is ideal? (4)

Solution:-



Consider a parallel circuit consisting of a coil and a capacitor as shown below. The impedances of two branches are:-

$\overline{Z_1} = R + jX_L$ $\quad\quad$ $\overline{Z_2} = -jX_C$

$\overline{Y_1} = \frac{1}{\overline{Z_1}} = \frac{1}{R+jX_L} = \frac{R-jX_L}{R^2+X_L^2}$ $\quad\quad$ $\overline{Y_2} = \frac{1}{\overline{Z_2}} = \frac{1}{-jX_C} = \frac{j}{X_C}$

Admittance of the circuit $\quad \bar{Y} = \overline{Y_1} + \overline{Y_2}$

$\bar{Y} = \frac{R-jX_L}{R^2+X_L^2} + \frac{j}{X_C} \quad = \frac{R}{R^2+X_L^2} - j\left(\frac{X_L}{R^2+X_L^2} - \frac{1}{X_C}\right)$

At resonance the circuit is purely resistive. Therefore, the condition for resonance is.

$$\frac{X_L}{R^2+X_L^2} - \frac{1}{X_C} = 0$$

$$\frac{X_L}{R^2+X_L^2} = \frac{1}{X_C}$$

$$X_L X_C = R^2 + X_L^2$$

$$\omega_0 L \frac{1}{\omega_0 C} = R^2 + {\omega_0}^2 L^2$$

$${\omega_0}^2 L^2 = \frac{L}{C} - R^2$$

$$\omega_0 = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

Where f_0 is called as the resonant frequency of the circuit.

If R is very small as compared to L then

$$\omega_0 = \sqrt{\frac{1}{LC}}$$

$$\boldsymbol{f_0 = \frac{1}{2\pi\sqrt{LC}}}$$

DYNAMIC IMPEDANCE OF A PARALLEL CIRCUIT.

At resonance the circuit is purely resistive the real part of admittance is $\frac{R}{R^2+X_L^2}$. Hence the dynamic impedance at resonance is given by,

$$Z_D = \frac{R^2 + X_L^2}{R}$$

At resonance ,

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

$$\boldsymbol{Z_D = \frac{L}{CR}}$$

Q1] e) What are the classification of DC motor? Specify one application for each one. (4)

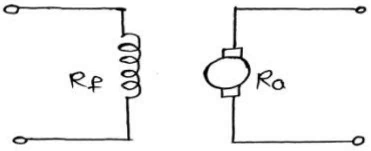
Solution:-

Depending upon the method of excitation of field winding ,DC machine are classified into two classes:-

1) Separately excited machines.
2) Self excited machines.

SEPARATELY EXCITED MACHINES

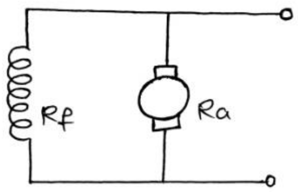
In separately excited machines the field winding is provided with a separate DC source to supply the field current as shown in figure.



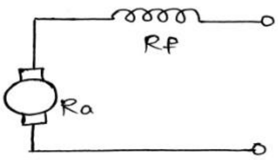
SELF EXCITED MACHINES

In case of self excited machines no, separate source is provided to drive the field current, but the field current is driven by its own emf generated across the armature terminals when the machine works as a generator self excited machine are further classified into the three types, depending upon the method in which the field winding is connected to the armature:

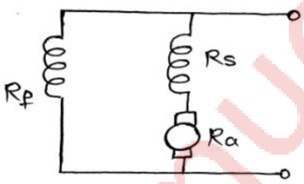
a) SHUNT WOUND MACHINES



b) SERIES WOUND MACHINES



c) COMPOUND WOUND MACHINES



Q1] f) Derive emf equation of a single phase transformer (4)

Solution:-

EMF EQUATION.

As the primary winding is excited by a sinusoidal alternating voltage, an alternating current flows in the winding producing a sinusoidally varying flux φ in the core.

$$\varphi = \varphi_m sin\omega t$$

As per Faraday's law of electromagnetic induction an emf e_1 is induced in the primary winding.

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

$$e_1 = -N_1 \frac{d}{dt}(\varphi_m sin\omega t)$$

$$e_1 = -N_1 \varphi_m \omega cos\omega t \;=\; -N_1 \varphi_m \omega \sin(\omega t - 90°) \;=\; 2\pi f N_1 \varphi_m \omega \sin(\omega t - 90°)$$

Maximum value of induced emf = $2\pi f \varphi_m N_1$

Hence, rms value of induced emf in primary winding is given by,

$$E_1 = \frac{E_{max}}{\sqrt{2}} = \frac{2\pi f N_1 \varphi_m}{\sqrt{2}} = 4.44 f N_1 \varphi_m$$

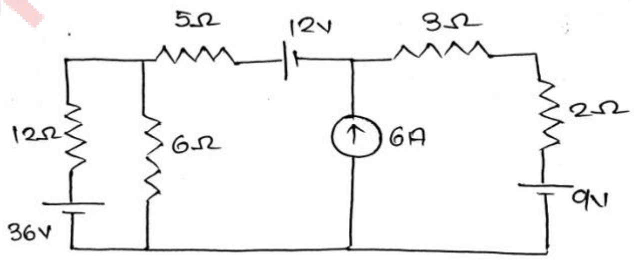
Similarly rms value of induced emf in the secondary winding is given by,

$$E_2 = 4.44 f N_2 \varphi_m$$

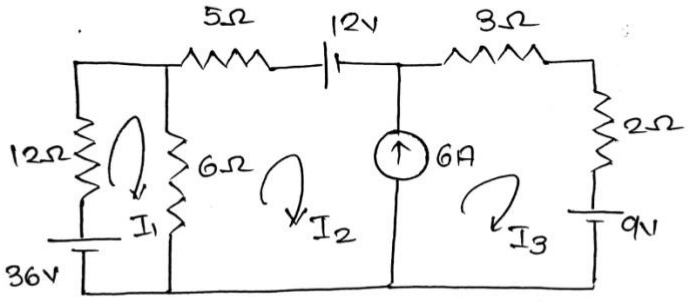
Also, $\frac{E_1}{N_1} = \frac{E_2}{N_2} = 4.44 f \varphi_m$

Thus emf per turn is same in primary and secondary winding and an equal emf is induced in each turn of the primary and secondary winding.

Q2] a)Using mesh analysis find current through 5Ω (8)



Solution:-



$I_3 - I_2 = 6$ ………….(1)

Applying KVL to mesh 1

$-36 - 12(I_1) + 6(I_1 - I_2) = 0$

$-12I_1 + 6I_1 - 6I_2 = 36$

$-6I_1 - 6I_2 = 36$

$6I_1 + 6I_2 = -36$ …………………..(2)

Applying KVL to mesh 2

-$6(I_2 - I_1) + 5I_2 + 12 = 0$

$-6I_2 + 6I_1 + 5I_2 + 12 = 0$

$6I_1 - I_2 = -12$ ……………………...(3)

From (1), (2) and (3)

$I_1 = -2.57A$, $I_2 = -3.428A$ and $I_3 = 2.571A$

Current through 5Ω = 3.428(←)A

Q2] b) An emf of 250V is applied to an impedance $Z_1 = (12.5 + j20)\Omega$. An impedance Z_2 is added in series with Z_1, the current become half of the origin and lead the supply voltage by 20°. Determine Z_2 (8)

Solution:-

V = 250∠0° $Z_1 = 12.5 + 20j$

$I_1 = \frac{\bar{V}}{\bar{Z_1}} = \frac{250\angle 0°}{12.5+20j} = \frac{250\angle 0°}{23.5849\angle 57.99}$

$I_1 = 10.600\angle -57.99$

$I_2 = \frac{250\angle 20°}{Z_2}$

$\frac{I_1}{2} = \frac{250\angle 20°}{Z_2}$

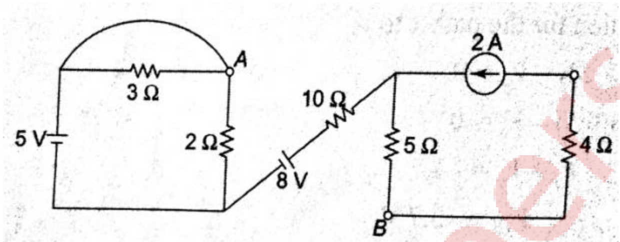
$Z_2 = \frac{500\angle 20°}{I_1}$

$Z_2 = \frac{500\angle 20°}{10.600\angle -57.99}$

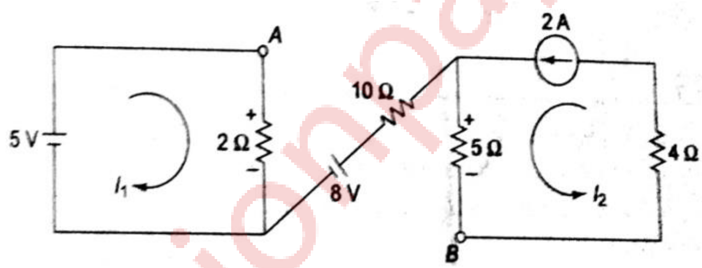
$Z_2 = 47.1698\angle 77.99$

$Z_2 = 9.815 + 46.131j$

Q2] c) Determine the potential difference V_{AB} for the given network **(4)**



Solution:-



The resistor of 3Ω is connected across a short circuit. Hence it gets shorted.

$I_1 = \frac{5}{2} = 2.5$A

$I_2 = 2A$

Potential difference, $V_{AB} = V_A - V_B$

Writing KVL equation for the path A to B,

$V_A - 2I_1 + 8 - 5I_2 - V_B = 0$

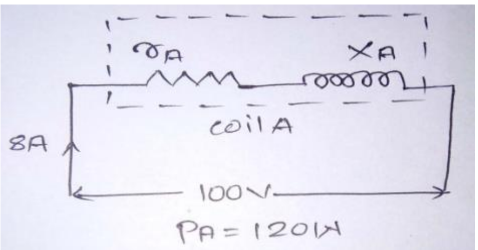
$V_A - 2(2.5) + 8 - 5(2) - V_B = 0$

$V_A - V_B = 7$

$V_{AB} = 7V$

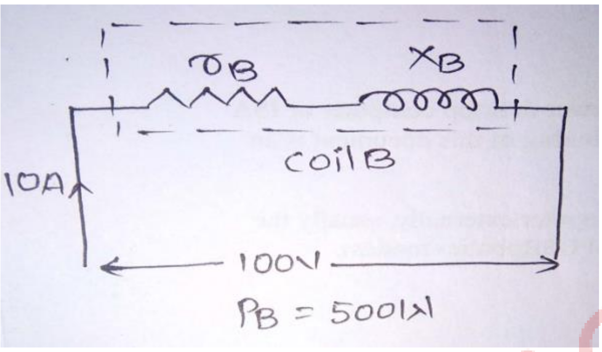
Q3] a) When a voltage of 100V, 50Hz is applied to an impedance A current taken is 8A lagging and power is 120W. When it is connected to an impedance B the current is 10A leading and power is 500W. what current and power will be taken if it is applied to the two impedances connected in series. (8)

Solution:-



Coil A : $V_A = 100V \quad I_A = 8A \quad P_A = 120W$

Coil B : $V_B = 100V \quad I_B = 10A \quad P_B = 500W$



For coil A , $Z_A = \frac{V_A}{I_A} = \frac{100}{8} = 12.5\Omega$

$P_A = I_A^2 r_A$

120 = $8^2 \times r_A$

$r_A = 1.875\Omega$

$X_A = \sqrt{12.5^2 - 1.875^2} = 12.36\,\Omega$

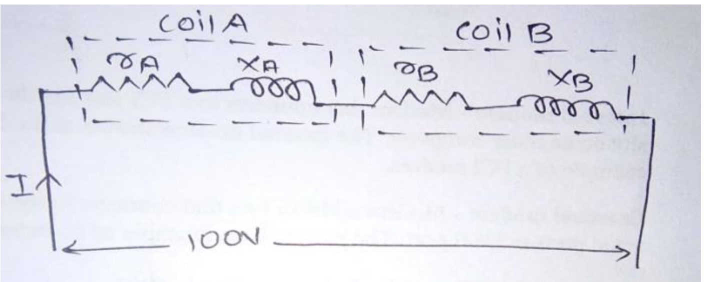
For coil B, $Z_B = \frac{V_B}{I_B} = \frac{100}{10} = 10\Omega$

$P_B = I_B^2 r_B$

500 = $10^2 \times r_B$

$r_B = 5\Omega$

$X_B = \sqrt{10^2 - 5^2} = 8.66\,\Omega$



When coils A and B are connected in series,

$\bar{Z} = r_A + jX_A + r_B + jX_B$

$\bar{Z} = 1.875 + j12.36 + 5 + j8.66$

$\bar{Z} = 6.875 + j21.02$

$\bar{Z} = 22.11\angle 71.89°$

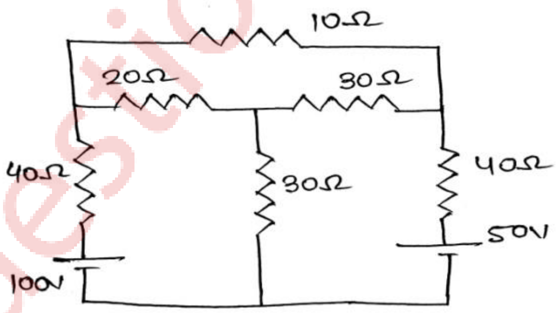
Z = 22.11Ω

$\varphi = 71.89°$

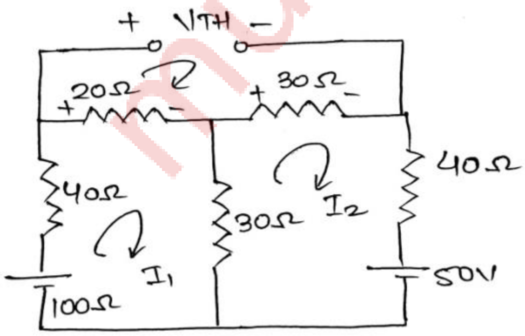
$I = \frac{V}{Z} = \frac{100}{22.11} = 4.52A$

P = $I^2(r_A + r_B)$ = $4.25^2 \times 6.875^2 = 140.64W$

Q3] b) Find current through 10Ω using Thevenin's theorem (8)



Solution:-



(1) Calculation of V_{TH}

Applying KVL to mesh 1

$-100 + 40I_1 + 20I_1 + 30(I_1 - I_2) = 0$

$40I_1 + 20I_1 + 30I_1 - 30I_2 = 100$

$90I_1 - 30I_2 = 100$ ………………(1)

Applying KVL to mesh 2

$30(I_2 - I_1) + 30I_2 + 40I_2 + 50 = 0$

$30I_2 - 30I_1 + 30I_2 + 40I_2 = -50$

-$30I_1 + 100I_2 = -50$

$30I_1 - 100I_2 = 50$ ………………………(2)

From (1) and (2) we get

$I_1 = 1.049$ and $I_2 = -0.185$

V_{TH} equation:-

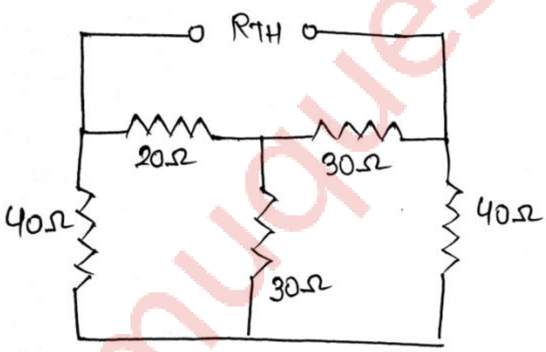
$V_{TH} - 30I_2 - 20I_1 = 0$

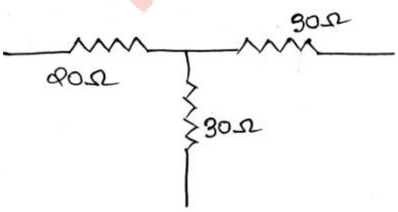
$V_{TH} - 30(-0.185) - 20(1.049) = 0$

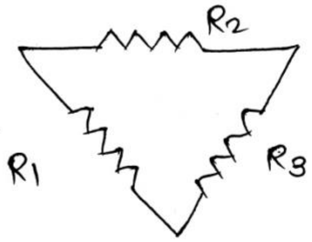
$V_{TH} = 15.43V$

(2) Calculation of R_{TH}

$R_1 = 20 + 30 + \frac{20\times30}{30} = 70\Omega$

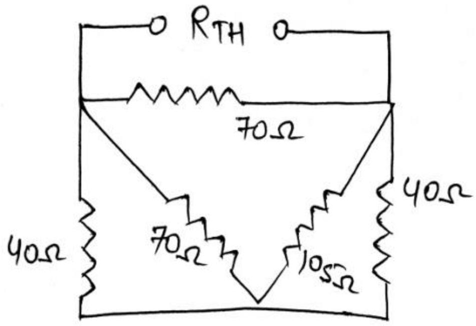






$R_2 = 20 + 30 + \frac{20 \times 30}{30} = 70\Omega$

$R_3 = 30 + 30 + \frac{30 \times 30}{20} = 105\Omega$



40 || 70 = 25.4545

105 || 40 = 28.9655

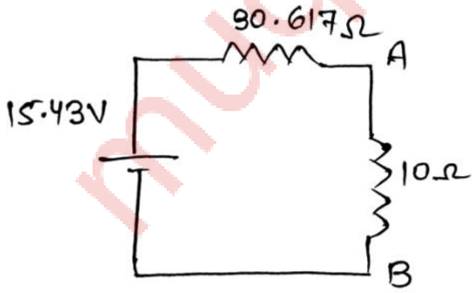
25.4545+28.9655 = 54.42Ω

$R_{TH} = 30.617\Omega$

(3) Calculation of I_L

$I_L = \frac{15.43}{30.617+10}$

$I_L = 0.3798A$



Q3] c) With the help of equivalent circuit of a single phase transformer show how total copper loss can be represented in primary of a transformer. (4)

Solution:-

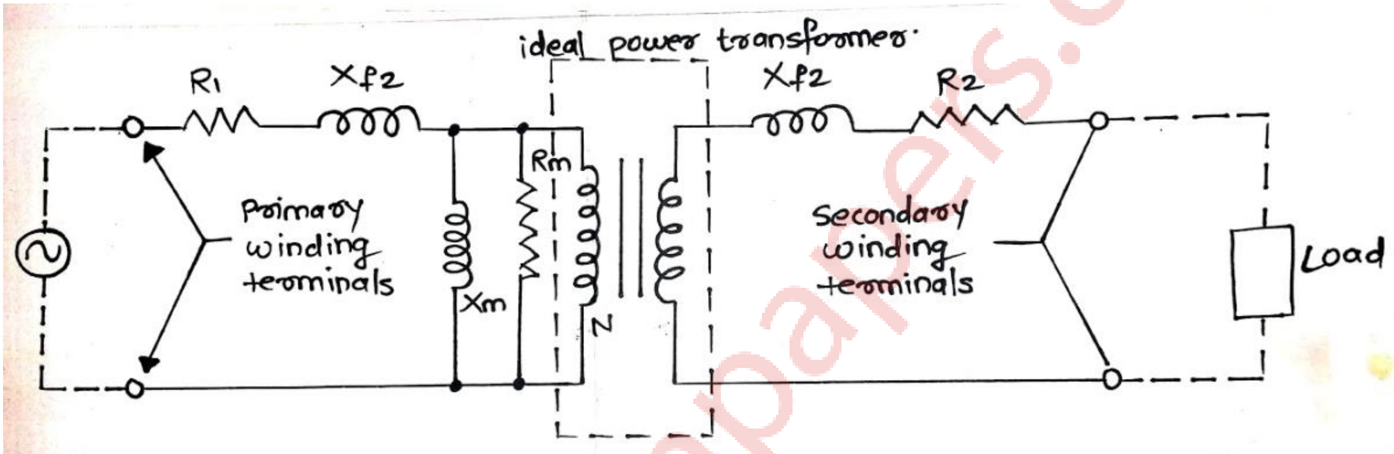
Copper Loss:- This loss is due to the resistances of primary and secondary windings.

$$W_{cu} = I_1^2 R_1 + I_2^2 R_2$$

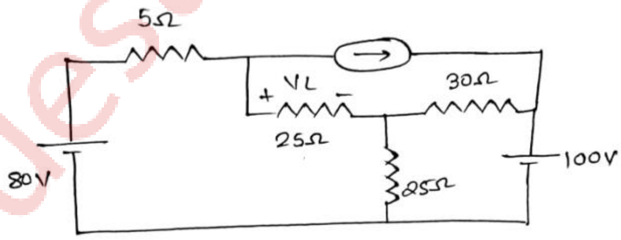
Where, R_1= Primary winding resistance

R_2 = secondary winding resistance.

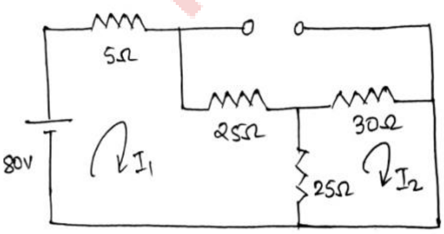
Copper loss depends upon the load on the transformer and its proportional to square of load current of kVA rating of the transformer.



Q4] a) Find V_L using super position theorem (8)



Solution:-



1) When 80V is active

Mesh analysis to mesh 1

$-80 + 5I_1 + 25I_1 + 25(I_1 - I_2) = 0$

$55I_1 - 25I_2 = 80$ ……………….(1)

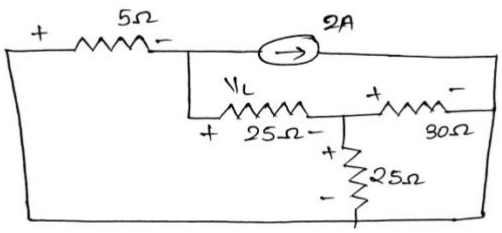
Mesh analysis to mesh 2

$-25(I_2 - I_1) + 30I_2 = 0$

$25I_1 + 5I_2 = 0$ ……………….(2)

From (1) and (2) we get,

$I' = 0.444A$

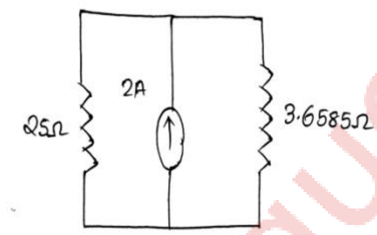


(2) when 2A is active

(25 | | 30) = 13.6363Ω

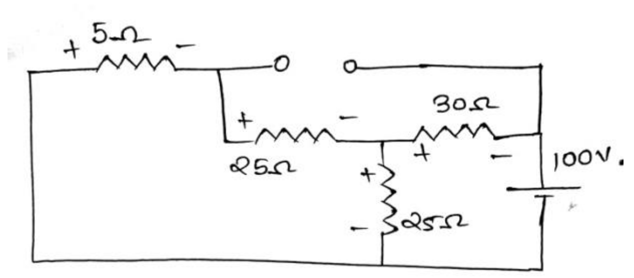
(13.6363 | | 5) = 3.6585Ω

Hence we get



$I'' = 2 \times \frac{3.6585}{3.6585+25} = 0.25531A$

(3) when 100V is active



$5I_1 + 25I_1 + 25(I_1 - I_2) = 0$

$55I_1 - 25I_2 = 0$ …………………(1)

$-25(I_2 - I_1) + 30I_2 + 100 = 0$

$25I_1 + 5I_2 = -100$ ……………….(2)

From (1) and (2)

$I''' = -2.77A$

current through V_L is:

= 0.444 + 0.25531 – 2.77

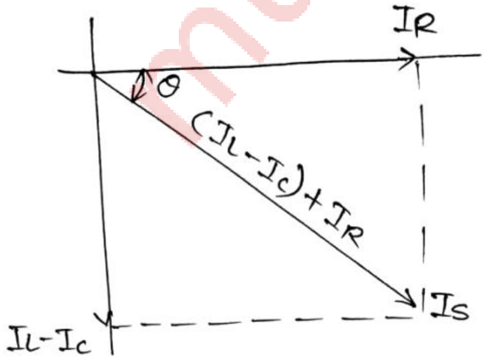
= -2.07069A

$I = 2.07069A$

Q4] b) In an R-L-C parallel circuit the current through resistor, inductor(pure) and capacitor are 20A, 15A and 40A respectively. What is the current taken from the supply? Draw phasor diagram. (4)

Solution:-

$I_R = 20A$, $I_L = 15A$ and I_C =40A



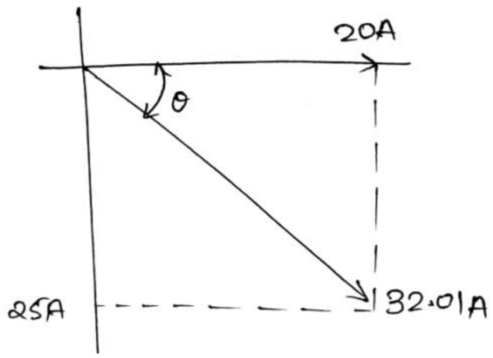
To calculate the source current according to phasor diagram,

$I_S^2 = I_R^2 + (I_L - I_C)^2$

$I_S^2 = 20^2 + (15 - 40)^2$

$I_S^2 = 1025$

$I_S = 32.01$ A



Q4] c) Two sinusoidal source of emf have rms value E_1 and E_2. When connected in series, with a phase displacement α the resultant voltage read on an electrodynamometer voltmeter 41.1V and with one source reserved 17.52V. When the phase displacement made zero a reading of 42.5V is observed. Calculate E_1, E_2 and α (8)

Solution:-

$\overline{E_1} = E_1\angle 0°$

$\overline{E_2} = E_2\angle \alpha°$

When two sources are connected in series,

$\sqrt{E_1^2 + E_2^2 + 2E_1E_2cos\alpha} = 41.1$

$E_1^2 + E_2^2 + 2E_1E_2cos\alpha = 1689.21$ ....(1)

When one of the source is reversed,

$\sqrt{E_1^2 + E_2^2 - 2E_1E_2cos\alpha} = 17.52$

$E_1^2 + E_2^2 - 2E_1E_2cos\alpha = 306.95$ ....(2)

When phase displacement is made zero,

$\sqrt{E_1^2 + E_2^2 + 2E_1E_2cos0} = 42.5$

$E_1 + E_2 = 42.5$

Adding eqn (1) and (2) we get,

$2(E_1^2 + E_2^2) = 1996.16$

$E_1^2 + E_2^2 = 998.08$

$(42.5 - E_2)^2 + E_2^2 = 998.08$

$1806.25 - 85E_2 + E_2^2 + E_2^2 = 998.08$

$E_2^2 - 42.5E_2^2 + 404.09 = 0$

Solving eq (2) from eq (1),

$E_2 = 28.14V$ or $E_2 = 14.36V$

$E_1 = 14.36V$ or $E_1 = 28.14V$

Subtracting eqn (2) from eqn (1),

$4E_1E_2cos\alpha = 1382.26$

$4 \times 14.37 \times 28.14cos\alpha = 1382.26$

$cos\alpha = 0.855$

$\alpha = 31.24°$

Q5] a) Prove that the power in a balanced three phase delta connected circuit can be deduced from the reading of two wattmeter. Draw relevant connections and vector diagrams. Draw a table to show the effect of power on wattmeter. (8)

Solution:-

Given figure shows a balanced star-connected load, the load may be assumed to be inductive. Let V_{RN}, V_{YN}, V_{BN} be the three phase voltages. I_R, I_Y, I_B be the phase currents. The phase currents will lag behind their respective phase voltages by angle φ. Current through current coil of $W_1 = I_R$

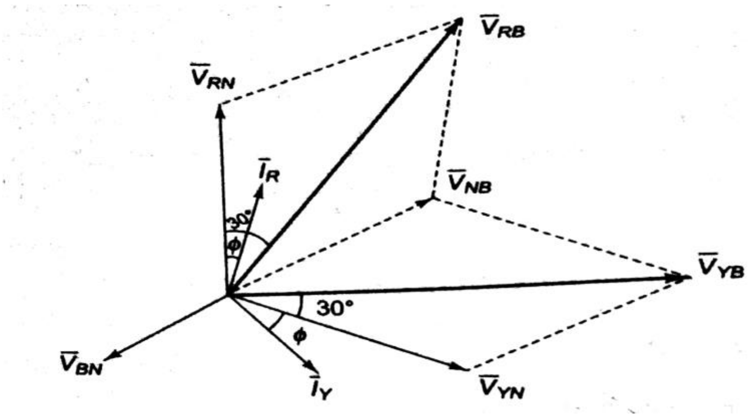
Voltages across voltage coil of $W_1 = V_{RB} = V_{RN} + V_{NB} = V_{RN} - V_{BN}$

From the phasor diagram, it is clear that the phase angle between V_{RB} and I_R is $(30° - \varphi)$

$W_1 = V_{RB}I_R\cos(30° - \varphi)$

Current through current coil of $W_2 = I_Y$

Voltage across voltage coil of $W_2 = V_{YB} = V_{YN} + V_{NB} = V_{YN} - V_{BN}$



From phasor diagram, it is clear that phase angle between V_{YB} and I_Y is $(30° + \varphi)$

$W_2 = V_{YB} I_Y \cos(30° + \varphi)$

But $I_R, = I_Y = I_L$

$V_{RB} = V_{YB} = V_L$

$W_1 = V_L I_L \cos(30° - \varphi)$

$W_2 = V_L I_L \cos(30° + \varphi)$

$W_1 + W_2 = V_L I_L \cos(30° - \varphi) + V_L I_L \cos(30° + \varphi)$

$W_1 + W_2 = V_L I_L (2cos30° cos\varphi)$

P(active power) = $W_1 + W_2 = \sqrt{3}\, V_L I_L (cos\varphi)$

Thus the sum of two wattmeter reading gives three phase power

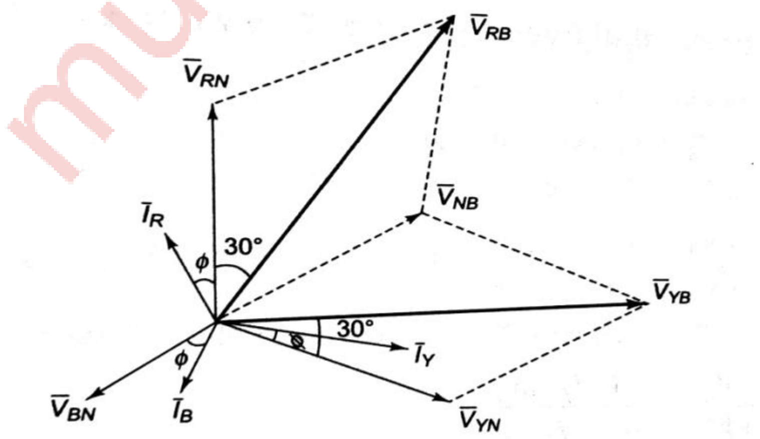
MEASUREMENT OF POWER FACTOR BY TWO-WATTMETER METHOD

(1) Lagging power factor

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

(2) Leading power factor

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



Q5] b) A 5kVA 200/400, 50Hz single phase transformer gave the following test results.

OC test on LV side	**200 V**	**0.7 A**	**60 W**
SC test on HVside	**22 V**	**16 A**	**120 W**

1. **Draw the equivalent circuit of the transformer and insert all parameter values.**
2. **Efficiency at 0.9 pf lead and rated load.**
3. **Current at which efficiency is maximum.** **(8)**

Solution:- 1) Equivalent circuit of the transform and parameters

From OC test(meters are connected on LV side i.e. primary)

$W_i = 60w$ $V_1 = 200V$ $I_0 = 0.7\text{Am}$

$\cos\varphi_0 = \frac{W_i}{V_1 I_0} = \frac{60}{200\times0.7} = 0.43$

$\sin\varphi_0 = (1 - 0.43^2)^{0.5} = 0.9$

$I_w = I_O cos\varphi_o = 0.7 \times 0.43 = 0.3A$

$R_O = \frac{V_1}{I_w} = \frac{200}{0.3} = 666.67\Omega$

$I_\mu = I_o sin\varphi_o = 0.7 \times 0.9 = 0.63\text{Am}$

$X_o = \frac{V_1}{I_\mu} = \frac{200}{0.63} = 317.46\Omega$

From SC test (meters are connected on HV side i.e. secondary)

$W_{sc} = 120w$ $V_{sc} = 22V$ $I_{sc} = 16A$

$Z_{02} = \frac{V_{sc}}{I_{sc}} = \frac{22}{16} = 1.375\Omega$

$R_{02} = \frac{W_{sc}}{I_{SC}^2} = \frac{120}{16^2} = 0.47\Omega$

$X_{02} = ({Z_{02}}^2 - {R_{02}}^2)^{0.5} = (1.375^2 - 0.47^2)^{0.5} = 1.29\Omega$

$K = \frac{400}{200} = 2$

$R_{01} = \frac{R_{02}}{K^2} = \frac{0.47}{4} = 0.12\Omega$

$X_{01} = \frac{X_{02}}{K^2} = \frac{1.29}{4} = 0.32\Omega$

2)Efficiency at rated load and 0.9 pf leading

$W_i = 60w = 0.60kw$

Since meters are connected on secondary in SC test,

$I_2 = \frac{5\times1000}{400} = 12.5A$

$W_{Cu} = I_2^2 R_{02} = 12.5^2 \times 0.47 = 73.43W = 0.073kW$

x = 1   pf = 0

$$\%\eta = \frac{\text{x } \times \text{full load KVA} \times \text{pf}}{(\text{x} \times \text{full load KVA} \times \text{pf}) + \text{W}_\text{i} + \text{x}^2\text{W}_\text{cu}} \times 100$$

$$\%\eta = \frac{1 \times 5 \times 0.9}{1 \times 5 \times 0.9 + 0.06 + 1 \times 0.073} \times 100$$

$\%\boldsymbol{\eta} = \mathbf{97.13}\%$

Regulation at rated load and 0.9 pf load,

$\cos\varphi = 0.9$

$\sin\varphi = 0.44$

$$\% \text{ regulation} = \frac{I_2(R_{02}cos\varphi - X_{02}sin\varphi)}{E_2} \times 100$$

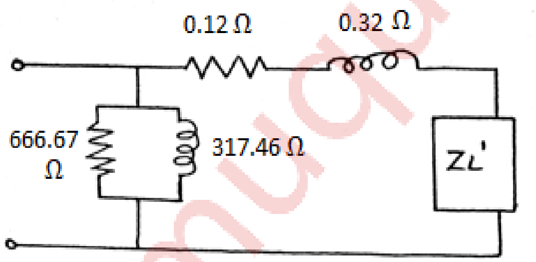
$$\% \text{ regulation} = \frac{12.5(0.47 \times 0.9 - 1.29 \times 0.44)}{400} \times 100$$

$\% \textbf{ regulation} = \mathbf{-0.45}\%$

Current at maximum efficiency,

$W_i = I_2^2 R_{02}$

$I_2 = \sqrt{\frac{W_i}{R_{02}}} = \sqrt{\frac{60}{0.47}} = 11.3$ A



Q5] c) Prove that if the phase impedance are same, power drawn by a balanced delta connected load is three times the power drawn by the balanced star connected load. (4)

Solution:-

Let a balanced load be connected in star having impedance per phase as Z_{ph}.

For a star-connected load

$V_{ph} = \frac{V_L}{\sqrt{3}}$

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{V_L}{\sqrt{3}Z_{ph}}$ => $I_{ph} = I_L = \frac{V_L}{\sqrt{3}Z_{ph}}$

Now, $P_Y = \sqrt{3}V_L I_L cos\varphi = \sqrt{3} \times V_L \times \frac{V_L}{\sqrt{3}Z_{ph}} \times cos\varphi = \frac{V_L^2}{Z_{ph}} cos\varphi$

For a delta-connected load

$V_{ph} = V_L$

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{V_L}{Z_{ph}}$ => $I_{ph} = \sqrt{3}I_L = \sqrt{3}\frac{V_L}{Z_{ph}}$

Now, $P_\Delta = \sqrt{3}V_L I_L cos\varphi = \sqrt{3} \times V_L \times \sqrt{3}\frac{V_L}{Z_{ph}} \times cos\varphi = 3\frac{V_L^2}{Z_{ph}} cos\varphi = 3P_Y$

$\boldsymbol{P_Y = \frac{1}{3} P_\Delta}$

Thus, power consumed by a balanced star-connected load is one third of that in the case of delta-connected load.

Q6] a) Three identical coils each having a reactance of 20Ω and resistance of 10Ω are connected in star across a 440V three phase line. Calculate for each method:

1. **Line current and phase current.**
2. **Active , reactive and apparent power.**
3. **Reading of each wattmeter connected to measure the power.** **(8)**

Solution:- $X_L = 20\Omega$ R = 10 Ω $V_L = 400\text{V}$

1. LINE CURRENT AND PHASE CURRENT.

$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}} = 230.94$ V

$\overline{Z_{ph}} = R + jX_L = 10 + j20$

$\overline{Z_{ph}} = 22.3606\angle 63.4349°$

$\varphi = 63.4349°$

Power factor = cos φ = cos(63.4349°) = 0.44721

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{230.94}{22.3606} = 10.3279$A

$I_{ph} = I_L = 10.3279$ A

2. Active, Reactive and apparent power.

Reactive power(Q) = $\sqrt{3} I_L V_L sin\varphi \ = \sqrt{3} \times 400 \times 10.3279 \times \sin(63.4349)$

= 6399.962W

Active power(P) = $\sqrt{3} I_L V_L cos\varphi$ = $\sqrt{3} \times 400 \times 10.3279 \times \cos(63.4349)$

= 3199.957 W

Apparent power(S) = $\sqrt{3} I_L V_L$ = $\sqrt{3} \times 400 \times 10.3279$

= 7155.3790 W

3. Readings of 2 wattmeter

Active power(P) = $\sqrt{3} I_L V_L cos\varphi$ = $\sqrt{3} \times 400 \times 10.3279 \times \cos(63.4349)$

= 3199.957 W

$w_1 + w_2 = 3199.9570$ ………………(1)

Also, tan$\varphi = \ \sqrt{3}\frac{w_1 - w_2}{w_1 + w_2}$

tan(63.4349) = $\sqrt{3}\frac{w_1 - w_2}{3199.9570}$

$w_1 - w_2 = 3694.9841$ ………….(2)

From (1) and (2) we get,

$w_1 = 3447.47055$ w

$w_2 = 247.51355$ w

Q6] b) A series resonant circuit has an impedance of 500Ω at resonance frequency. The cut of frequency observed are 10kHz and 100Hz, Determine:

1. **Resonant frequency**
2. **Value of R,L and C.**
3. **Q factor at resonance** **(6)**

Solution:- R = 500Ω $f_1 = 100$Hz $f_2 = 10$kHz

1. RESONANCE FREQUENCY.

BW = $f_2 - f_1 = 10{,}000 - 10 = 9900Hz$

$f_1 = f_0 - \frac{R}{4\pi L}$ ……………….(1)

$f_2 = f_0 + \frac{R}{4\pi L}$ ……………….(2)

Adding (1) and (2),

$f_1 + f_2 = 2f_0$

$f_0 = \frac{f_1+f_2}{2} = \frac{10+10000}{2} = 5050Hz$

2. Values of R, L and C

R = 500Ω

BW = $\frac{R}{2\pi L}$

9900 = $\frac{500}{2\pi L}$

L = 8.038mH

$X_{L_0} = 2\pi f_0 L = 2\pi \times 5050 \times 8.038 \times 10^{-3} = 255.05\Omega$

At resonance , $X_{L_0} = X_{C_0} = 255.05\Omega$

$X_{C_0} = \frac{1}{2\pi f_0 C}$

$255.05 = \frac{1}{2\pi \times 5050 \times C}$

$C = 0.12\mu F$

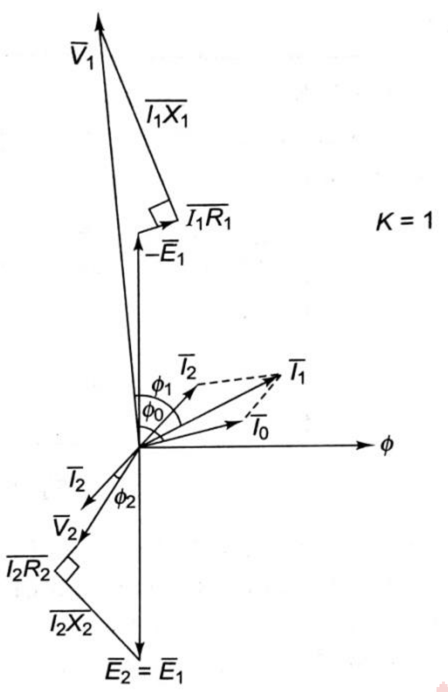
3. QUALITY FACTOR.

$Q_0 = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{500}\sqrt{\frac{8.038\times10^{-3}}{0.12\times10^{-6}}} = 0.5176$

$Q_0 = 0.5176$

Q6] c) Draw and illustrate transformer phasor diagram for lagging power factor. (6)

Solution:-



$\overline{V}_1$
$\overline{I_1X_1}$
$\overline{I_1R_1}$
$-\overline{E}_1$
K = 1
$\overline{I}_2$
$\overline{I}_1$
ϕ_1
ϕ_0
$\overline{I}_0$
ϕ
$\overline{I}_2$
ϕ_2
$\overline{V}_2$
$\overline{I_2R_2}$
$\overline{I_2X_2}$
$\overline{E}_2 = \overline{E}_1$