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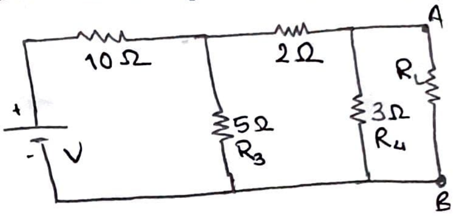
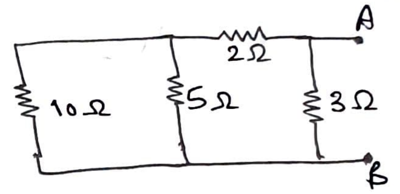
Section: C.S.E. 'K'

ELECTRICAL ASSIGNMENT - I

Q.1. Calculate the value of R_L at which maximum power transfer takes place. Calculate the maximum power.



Soln: To find R_{th},

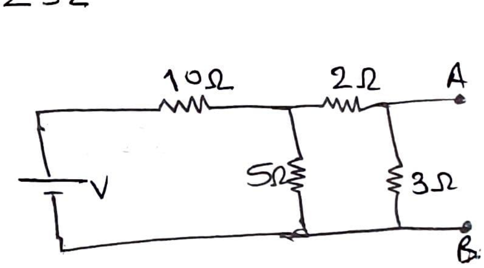


$$R_{th} = \frac{\left(\frac{10}{3}+2\right)\times 3}{\left(\frac{10}{3}+2\right)+3} = 1.92\,\Omega$$

we know, for P_{max},

$$R_L = R_{th} = 1.92\,\Omega$$

Now,



$$R_{eq} = \frac{5}{2} + 10 = 12.5\,\Omega$$

Total Current in Circuit, $= \frac{V}{12.5}$ A

Current through $3\Omega = \frac{V}{12.5\times 2} = \frac{V}{25}$ A

$\therefore V_{3\Omega} = \frac{3}{25} V = 0.12\, V$

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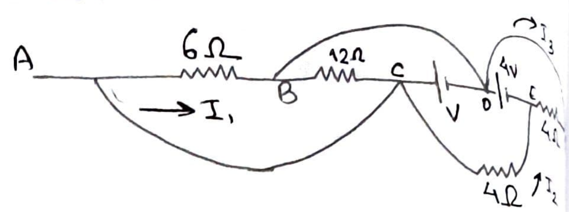
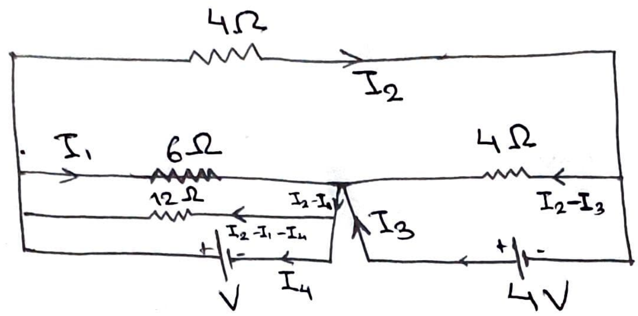
2. Find the currents I_1, I_2, I_3 and powers delivered by the sources of the network shown below:



Soln:-

Remaking the circuit,



Using mesh analysis,

(i) $4I_2 + 4(I_2 - I_3) - 6I_1 = 0$

$\therefore 6I_1 - 8I_2 + 4I_3 = 0$ —(i)

(ii) $4(I_2 - I_3) = -4V,$

$\therefore 4I_2 - 4I_3 = -4V$ —(ii)

(iii) $6I_1 + 12(I_2 - I_1 - I_4) = 0$

$\therefore 6I_1 - 12I_2 + 12I_4 = 0$ —(iii)

(iv) $12(I_2 - I_1 - I_4) = -1V$

$\therefore +12I_1 - 12I_2 + 12I_4 = 1V$ —(iv)

This gives,

$I_1 = 1V$ A

$I_2 =$ ~~XXXX~~ $1.25V$ A

$I_3 = 2.25V$ A

for, $V = 60V$,

$I_1 = 6V$, $I_2 = 75A$; $I_3 = 135A$

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$\therefore$ Power from source supplies,

Power delivered by $V = \frac{3}{2} \times V^2 = \frac{3}{2} \times (60)^2$

$= 5400\ W$

$= 5.4\ KW$

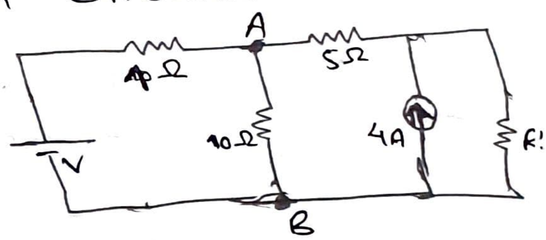
Power delivered by $4V = 4V\ I_3$

$= 4 \times 60 \times 135$

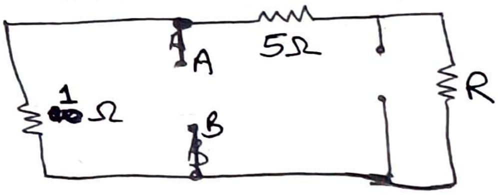
$= 32400\ W$

$= 32.4\ KW$

3. Find the current through $10\ \Omega$ resistor using Thevenin's theorem for the given circuit:



Soln: for R_{th},

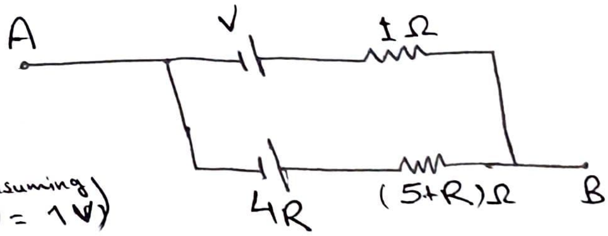


$$R_{th} = \frac{(5+R) \times 1}{5+R+1}$$

for $R = 60\ \Omega$,

$R_{th} = 0.984\ \Omega$

for V_{th},



(Assuming $V = 1V$)

$$V_{th} = \frac{\frac{1V}{1} + \frac{4 \times 60}{5+60}}{1 + \frac{1}{5+60}}$$

$$= \frac{1 + \frac{240}{65}}{1 + \frac{1}{65}}$$

$\therefore V_{th} = 4.62\ V$

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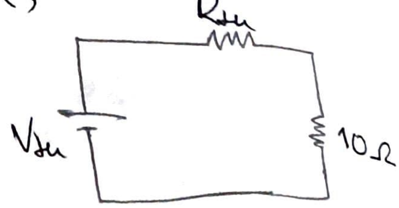
Making Thevenin's Equivalent Circuit,



Current through 10Ω,

$$= \frac{V_{th}}{10 + R_{th}}$$

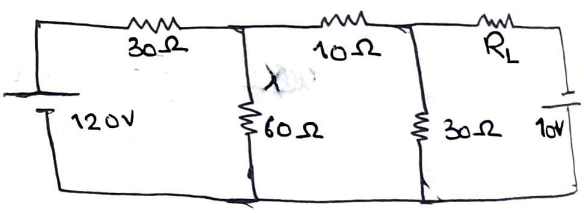
$$= \frac{4.62}{10 + 0.984}$$

$$\therefore I = 0.420\ A$$

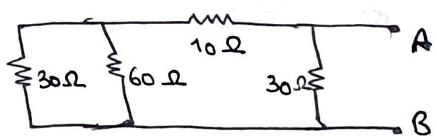
(Taking V = 1V
Taking R = 60Ω)

4. Obtain value of R_L and P_{max} through maximum power transform ~~theorem~~ theorem for given circuit.

Soln:- for R_{th},



$$R_{th} = \frac{(20+10) \times 30}{20+10+30}$$

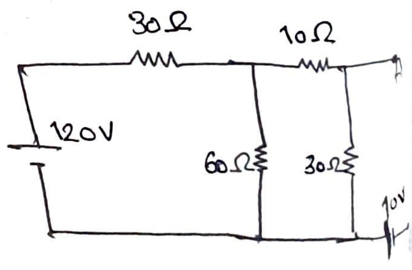


$$\therefore R_{th} = 15\Omega$$

In max power theorem,

$$R_L = R_{th} = 15\Omega$$

Now,



$$R_{eq} = 30 + \frac{60(30+10)}{60+30+10}$$

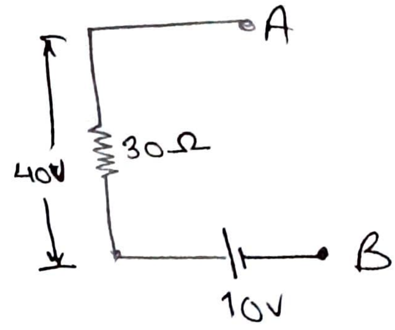
$$\therefore R_{eq} = 54\Omega$$

$\therefore$ Total current in circuit $= \frac{120}{54} = 2.22A$

Current through 10Ω resistor $= \frac{20}{9} \times \frac{60}{60+40} = 1.33A$

for V_{th},

Here, $V_{80\Omega} = 30 \times \frac{4}{3} = 40\,V$



$V_A - 10\,V = 40V$

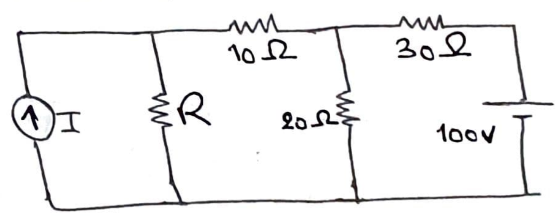
$\therefore V_A = 50V$

$V_{AB} = 50 - 0 = 50V$

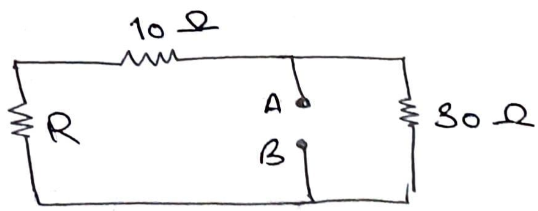
$\therefore V_{th} = V_{AB} = 50\,V$

So, $P_{max} = \frac{V_{th}^2}{4R_L} = \frac{2500}{4 \times 15} = 41.67\,W$

5. Find the current through 20Ω resistor using thevenin's theorem for the circuit :



Soln: for R_{th},

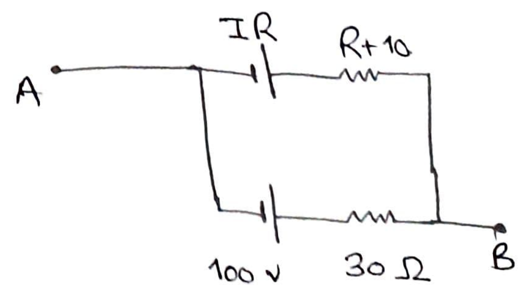


$R_{th} = \frac{30 \times (R+10)}{30 + R + 10}$

for $R = 60\,\Omega$

$R_{th} = 21\,\Omega$

for V_{th},



$V_{th} = \dfrac{\frac{100}{30} + \frac{IR}{R+10}}{\frac{1}{30} + \frac{1}{R+10}}$

for $I = R = 60$,

$V_{th} = 115\,0V$

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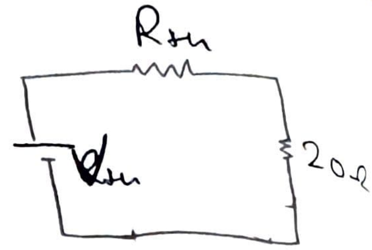
Making Thevenin's eqv. circuit,



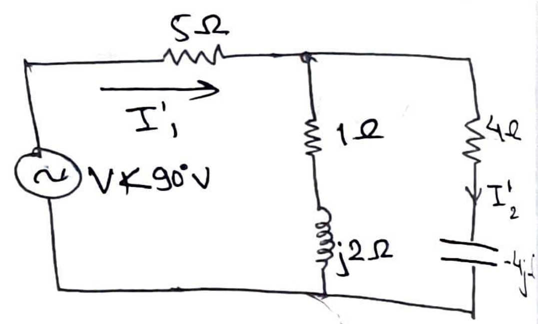
Current through 20Ω,

$$= \frac{V_{th}}{20 + R_{th}}$$

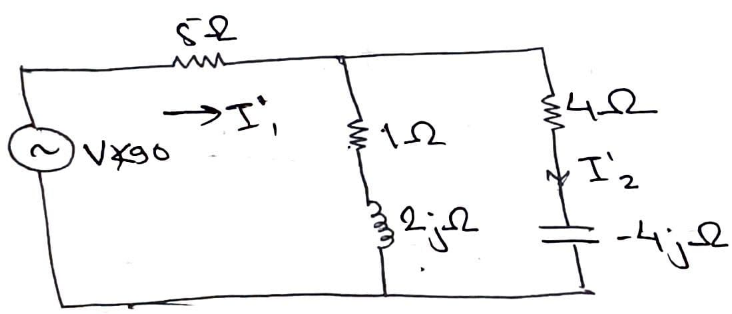
$$= \frac{1150}{20+21}$$

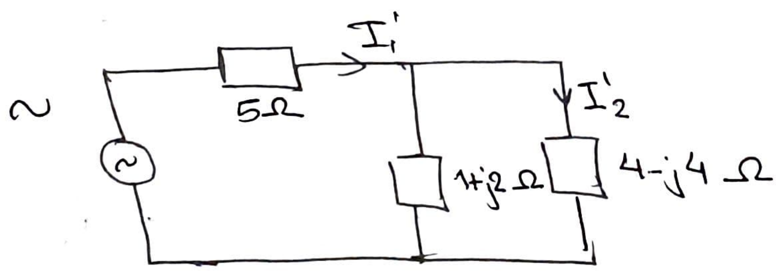
$$\therefore I = 28.04 A$$

6. Verify the reciprocity theorem (for I_2') in the given circuit,



Soln:- CASE I:





$$Z_{eq} = 5 + \frac{(1+j2)(4-j4)}{5-j2} = 6.96\angle 12.59°\,\Omega$$

So, $$I_1' = \frac{V\angle 90°}{6.96\angle 12.59°}$$

for $V = 60V$,

$$I_1' = 8.62\angle 77.41°\ A$$

And, $$I_2' = I_1 \times \frac{(1+j2)}{5-j2} = 3.5773\angle 162.64°\ A$$

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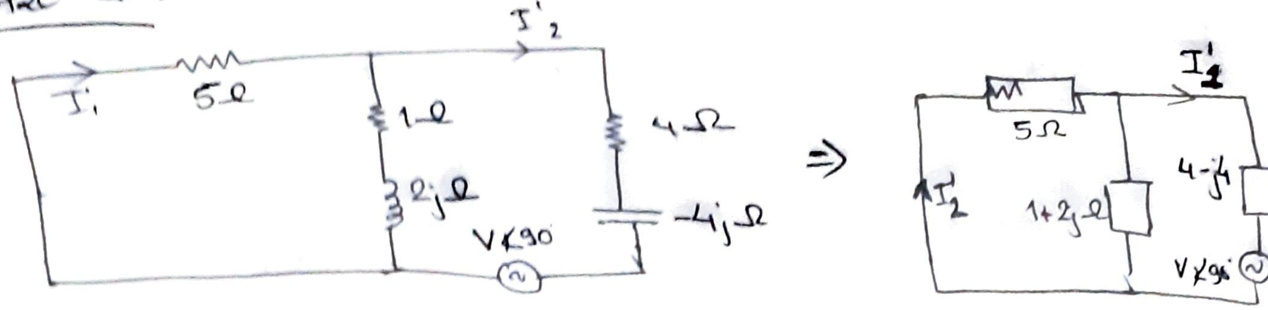
CASE II :



$$Z_{eq} = 4 - j4 + \frac{5(1+j2)}{6+j2} = 5.93\angle -27.64°\ \Omega$$

So,

$$I'_1 = \frac{V\angle 90}{5.93\angle -27.64°}$$

for $V = 60V$,

$$I'_1 = 10.118\angle 117.64°\ A$$

And,

$$I'_2 = I'_1 \times \frac{(1+j2)}{6+j2}$$

$$\therefore I'_2 = 3.571\angle 162.64°\ A$$

Since, I'_2 in case I = I'_2 in case II

$\therefore$ Reciprocity Theorem has been proved.

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7. An inductor draws 5 A when connected to 100V, 50 Hz supply. The resistance of the coil is 5 Ω. Determine (i) Inductance
(ii) Real Power, Reactive Power
(iii) Apparant Power.

Soln:-

Given,

$f = 50Hz \rightarrow \omega = 2\pi f = 314 \text{ rad/s}$

$I = 5A$

$V = 100V$

So, $Z = \frac{100}{5} = 20\,\Omega$

$R = 5\,\Omega$

(i) So,

$X_L = \omega L = 314L$

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

or, $20 = \sqrt{5^2 + (314L)^2}$

or, $20 = \sqrt{25 + 98596L^2}$

or $400 = 25 + 98596L^2$

$\therefore L = \sqrt{\frac{375}{98596}} = 0.0616 \text{ H}$

$\therefore$ Inductance $= 62 \text{ mH}$

(ii) $\cos\theta = \frac{R}{Z} = \frac{5}{20} = \frac{1}{4} = 0.25$

$\therefore$ Real Power $= VI\cos\theta = 100 \times 5 \times 0.25 = 125 W$

$\therefore$ Reactant Power $= VI\sin\theta = 100 \times 5 \times \sqrt{1-(0.25)^2} = 484.12$

(iii) $\therefore$ Apparant Power $= VI = 100 \times 5 = 500 \text{ VA}$

[1912160]

8. A series RC circuit has resistance of 50Ω, and capacitance of $1000\mu f$ connected in series across a single phase 230V, 50Hz supply. Calculate
(i) current drawn by circuit
(ii) Power factor of the circuit
(iii) Active and reactive power consumed by circuit.
Draw the Phasor diagram.

Soln:- Given, $f = 50Hz \rightarrow \omega = 2\pi f = 314$ rad/s

$R = 50\Omega$

$C = 1000\mu f = 10^{-3} f$

So, $X_c = \frac{1}{\omega C} = 3.185\ \Omega$

$V = 230V$

$Z = \sqrt{R^2 + X_c^2} = \sqrt{50^2 + (3.185)^2} = 50.101\Omega$

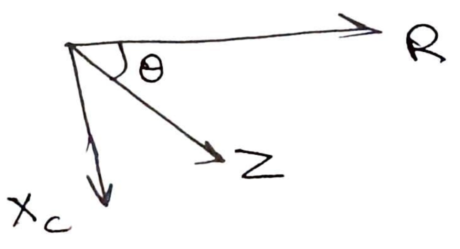
(i) So, Current, $I = \frac{V}{Z} = \frac{230}{50.101} = 4.59\ A$

(ii) Power factor, $\cos\theta = \frac{R}{Z} = \frac{50}{50.101} = 0.997$

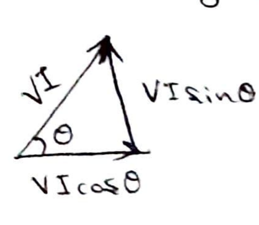
(iii) ∴ Active power $= VI\cos\theta = 230 \times 4.59 \times 0.997$
$= 1052.53W$

∴ Reactive Power $= VI\sin\theta = 230 \times 4.59 \times \sqrt{1-(0.997)^2}$
$= 81.71$ VAR

(iv) Phasor diagram



Power Triangle



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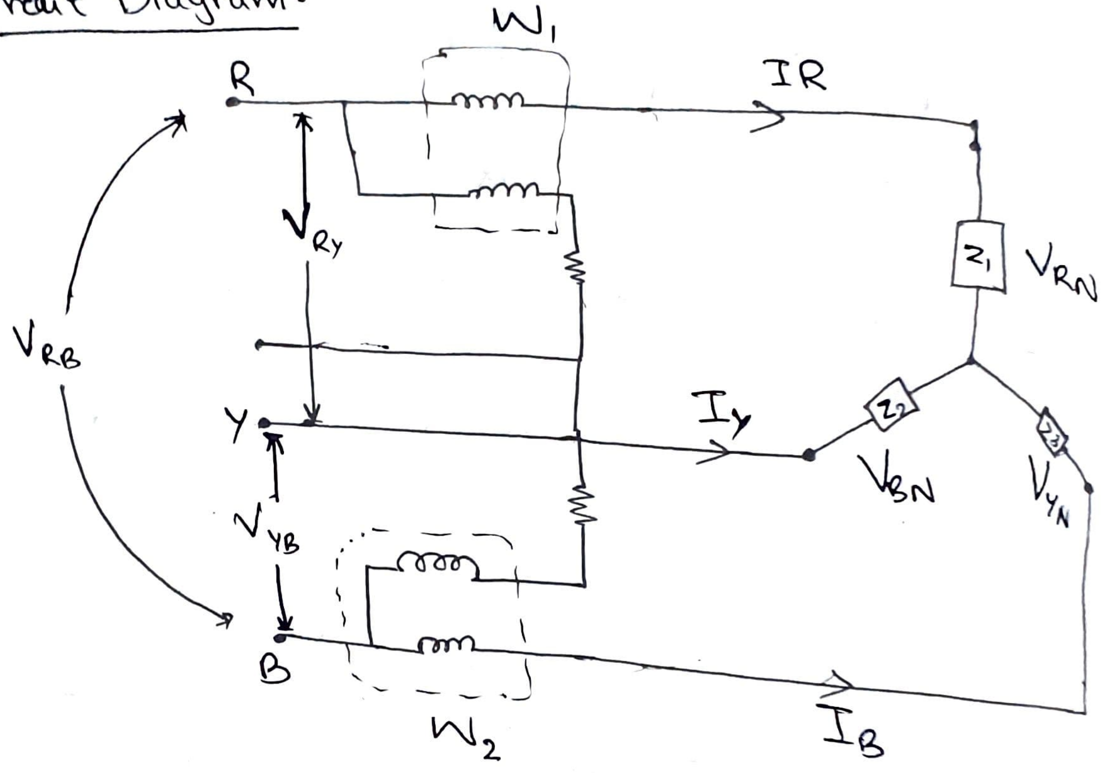
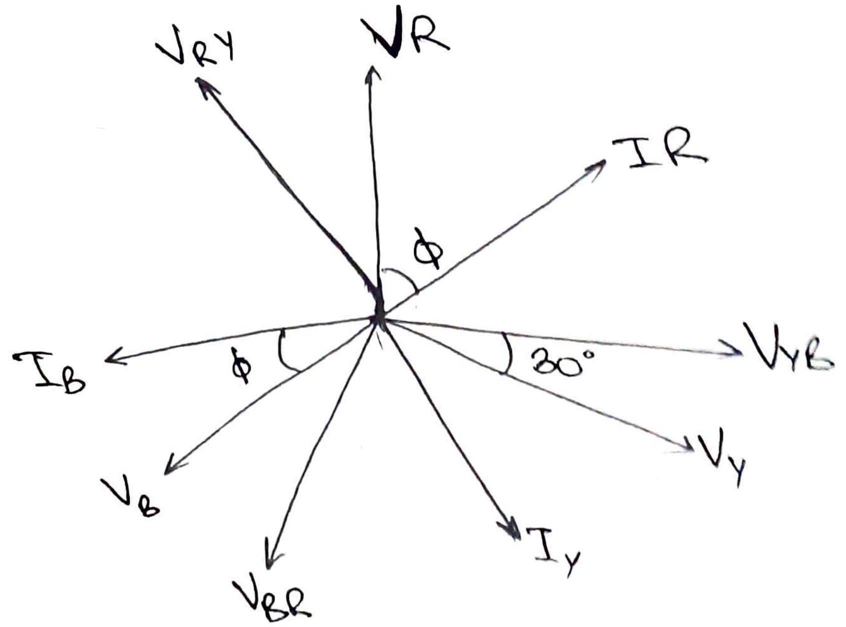
9. Prove that, the total power measured in a three phase system using two wattmeter method is $\sqrt{3} V_L I_L \cos\theta$ with relevent phasor diagrams.

Soln: Circuit Diagram:



Phasor Diagram:



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Total Power of the System is:

$$W = I_R \cdot V_{RN} + I_Y \cdot V_{YN} + I_B \cdot V_{BN}$$

Also, the sum of two wattmeters is,

$$W_1 + W_2 = I_R \cdot V_{RN} + I_Y \cdot V_{YN} + I_B \cdot V_{BN}$$

$$\Rightarrow W = W_1 + W_2$$

Now, I_{Ph} lags behind V_{Ph} by $\phi = \phi_P$

Power of two wattmeters.

$$\therefore W_1 = V_{RY} I_R \cos\theta$$

$$= V_{RY} I_R \cos(30^\circ + \phi)$$

$$= \sqrt{3} V_{Ph} I_{Ph} \cos(30^\circ + \phi)$$

and, $W_2 = V_{BY} I_B \cos\theta$

$$= \sqrt{3} V_{Ph} I_{Ph} \cos(30^\circ - \phi)$$

$\therefore$ Total Power, $W = W_1 + W_2$

$$= \sqrt{3} V_{Ph} I_{Ph} \left[\cos(30^\circ + \phi) + \cos(30^\circ - \phi) \right]$$

$$= V_L I_L \; 2 \cdot \frac{\sqrt{3}}{2} \cos\phi$$

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

Hence, Proved.

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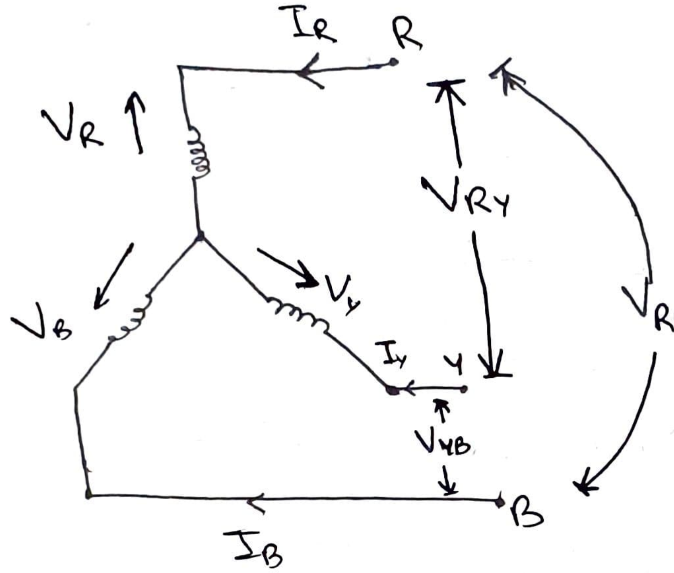
10. With necessary phasor diagrams, Prove that,

(a) In star connected system $V_L = \sqrt{3} * V_P$

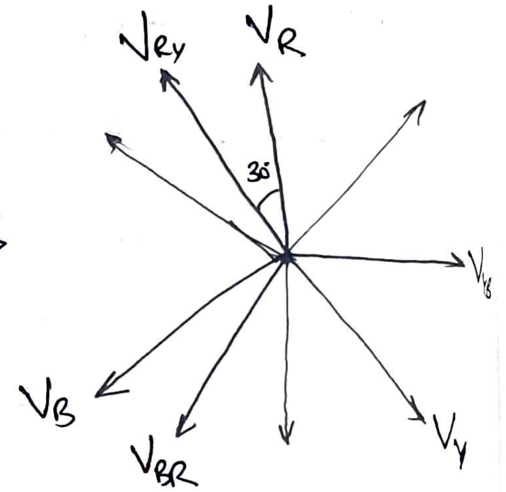
(b) In delta connected system $I_L = \sqrt{3} * I_P$

Soln:-

(a) In Star connected system,



$\Rightarrow$



We know,

$$V_R = V_B = V_Y = V_{Ph}$$

$$V_{BY} = V_{YB} = V_{BR} = V_L$$

$$\therefore V_{RY} = V_R - V_Y = \sqrt{V_R^2 + V_Y^2 + 2V_RV_Y\cos 30^\circ}$$

$$= \sqrt{2V_{Ph}^2 + V_{Ph}^2}$$

$$\therefore V_{RY} = \sqrt{3}\, V_{Ph}$$

Similarly, $V_{YB} = \sqrt{3}\, V_{Ph}$

and, $V_{BR} = \sqrt{3}\, V_{Ph}$

$\therefore V_L = \sqrt{3}\, V_P$. Hence Proved.

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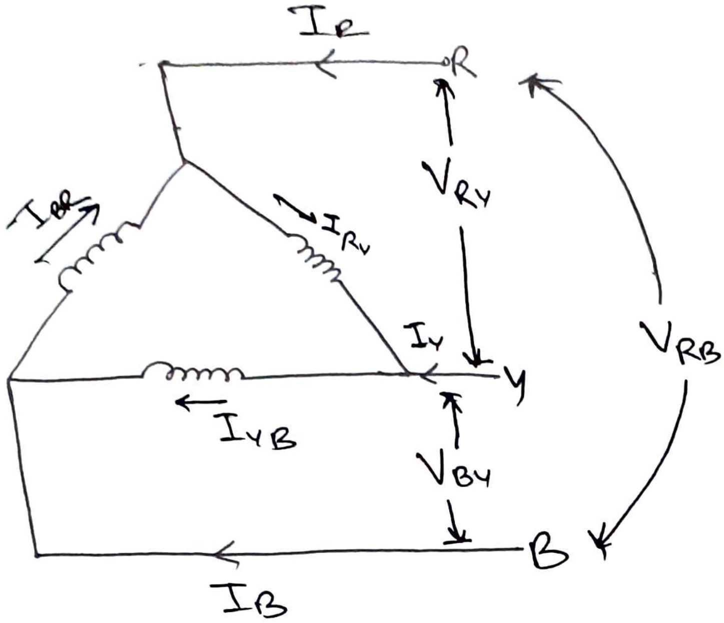
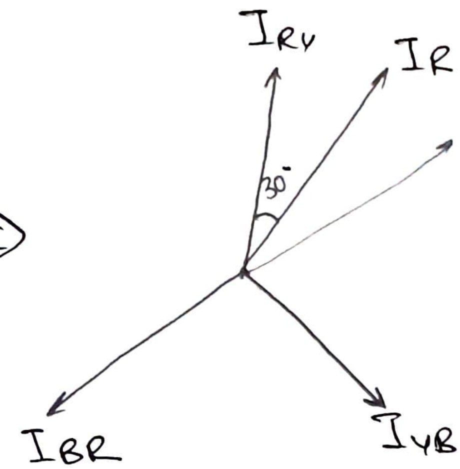
(b) In delta connected system,



$\Rightarrow$



We know,

$$I_R = I_Y = I_B = I_L$$

$$I_{RY} = I_{YB} = I_{BR} = I_{ph}$$

By KCL, $I_R + I_{BR} = I_{RY}$

So, $I_R = I_{RY} - I_{BR}$

$$= \sqrt{I_{RY}^2 + I_{BR}^2 + 2 I_{RY} I_{BR} \cos 30^\circ}$$

$$= \sqrt{2 I_{Ph}^2 + I_{Ph}^2}$$

$\therefore I_R = \sqrt{3}\, I_{Ph}$

Similarly, $I_Y = \sqrt{3}\, I_{Ph}$

$I_B = \sqrt{3}\, I_{Ph}$

$\therefore I_L = \sqrt{3}\, I_{Ph}$. Hence, Proved.