SAP ID - 60004200132
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Div - J1

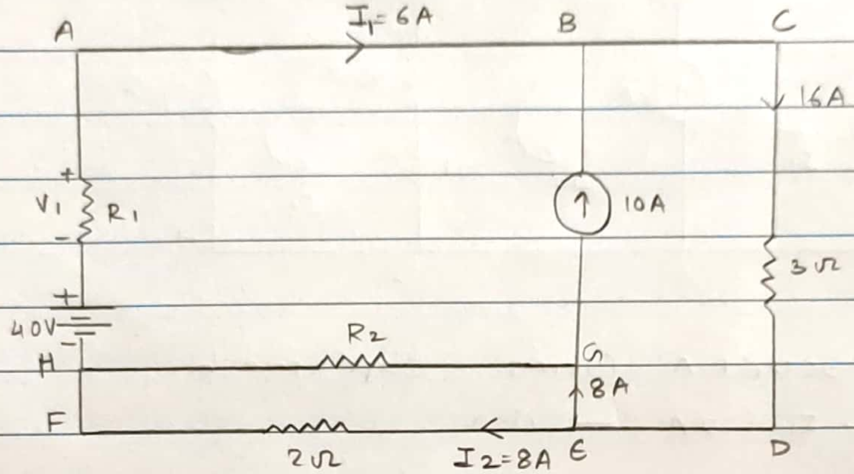
28/05/2021

MAEER's MIT

BEE

Q. 1

→ (a)



Applying KCL at B,

$$I_1 + 10 - 16 = 0$$

$$I_1 = 6A$$

Now,

~~Applying KVL in ABCDEFA,~~

$\cancel{40 - 6R_1 - 16(3)}$

Applying KCL at point E,

$$I_2 + 8 = 16$$

$$I_2 = 8A$$

Applying KVL in loop ABCDEFA,

$$40 + V_1 - 16 \times 3 - 2(8) = 0$$

$$40 + V_1 - 48 - 16 = 0$$

$$V_1 = 48 + 16 - 40$$

$$\boxed{V_1 = 24V}$$

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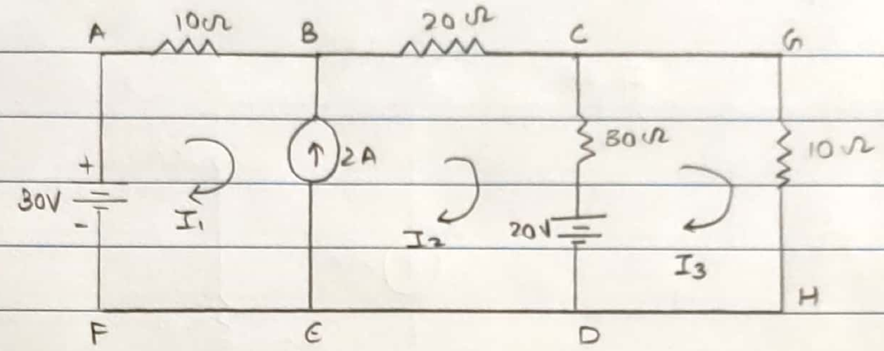
Q. 1

→ b)



Loop ABCDEFA forms supermesh.

$\therefore \quad I_2 - I_1 = 2A \quad — (i)$

Mesh equation for CGHDC,

$-40 I_3 + 30 I_2 + 20 = 0$

$\therefore \quad 30 I_2 - 40 I_3 = -20 \quad — (2)$

Supermesh equation for ABCDEFA,

$-10 I_1 - 50 I_2 + 30 I_3 - 20 + 30 = 0$

$\therefore \quad -10 I_1 - 50 I_2 + 30 I_3 = -10 \quad — (3)$

Solving (i), (2) and (3) equation we get,

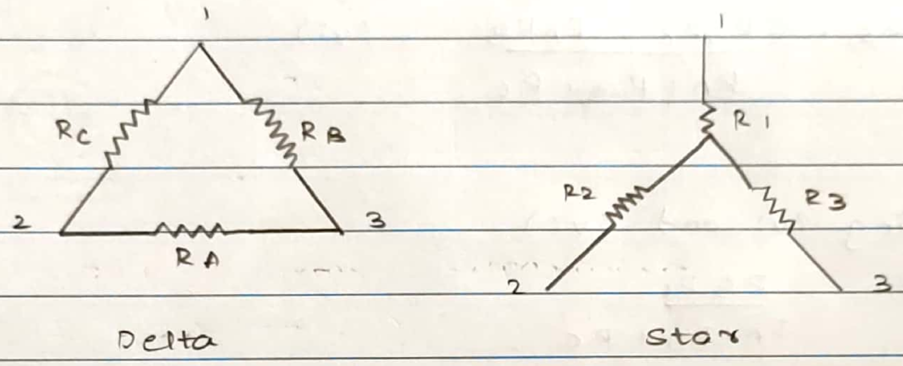
$I_1 = -0.8A$

$I_2 = 1.2A$

$I_3 = 1.4A$

Q. 2

→ a) Delta to star transformation



The resistance between terminals 1 and 2 in delta transformation is : $\frac{R_C(R_A+R_B)}{R_A+R_B+R_C}$ .... (i)

Resistance between terminal (1) and (2) in star transformation, : R_1+R_2 ... (ii)

Since, two networks are electrically equivalent

$$R_1+R_2 = \frac{R_C(R_A+R_B)}{R_A+R_B+R_C} \quad \text{.... (iii)}$$

Similarly,

$$R_2+R_3 = \frac{R_A(R_B+R_C)}{R_A+R_B+R_C} \quad \text{... (iv)}$$

$$R_3+R_1 = \frac{R_B(R_A+R_C)}{R_A+R_B+R_C} \quad \text{.... (v)}$$

Subtracting (iii) and (iv)

$$R_1 - R_3 = \frac{R_B R_C - R_A R_B}{R_A + R_B + R_C} \quad \ldots (vi)$$

Adding (v) and (vi)

$$R_1 = \frac{R_B R_C}{R_A + R_B + R_C}$$

Similarly,

$$R_2 = \frac{R_A R_C}{R_A + R_B + R_C}$$

$$R_3 = \frac{R_A R_B}{R_A + R_B + R_C}$$

Now, For star to delta transformation,

Multiplying $R_1 R_2$,

$$R_1 R_2 = \frac{R_A R_B R_C^2}{(R_A + R_B + R_C)^2} \quad \ldots (vii)$$

multiplying $R_2 R_3$,

$$R_2 R_3 = \frac{R_A^2 R_B R_C}{(R_A + R_B + R_C)^2} \quad \ldots (viii)$$

multiplying $R_3 R_1$,

$$R_3 R_1 = \frac{R_A R_B^2 R_C}{(R_A + R_B + R_C)^2} \quad \ldots (ix)$$

Adding (vii), (viii) and (ix),

$$R_1R_2 + R_2R_3 + R_3R_1 = \frac{R_AR_BR_C(R_A+R_B+R_C)}{(R_A+R_B+R_C)^2}$$

$$= \cancel{R_A+R_B+} \frac{R_AR_BR_C}{R_A+R_B+R_C}$$

$$= R_AR_1 = R_BR_2 = R_CR_3$$

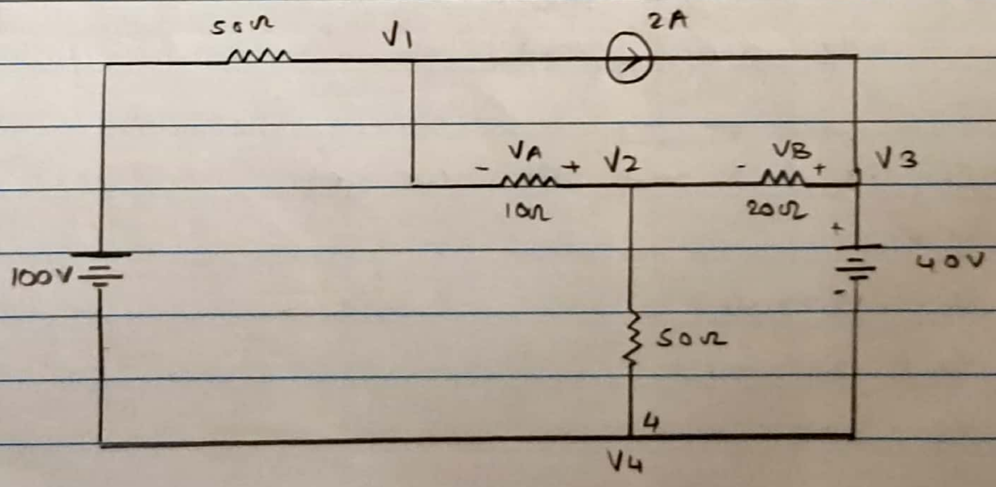
Hence, $R_A = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$

$$R_B = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

$$R_C = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$

Q.2

→ b)



V_1, V_2, V_3, V_4 are nodes where $V_4 = 0\,V$

Applying KCL at node 1

$$\frac{V_1 - 100}{50} + \frac{V_1 - V_2}{10} + 2 = 0$$

$\therefore \quad 0.12 V_1 - 0.1 V_2 = 0 \quad — (i)$

Applying KCL at node 2,

$$\frac{V_2 - V_1}{10} + \frac{\cancel{V_2}}{\cancel{10}} \frac{V_2}{50} + \frac{V_2 - V_3}{20} = 0$$

$\therefore \; -0.1 V_1 + 0.17 V_2 - 0.05 V_3 = 0 \quad - (2)$

Since node 3 is directly connected to voltage source of 40V.

$\therefore \; V_3 = 40V \quad — (3)$

Solving (i), (ii) and (iii) we get

$V_1 = 19.230V$

$V_2 = 23.07V$

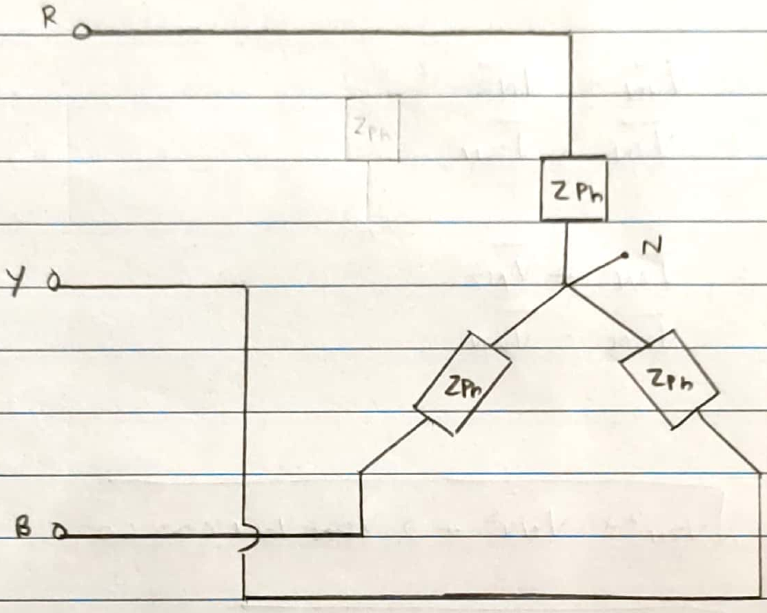
$V_3 = 40V$

$\therefore V_a = V_2 - V_1 = 23.07 - 19.23 = 3.84V$

$V_B = V_3 - V_2 = 40 - 23.07 = 16.93V$

Q.4

→



3 PHASE STAR CONNECTION

⇒ Relation between line voltage and Phase voltage.

Let $V_{RN} = V_{YN} = V_{BN} = V_{Ph}$

where V_{ph} indicates the rms value of phase voltage.

$$\bar{V}_{RN} = V_{ph} \angle 0^\circ$$
$$\bar{V}_{YN} = V_{ph} \angle -120^\circ$$
$$\bar{V}_{BN} = V_{ph} \angle -240^\circ$$

Let $\bar{V}_{RY} = V_{YB} = V_{BR} = V_L$

where V_L is rms value of line voltage.

∴ Applying KVL,

$$\bar{V}_{RY} = \bar{V}_{RN} + \bar{V}_{NY}$$
$$= \bar{V}_{RN} - \bar{V}_{YN}$$

Similarly,

$$\overline{V_{YB}} = \overline{V_{YN}} + \overline{V_{NB}}$$
$$= \overline{V_{YN}} - \overline{V_{BN}}$$

$$\overline{V_{BR}} = \overline{V_{BN}} + \overline{V_{NR}}$$
$$= \overline{V_{BN}} - \overline{V_{RN}}$$

Now,

$$V_{RY} = \sqrt{V_{RN}^2 + V_{NY}^2 + 2 V_{RN} V_{NY} \cos 60}$$

$$\therefore V_L = \sqrt{V_{Ph}^2 + V^2_{Ph} + 2 V_{Ph}^2 \cos 60}$$

$$\therefore \boxed{V_L = \sqrt{3}\, V_{Ph}}$$

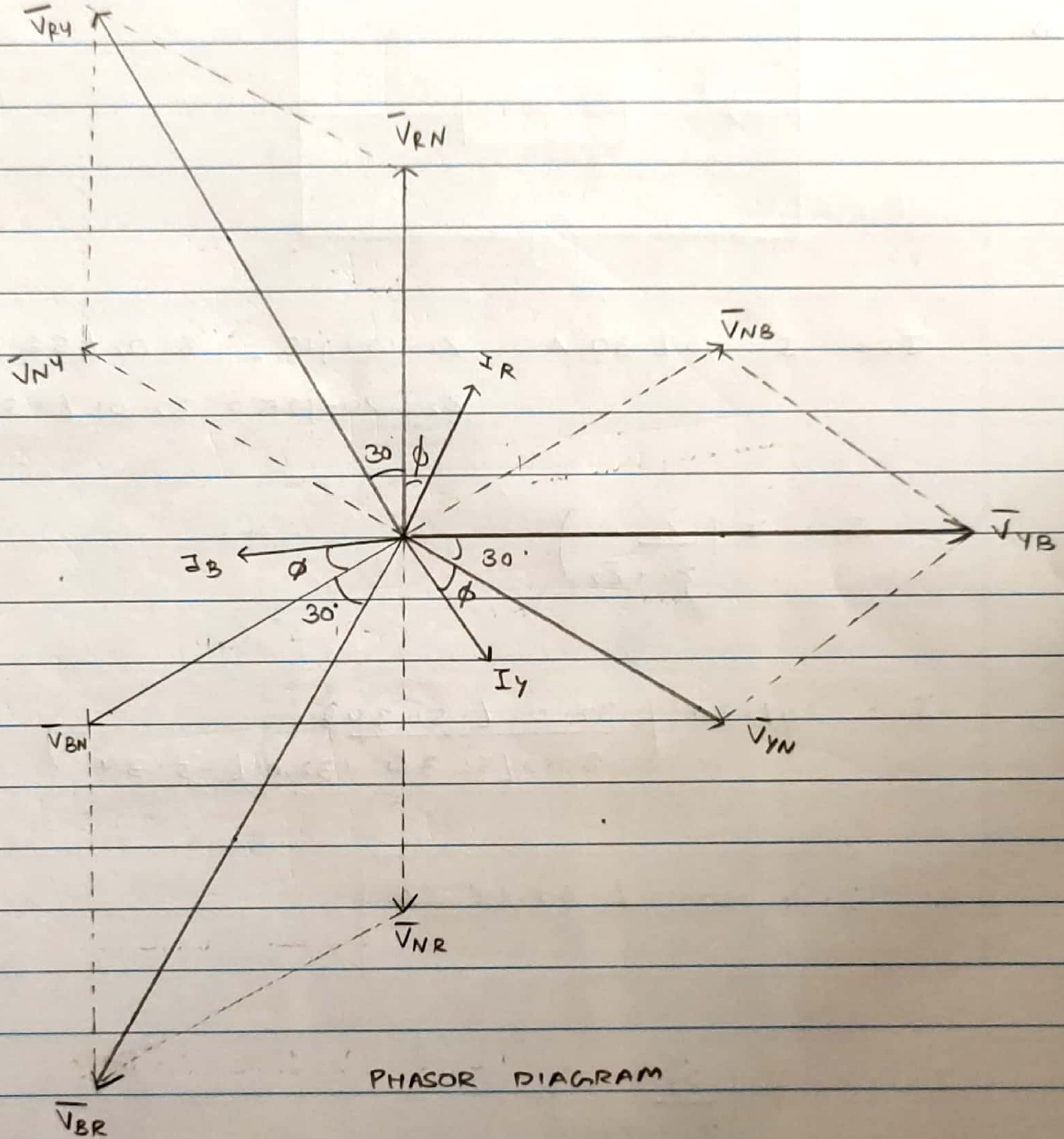
Thus, in a star connected three-phase system, $V_L = \sqrt{3}\, V_{ph}$ and line voltages lead respective voltage by 30°.

⟹ Relation between line current and phase current:

From the diagram, it is clear that line current is equal to the phase current.

$$\therefore \boxed{I_L = I_{ph}}$$

⟹ Phasor diagram (Lagging Power factor)



PHASOR DIAGRAM

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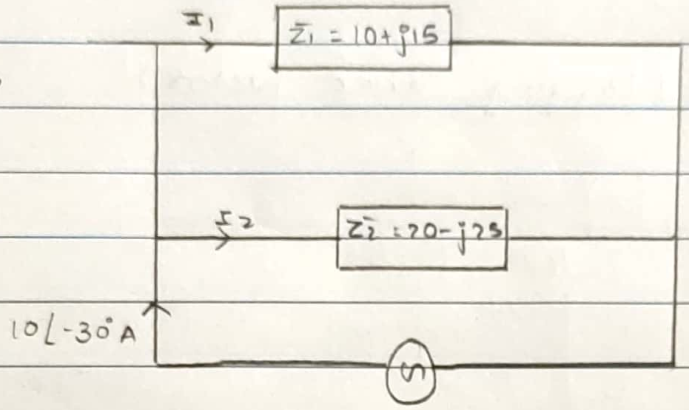
Q. 6

a)



$I = 10\angle -30^\circ A$, $Z_1 = 10 + j15 = 18.02\angle 56.30$

$Z_2 = 20 - j25 = 32.01\angle -51.34$

$$\therefore\ I_1 = I\left(\frac{\bar{Z_2}}{\bar{Z_1} + \bar{Z_2}}\right)$$

$$I_1 = 10\angle -30\left(\frac{32.01\angle -51.34}{18.02\angle 56.30 + 32.01\angle -51.34}\right)$$

$$\therefore\ \boxed{I_1 = 10.12\angle -62.89^\circ\ A}$$

$$I_2 = I\left(\frac{\bar{Z_1}}{\bar{Z_1} + \bar{Z_2}}\right)$$

$$I_2 = 10\angle -30\left(\frac{18.02\angle 56.30}{18.02\angle 56.30 + 32.01\angle -51.34}\right)$$

$$\boxed{I_2 = 5.699\angle 44.74^\circ}$$

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$$Z_1 = 10 + j15$$
$$= R_1 + jX_L$$

$R_1 = 10\,\Omega$

$I_1 = 10.12\,A$

Power loss will only due to resistance in Z_1 and Z_2

$$\therefore P_1 = I_1^2 R_1$$
$$= (10.12)^2 \times 10$$

$$\therefore \boxed{P_1 = 1024.144\,W}$$

$I_2 = 5.699$, $R_2 = 20$

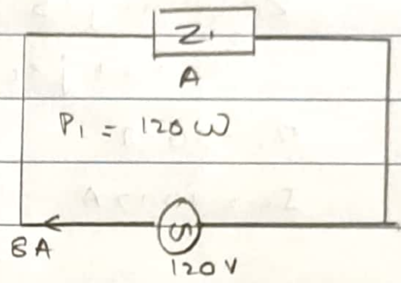
$$\therefore P_2 = I_2^2 R_2$$
$$= (5.699)^2 \times 20$$

$$\boxed{P_2 = 649.572\,W}$$

Q. 6

→ b)

Case (i)



$I_1 = 8\ A$

$Z_1 = \frac{V}{I} = \frac{120}{8} = 15\ \Omega$

$P_1 = 120\ W$

$\therefore I_1^2 R_1 = 120$

$\therefore R_1 = \frac{120}{8^2} = 1.875\ \Omega$

$\therefore Z_1^2 = \sqrt{R^2 + X_{L1}^2}$

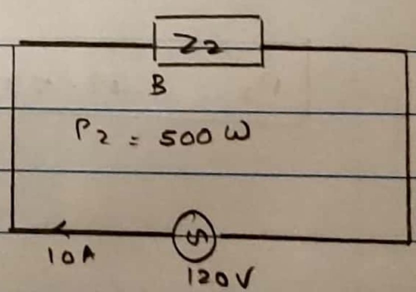
$Z_1^2 = R^2 + X_{L1}^2$

$15^2 = (1.875)^2 + X_{L1}^2$

$X_{L1} = 14.88\ \Omega$

$\therefore Z_1 = 1.875 + j14.88 = 15 \angle 82.81$

Case (ii)



$I_2 = 10A$

$Z_2 = \frac{V}{I_2} = \frac{120}{10} = 12\ \Omega$

$P_2 = 500\ W$

$I_2^2 R_2 = 500$

$10^2 R_2 = 500$

$\therefore R_2 = 5\ \Omega$

$\therefore Z_2^2 = R_2^2 + X_{L2}^2$

$X_L^2 = \sqrt{12^2 - 5^2}$

$X_{L2} = 10.90\,\Omega$

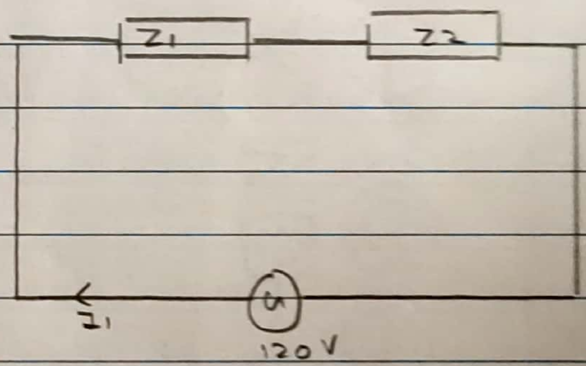
$\therefore Z_2 = R_2 + jX_{L2}$

$= 5 + j10.90$

$Z_2 = 12\angle 65.35$

NOW,

Case (iii)



$\bar{Z}_{eff} = \bar{Z}_1 + \bar{Z}_2$

$= 15\angle 82.81 + 12\angle 65.35$

$= 26.69\angle 75.05$

$= 6.88 + j25.788$

$\therefore Z_{eff} = 26.69$

$\therefore I = \frac{120}{Z_{eff}} = \frac{120}{26.69} = 4.496\,A$

$\therefore \boxed{I = 4.496\,A}$

Scanned with CamScanner

Total Power $= (4.496)^2 \times (6.88)$

$= 139.072 W$

$\therefore$ $\boxed{\text{Total Power} = 139.072\ W}$