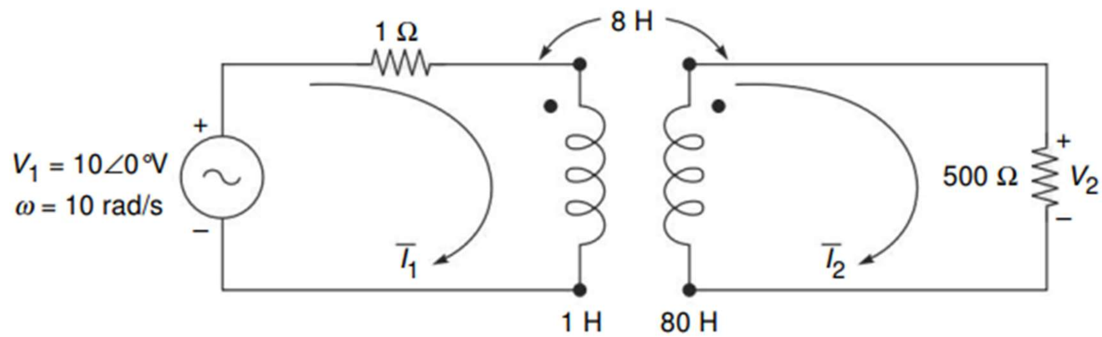
Tutorial 8

1. For the magnetic circuit shown in the Figure below, find the magnitude of V_2 / V_1 i.e. $| V_2 / V_1 |$.



Solⁿ: Writing the mesh equations, for these two meshes, we get,

$$[1 + j10 \times 1]\bar{I}_1 - j10 \times 8\,\bar{I}_2 = 10\angle 0^\circ \quad \text{(Mesh 1)}$$

$$(1+j10)\,I_1 - j80\,I_2 = 10\angle 0^\circ \quad -(1)$$

$$-j10 \times 8\,I_1 + (500 + j10 \times 80)\,I_2 = 0 \quad \text{(Mesh 2)}$$

or

$$j80\,I_1 - (500 + j800)\,I_2 = 0 \quad -(2)$$

from eq(2), we get,

$$\bar{I}_1 = \left(\frac{500 + j800}{j80}\right) I_2 = (10 - j6.25)\,I_2 \quad -(3)$$

Substituting eqⁿ (3) in eqⁿ (1), we get.

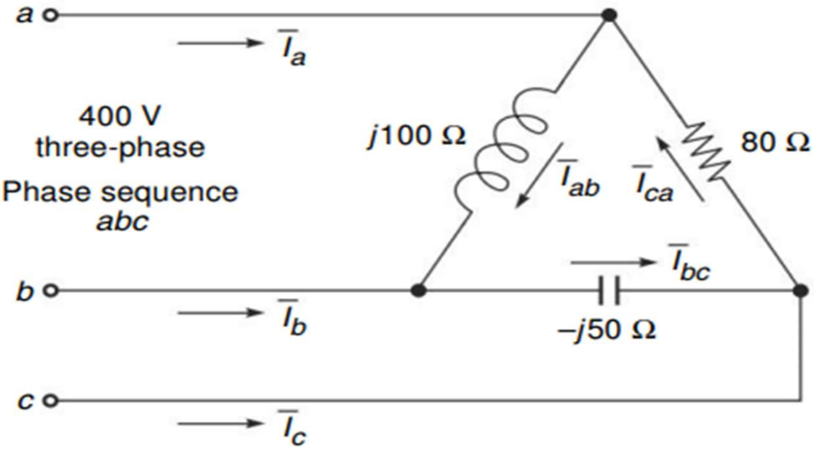
$$[(1+j10)(10 - j6.25) - j80]\,\bar{I}_2 = 10\angle 0^\circ$$

$$\bar{I}_2 = 0.135\angle -10.7^\circ \text{ A}$$

$$\bar{V}_2 = 500\,I_2 \simeq 68\angle -10.7^\circ \text{ V.}$$

$$\frac{\bar{V}_2}{\bar{V}_1} \simeq 6.8\angle -10.7^\circ$$

2. In an unbalanced delta-connected load shown in the figure below, find the magnitude of line current Ic.



$\bar{V}_{ab} = 400\angle 0^\circ$, $V_{bc} = 400\angle -120^\circ$, $V_{ca} = 400\angle -240^\circ$

$\bar{I}_{ab} = \dfrac{400\angle 0^\circ}{j100} = -j4$ A.

$\bar{I}_{bc} = \dfrac{400\angle -120^\circ}{-j50} = -8\angle -30^\circ$ A.

$= 6.928 - j4$ A.

$\bar{I}_{ca} = \dfrac{400\angle -240^\circ}{80} = 5\angle -240^\circ$ A

$= -2.5 + j4.33$

$\bar{I}_a = \bar{I}_{ab} - \bar{I}_{ca} = (-j4) - (-2.5 + j4.33)$

$\bar{I}_a = 2.5 + j0.33 = \underline{\underline{2.522\angle 7.5^\circ \text{A}}}$

$\bar{I}_b = \bar{I}_{bc} - \bar{I}_{ab} = (6.928 - j4) - (-j4)$

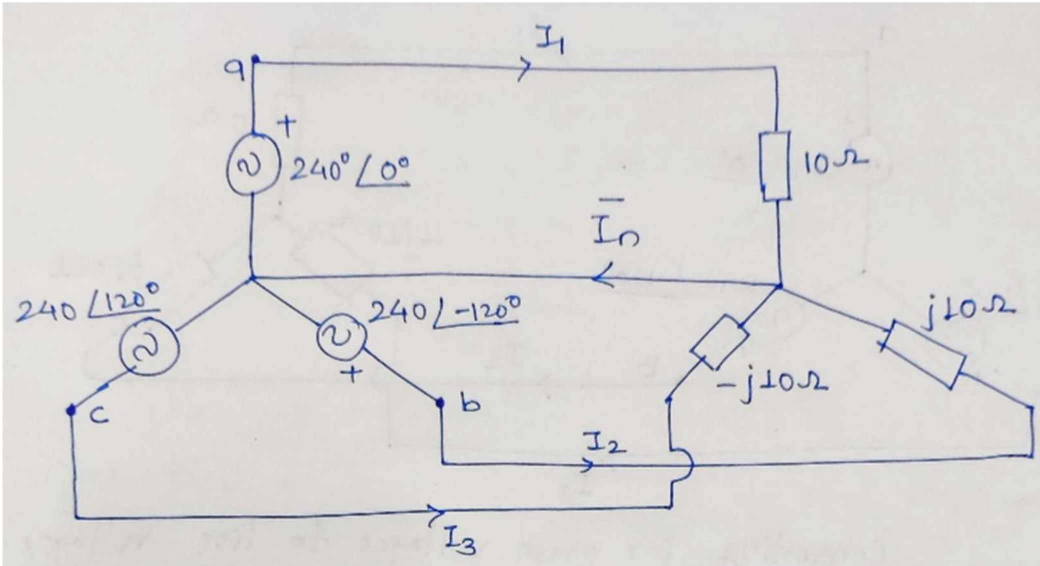
$\bar{I}_b = \underline{\underline{6.928\angle 0^\circ}}$ A.

$I_c = I_{ca} - I_{bc} = (-2.5 + j4.33) - (6.928 - j4)$

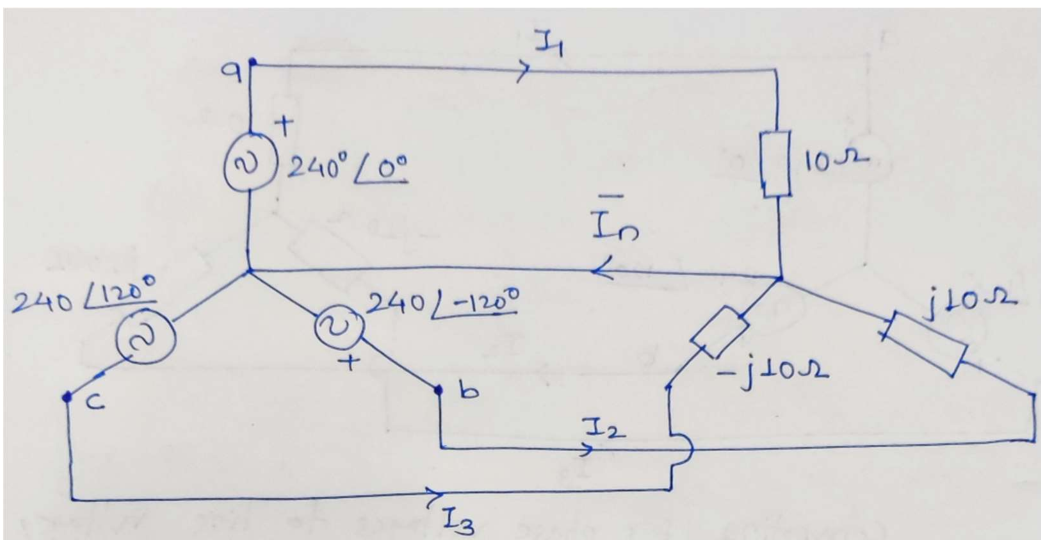
$I_c = -9.428 + j8.33 = 12.581\angle 138.5^\circ$ A.

$I_c = \underline{\underline{12.581}} \angle 138.5^\circ$ A

3. For the circuit shown below, find the magnitude of neutral current (In) flowing in Amperes.



Solution -



$$\bar{I}_1 = \frac{240\angle 0^\circ}{10} = 24 \text{ Amp}$$

$$\bar{I}_2 = \frac{240\angle -120^\circ}{j10} = (-20.785 + j12) \text{ Amp}$$

$$\bar{I}_3 = \frac{240\angle 120^\circ}{-j10} = (-20.785 - j12) \text{ Amp}$$

$$\boxed{\bar{I}_n = \bar{I}_1 + \bar{I}_2 + \bar{I}_3 = -17.56 \text{ Amp}}$$

4. The two-wattmeter method produces wattmeter readings P1 = 1560 W, P2 = 2100 W, when connected to a Delta connected load. The Line-Line voltage of the supply is 220 V. Calculate the magnitude of phase impedance of the load in ohms.

Given, $P_1 = 1560$ Watts, $P_2 = 2100$ Watts

So, avg real power $P = P_1 + P_2 = 3660$ watts

Avg reactive power $\Rightarrow Q = \sqrt{3}\,(P_2 - P_1) = 935.3$ VAR

p.f. angle, $\phi = \tan^{-1}(Q/P) = 14.33^\circ$

$\therefore$ p.f. $= \cos\phi = 0.9689$

Consider, Z_p as per phase Impedance

$\therefore$ per phase active power $= \frac{P}{3} = 1220$ watts

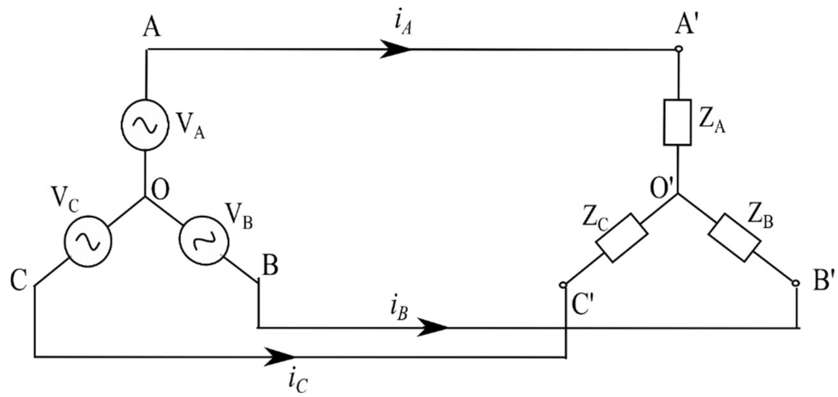
$$\therefore \frac{P}{3} = V_{ph} \cdot I_{ph} \cdot \cos\phi$$

$$I_{ph} = \frac{1220}{220 \times 0.9689} = 5.723 \angle -14.33^\circ \text{ Amp}$$

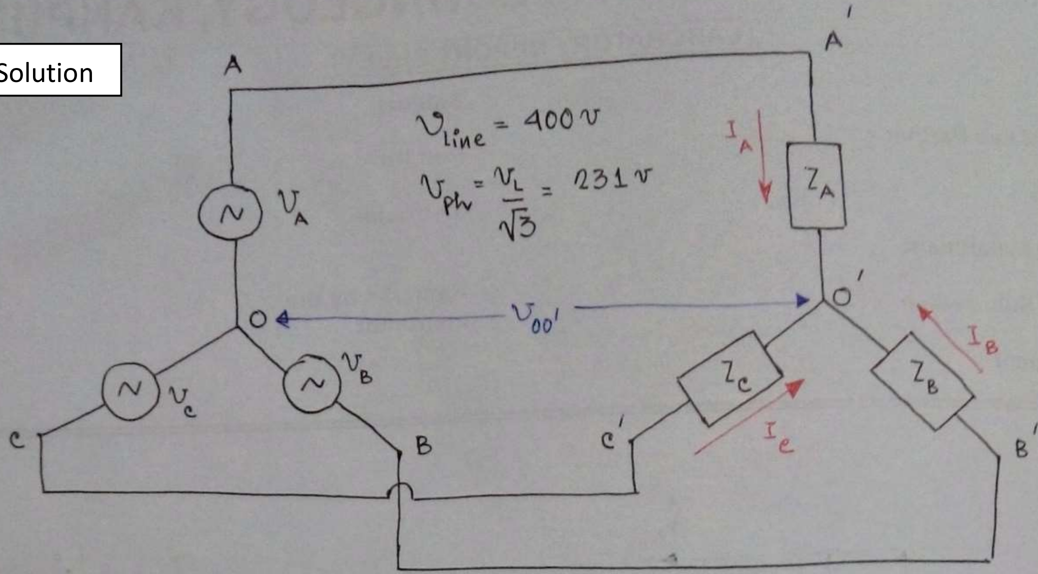
$$\boxed{\therefore Z_p = \frac{220}{5.723 \angle -14.33^\circ} = 38.44 \angle 14.33^\circ \ \Omega}$$

$$\boxed{Z_p = (37.24 + j\,9.51)\ \Omega}$$

5. A 3-phase 3-wire system of 400 V (line-to-line) has impedances, Z_A = (20 - j20) Ω, Z_B = (50 + j0) Ω and Z_C = (30+j52)Ω, as shown in the figure below. Neglecting impedances of the lines connecting source to load (i.e. A-A', B-B' and C-C'), calculate the magnitude of voltage difference between O and O' (|Voo'|). Phase sequence is ABC.



Solution



$$V_{OA} + V_{A'O'} + V_{O'O} = 0 \Rightarrow V_{OO'} = V_{OA} + V_{AO'}$$

$$= V_A - I_A Z_A$$

Similarly, for 'B' & 'C' phases

$$V_{OO'} = V_B - I_B Z_B \; ; \quad V_{OO'} = V_C - I_C Z_C$$

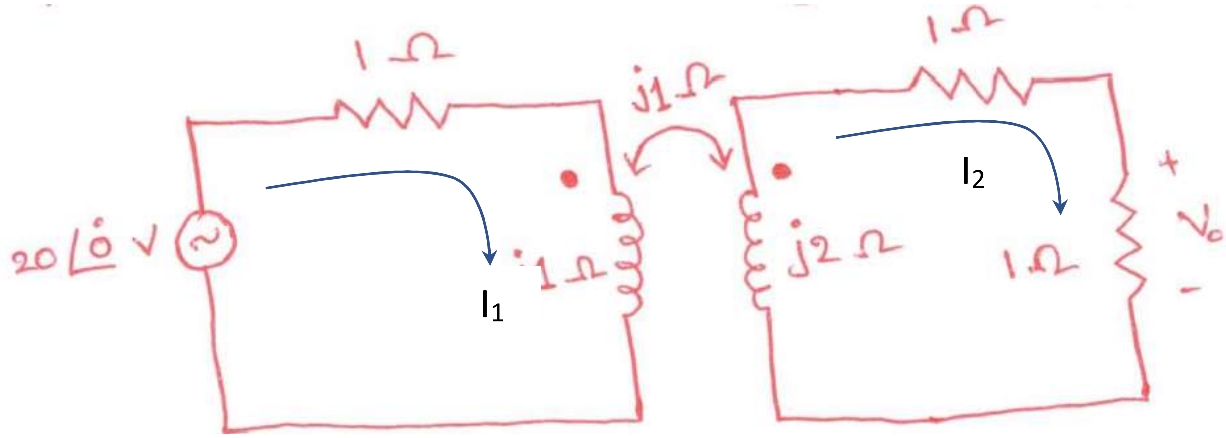
$$I_A = \frac{V_A - V_{OO'}}{Z_A} \; ; \quad I_B = \frac{V_B - V_{OO'}}{Z_B} \; ; \quad I_C = \frac{V_C - V_{OO'}}{Z_C}$$

$$I_A + I_B + I_C = 0 \Rightarrow \frac{V_A - V_{OO'}}{Z_A} + \frac{V_B - V_{OO'}}{Z_B} + \frac{V_C - V_{OO'}}{Z_C} = 0$$

$$V_{OO'} = \frac{\frac{V_A}{Z_A} + \frac{V_B}{Z_B} + \frac{V_C}{Z_C}}{\frac{1}{Z_A} + \frac{1}{Z_B} + \frac{1}{Z_C}} = \frac{\frac{231\angle 0^\circ}{(20-j20)} + \frac{231\angle -120^\circ}{50} + \frac{231\angle 120}{(30+j52)}}{\frac{1}{20-j20} + \frac{1}{50} + \frac{1}{30+j52}}\,V$$

$$= 136.92\angle 32.37^\circ\,V.$$

6. Consider the coupled circuit shown in the figure below –



Find the magnitude of the voltage V_0.

Solution -

Mesh - 1 : $20\angle 0^\circ - 1I_1 - j1I_1 + j1I_2 = 0$

$$I_1(1+j) - jI_2 = 20\angle 0^\circ \quad \text{——} \ (1)$$

Mesh - 2 : $-j2I_2 - 1I_2 - 1I_2 + j1I_1 = 0$

$$-j1I_1 + I_2(2+j2) = 0 \quad \text{——} \ (2)$$

Solving eq (1) & (2), we get

$$I_2 = 4.85\angle 14^\circ \ \text{A}$$

voltage, V_0 is, $V_0 = I_2(1) = 4.85\angle 14^\circ$ V