

BEEE203L

CIRCUIT THEORY



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MODULE – III

Three Phase Systems

Contents

Network Theorems for AC Circuits

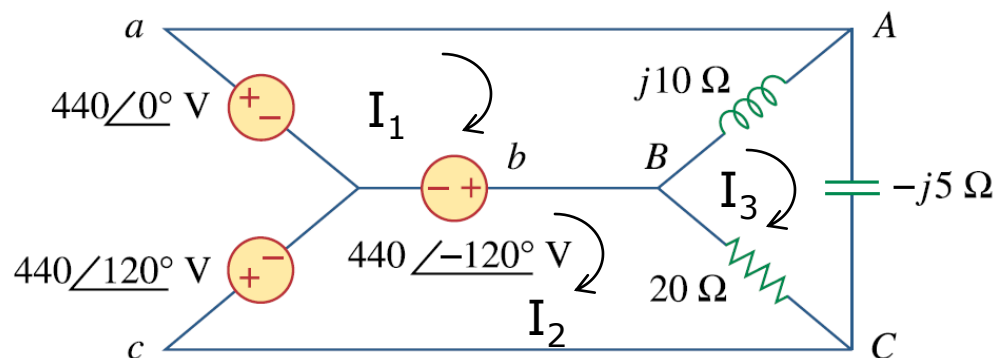
- Review of Balanced System
- Unbalanced System
 - Delta connected loads
 - Three wire star connected loads
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- Analysis of unbalanced 3 wire star load
 - Kirchhoff's law
 - Loop current method
 - Star delta conversion method
 - Millman's theorem

P3.9**4**

Refer to the unbalanced circuit of Fig.

Calculate:

- (a) the line currents
- (b) the real power absorbed by the load
- (c) the total complex power supplied by the source

**Method I – Mesh Analysis**

For mesh 1,

$$440\angle -120^\circ - 440\angle 0^\circ + j10(\mathbf{I}_1 - \mathbf{I}_3) = 0$$

$$\mathbf{I}_1 - \mathbf{I}_3 = \frac{(440)(1.5 + j0.866)}{j10} = 76.21\angle -60^\circ \quad (1)$$

For mesh 2,

$$440\angle 120^\circ - 440\angle -120^\circ + 20(\mathbf{I}_2 - \mathbf{I}_3) = 0$$

$$\mathbf{I}_3 - \mathbf{I}_2 = \frac{(440)(j1.732)}{20} = j38.1 \quad (2)$$

For mesh 3,

$$j10(\mathbf{I}_3 - \mathbf{I}_1) + 20(\mathbf{I}_3 - \mathbf{I}_2) - j5\mathbf{I}_3 = 0$$

Substituting (1) and (2) into the equation for mesh 3 gives,

$$\mathbf{I}_3 = \frac{(440)(-1.5 + j0.866)}{j5} = 152.42 \angle 60^\circ \quad (3)$$

From (1),

$$\mathbf{I}_1 = \mathbf{I}_3 + 76.21 \angle -60^\circ = 114.315 + j66 = 132 \angle 30^\circ$$

From (2),

$$\mathbf{I}_2 = \mathbf{I}_3 - j38.1 = 76.21 + j93.9 = 120.93 \angle 50.94^\circ$$

$$\mathbf{I}_a = \mathbf{I}_1 = \underline{\underline{132 \angle 30^\circ \text{ A}}}$$

$$\mathbf{I}_b = \mathbf{I}_2 - \mathbf{I}_1 = -38.105 + j27.9 = \underline{\underline{47.23 \angle 143.8^\circ \text{ A}}}$$

$$\mathbf{I}_c = -\mathbf{I}_2 = \underline{\underline{120.9 \angle 230.9^\circ \text{ A}}}$$

$$(b) \quad S_{AB} = |I_1 - I_3|^2 (j10) = j58.08 \text{ kVA}$$

$$S_{BC} = |I_2 - I_3|^2 (20) = 29.04 \text{ kVA}$$

$$S_{CA} = |I_3|^2 (-j5) = (152.42)^2 (-j5) = -j116.16 \text{ kVA}$$

$$S = S_{AB} + S_{BC} + S_{CA} = 29.04 - j58.08 \text{ kVA}$$

Real power absorbed = 29.04 kW

(c) Total complex supplied by the source is

$$S = \underline{29.04 - j58.08 \text{ kVA}}$$

Method II

$$V_{AB} = 762 \cdot 102 \angle 30^\circ; \quad V_{BC} = 762 \cdot 102 \angle -40^\circ$$

$$V_{CA} = 762 \cdot 102 \angle 150^\circ$$

$$I_{AB} = \frac{V_{AB}}{Z_{AB}} = \frac{762 \cdot 102 \angle 30^\circ}{j10} = 76.2 \angle -60^\circ$$

$$I_{BC} = \frac{V_{BC}}{Z_{BC}} = \frac{762 \cdot 102 \angle -90^\circ}{20} = 38.11 \angle -90^\circ$$

$$I_{CA} = \frac{V_{CA}}{Z_{CA}} = \frac{762 \cdot 102 \angle 150^\circ}{-j5} = 152.42 \angle -120^\circ$$

$$I_a = I_{AB} - I_{CA} = 76.2 \angle -60^\circ - 152.42 \angle -120^\circ = 132 \angle 30^\circ$$

$$I_b = I_{BC} - I_{AB} = 38.11 \angle -90^\circ - 76.2 \angle -60^\circ = 47.22 \angle 143.8^\circ$$

$$I_c = I_{CA} - I_{BC} = 152.42 \angle -120^\circ - 38.11 \angle -90^\circ = 120.9 \angle -130.1^\circ$$

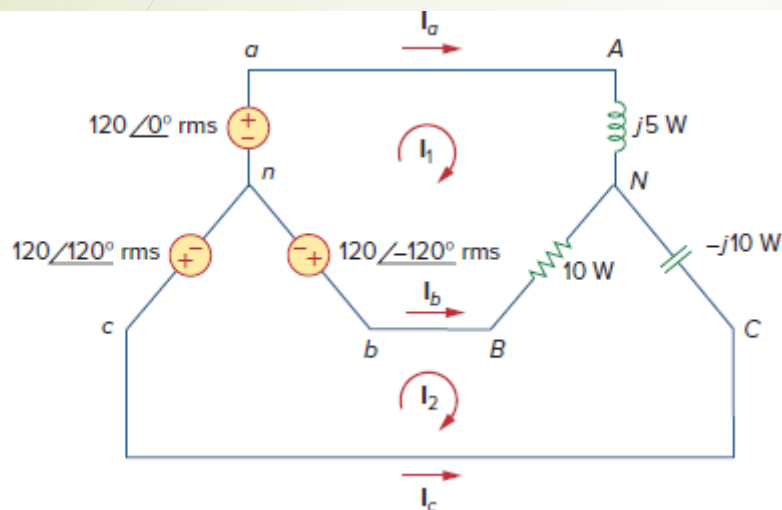
$$S_{AB} = I_{AB}^2 \times Z_{AB} = 76.2^2 \times j10 = j58.064 \text{ kVA}$$

$$S_{BC} = I_{BC}^2 \times Z_{BC} = 38.11^2 \times 20 = 29.05 \text{ kW}$$

$$S_{CA} = I_{CA}^2 \times Z_{CA} = 152.42^2 \times -j5 = -j116.16 \text{ kVA}$$

P3.10 For the unbalanced circuit in Fig. , find: (a) the line currents, (b) the total complex power absorbed by the load, and (c) the total complex power absorbed by the source.

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$$\mathbf{I}_a = \mathbf{I}_1 = 56.78 \text{ A},$$

$$\mathbf{I}_b = 25.46 \angle 135^\circ \text{ A}$$

$$\mathbf{I}_c = 42.75 \angle -155.1^\circ \text{ A}$$

$$\mathbf{S}_L = \mathbf{S}_A + \mathbf{S}_B + \mathbf{S}_C = 6480 - j2156 \text{ VA}$$

$$\mathbf{S}_s = \mathbf{S}_a + \mathbf{S}_b + \mathbf{S}_c = -6480 + j2156 \text{ VA}$$