

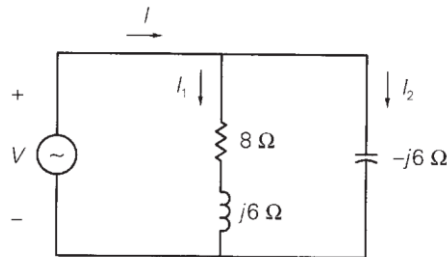
EE3123 Test 1 (Total 4 questions)

Name:

Student No.:

Q1 – For the single-phase circuit shown below, $I = 100\angle 0^\circ$ A.

- Compute the phasors I_1 , I_2 , and V .
- Convert the phasors I_1 , I_2 , and V to instantaneous form.
- Determine the source power triangle.
- Draw a phasor diagram showing I , I_1 , I_2 , and V .



Solution

(a)

$$\bar{I}_1 = 100\angle 0^\circ \frac{-j6}{8 + j6 - j6} = 100 \frac{6\angle -90^\circ}{8} = 75\angle -90^\circ \text{ A}$$

$$\bar{I}_2 = \bar{I} - \bar{I}_1 = 100\angle 0^\circ - 75\angle -90^\circ = 125\angle 36.87^\circ \text{ A}$$

$$\bar{V} = \bar{I}_2(-j6) = (125\angle 36.87^\circ)(6\angle -90^\circ) = 750\angle -53.13^\circ \text{ V}$$

(b)

$$i_1(t) = 75 \times \sqrt{2} \cos(\omega t - 90^\circ) = 106.1 \cos(\omega t - 90^\circ)$$

$$i_2(t) = 125 \times \sqrt{2} \cos(\omega t + 36.87^\circ) = 176.8 \cos(\omega t + 36.87^\circ)$$

$$v(t) = 750 \times \sqrt{2} \cos(\omega t - 53.13^\circ) = 1060.7 \cos(\omega t - 53.13^\circ)$$

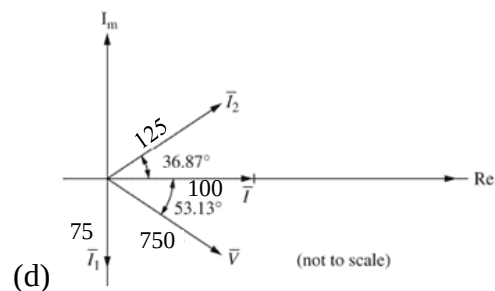
(c)

$$S = \bar{V}\bar{I}^* = (750\angle -53.13^\circ)(100\angle 0^\circ) \text{ KVA}$$

$$= 75\angle -53.13^\circ \text{ KVA}$$

$$P = 75 \cos(-53.13^\circ) = 45 \text{ kW}$$

$$Q = 75 \sin(-53.13^\circ) = -60 \text{ kVAR}$$



Q2 – A source supplies power to the following three loads connected in parallel: (1) a lighting load drawing 100 kW; (2) an induction motor drawing 100 kVA at 0.8 power factor lagging; and (3) a synchronous motor operating at 100 hp, 85% efficiency and 0.9 power factor leading (1 hp=0.746 kW).

- (a) Determine the real, reactive, and apparent power delivered by the source.
- (b) Draw the source power triangle.

Solution

(a)

$$\bar{S}_1 = P_1 + jQ_1 = 100 + j0$$

$$\bar{S}_2 = 100 \angle \cos^{-1} 0.8 = 80 + j60$$

$$\bar{S}_3 = \frac{100 \times 0.746}{0.85 \times 0.9} \angle -\cos^{-1} 0.9 = 97.52 \angle -25.84^\circ = 87.77 - j42.51$$

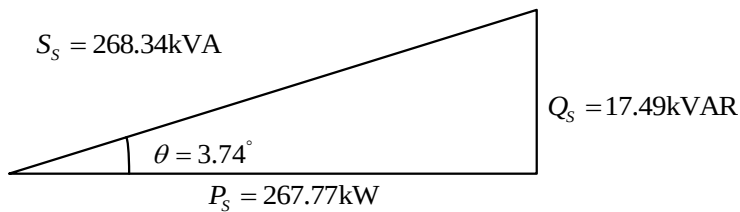
$$\bar{S}_s = \bar{S}_1 + \bar{S}_2 + \bar{S}_3 = 267.77 + j17.49 = 268.34 \angle 3.74^\circ$$

$$P_s = \text{Re}(\bar{S}_s) = 267.77 \text{ kW}$$

$$Q_s = \text{Im}(\bar{S}_s) = 17.49 \text{ kVAR}$$

$$S_s = |\bar{S}_s| = 268.34 \text{ kVA}$$

(b)

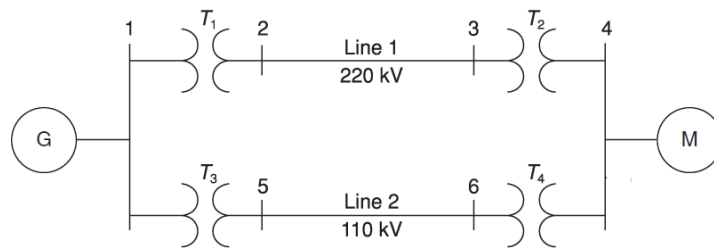


Q3 – Below figure shows the one line diagram of a three-phase power system. Lines 1 and 2 have series reactances of 60 and 80 Ω , respectively. The data are given as follows:

G: 90 MVA	22 kV	$x=0.18$ per unit
T1: 50 MVA	22/220 kV	$x=0.10$ per unit
T2: 40 MVA	220/11 kV	$x=0.06$ per unit
T3: 40 MVA	22/110 kV	$x=0.064$ per unit
T4: 40 MVA	110/11 kV	$x=0.08$ per unit
M: 66.5 MVA	10.45 kV	$x=0.185$ per unit

By selecting a common base of 90 MVA and 22 kV on the generator side.

Draw an impedance diagram showing all impedances in per-unit.



Solution

The voltage bases for the remaining buses in accordance with the transformer turns ratios.

Thus, per-unit reactances on the selected base are given by

$$G : X = 0.18 \left(\frac{90}{90} \right) = 0.18; T_1 : X = 0.1 \left(\frac{90}{50} \right) = 0.18$$

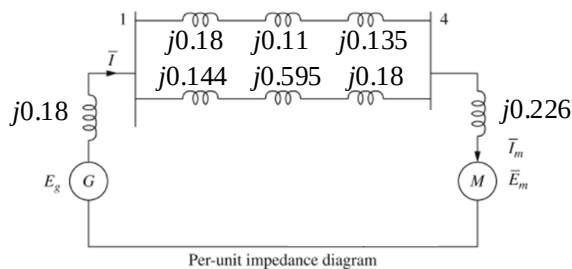
$$T_2 : X = 0.06 \left(\frac{90}{40} \right) = 0.135; T_3 : X = 0.064 \left(\frac{90}{40} \right) = 0.144;$$

$$T_4 : X = 0.08 \left(\frac{90}{40} \right) = 0.18; M : X = 0.185 \left(\frac{90}{66.5} \right) \left(\frac{10.45}{11} \right)^2 = 0.226$$

$$\text{For Line 1, } Z_{BASE} = \frac{(220)^2}{90} = 537.78 \Omega \text{ and } X = \frac{60}{537.78} = 0.11$$

$$\text{For Line 2, } Z_{BASE} = \frac{(110)^2}{90} = 134.44 \Omega \text{ and } X = \frac{80}{134.44} = 0.595$$

The per-unit equivalent circuit is shown below:

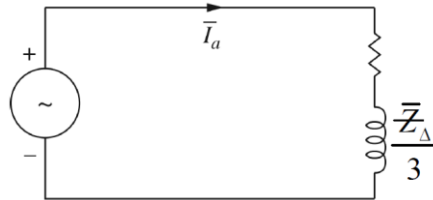


Q4 – A balanced Δ -connected impedance load with $(15 + j9) \Omega$ per phase is supplied by a balanced three-phase 50-Hz, 381-V (line voltage as referenced) source.

(a) Calculate the line current, the total real and reactive power absorbed by the load, the load power factor, and the apparent load power.

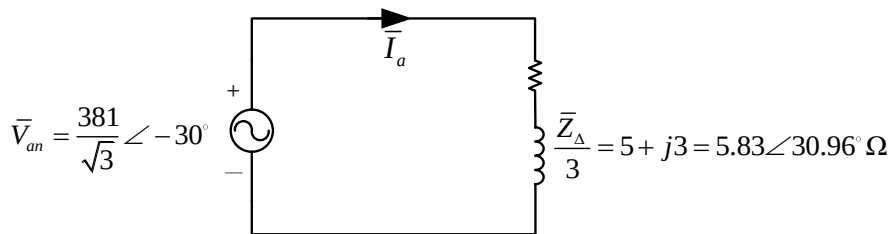
(b) Sketch a phasor diagram showing the line currents, and the Δ -load currents. Use V_{ab} as the reference.

(Tip: per-phase equivalent circuit as below.)



Solution

(a) With $\bar{V}_{an}$ as reference



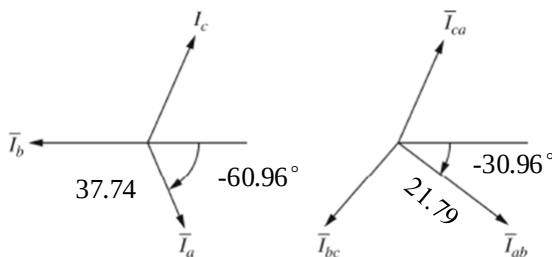
$$\bar{I}_a = \frac{\bar{V}_{an}}{(\bar{Z}_{\Delta} / 3)} = \frac{220 \angle -30^\circ}{5.83 \angle 30.96^\circ} = 37.74 \angle -60.96^\circ \text{ A}$$

$$\begin{aligned} \bar{S}_{3\phi} &= 3\bar{V}_{an}\bar{I}_a^* = 3(220 \angle -30^\circ)(37.74 \angle +60.96^\circ) \\ &= 24908.4 \angle 30.96^\circ = 21359.6 + j12813.87 \end{aligned}$$

$P_{3\phi} = 21.359 \text{ kW}$; $Q_{3\phi} = 12.813 \text{ kVAR}$; both absorbed by the load

$$pf = \cos(30.96^\circ) = 0.858 \text{ Lagging}; S_{3\phi} = |\bar{S}_{3\phi}| = 24.908 \text{ kVA}$$

(b)



$$\bar{I}_a = 37.74 \angle -60.96^\circ \text{ A} \quad \bar{I}_{ab} = 21.79 \angle -30.96^\circ \text{ A}$$

-----The End-----