KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

ELECTRICAL ENGINEERING DEPARTMENT

EE 306

Solved HW # 1: Three-Phase Circuits

3 - 19

$S = 500$ MVA , $V_L = V_{ph} = 345$ kV , Δ - load , PF = 0.866 lagging

$I_{ph} = \frac{(500,000/3)}{345} \angle -\cos^{-1} 0.866 = 483.1 \angle -30^\circ$ A

(a) $Z_{\Delta,ph} = \frac{345 \angle 0 \text{ kV}}{483.1 \angle -30 \text{ A}} = 714.2 \angle 30^\circ \ \Omega$

$Z_{Y,ph} = \frac{1}{3} Z_{\Delta,ph} = 238 \angle 30^\circ \ \Omega$

(b) $I_{ph} = 483.1 \angle -30^\circ$ A

$I_L = \sqrt{3}\, I_{ph} \angle 30^\circ = \sqrt{3}\,(483.1 \angle -30^\circ) \angle 30^\circ = 836.8 \angle 0^\circ$ A

(c) $P_{ph} = \frac{500}{3} \cos 30^\circ = 144.3$ MW

$Q_{ph} = \frac{500}{3} \sin 30^\circ = 83.3$ MVAR

(d) $P_T = 3 P_{ph} = 500 \cos 30^\circ = 433$ MW

$Q_T = 3 Q_{ph} = 500 \sin 30^\circ = 250$ MVAR

3-22

$S_M = 40\ kVA$, $V_M = 230\ V$, $PF_M = 0.65$ lagging

$P_M = 40\,(0.65) = 26\ kW$

$\theta_M = \cos^{-1} 0.65 = 49.46°$

(a) $Q_M = P_M \tan\theta_M = 26 \tan 49.46° = 30.4\ kVAR$

$PF_{new} = 0.95$

$\theta_{new} = \cos^{-1} 0.95 = 18.19°$

$Q_{new} = P_M \tan\theta_{new} = 8.54\ kVAR = Q_M + Q_C$

$\therefore\ Q_C = Q_{new} - Q_M = 8.54 - 30.4 = -21.86\ kVAR$

(b) $I_{before} = \dfrac{40{,}000}{\sqrt{3}\,(230)} \angle -\cos^{-1} 0.65 = 100 \angle -49.46°$

$I_{after} = \dfrac{26{,}000}{\sqrt{3}\,(230)(0.95)} \angle -\cos^{-1} 0.95 = 68.7 \angle -18.19°$

3-25

$P_1 = 50\text{ kW}$, $V = 460\ V_{LL}$, $PF = 0.866$ lagging

$S_2 = 36\text{ kVA}$, $V = 460\ V_{LL}$, $PF = 0.9$ leading

$Z_{per} = 0.5 + j2.0\ \Omega$, $\mathbf{V}_{ph} = \frac{460}{\sqrt{3}}\angle 0° = 265.6\angle 0°\ V_{LN}$

$$\mathbf{I}_1 = \frac{50{,}000\ \angle -\cos^{-1} 0.866}{\sqrt{3}(460)(0.866)} = 72.46\angle -30°\ A$$

$$\mathbf{I}_2 = \frac{36{,}000}{\sqrt{3}(460)}\angle \cos^{-1} 0.9 = 45.18\angle 25.8°\ A$$

(a)

$$Z_1 = \frac{265.6\angle 0°}{72.46\angle -30°} = 3.66\angle 30°\ \Omega$$

$$Z_2 = \frac{265.6\angle 0°}{45.18\angle 25.8°} = 5.88\angle -25.8°\ \Omega$$

(b) $\mathbf{I}_T = \mathbf{I}_1 + \mathbf{I}_2 = 72.46\angle -30° + 45.18\angle 25.8° = 104.7\angle -9.1°$

(c)

$$\mathbf{V}_S = \mathbf{V}_{ph} + Z_{per}\mathbf{I}_T = 265.6\angle 0° + (0.5 + j2.0)(104.7\angle -9.1°)$$

$$= 402.7\angle 28.5°\ V_{LN}$$

$$= 697.5\angle 58.5°\ V_{LL}$$

(d)

$$S_S = \sqrt{3}\mathbf{V}_S\mathbf{I}_T^* = \sqrt{3}(697.5\angle 28.5°)(104.7\angle -9.1°)^*$$

$$= 126.5\angle 38.6°\ \text{kVA}$$

$$= 98.86 + j78.92\ \text{kVA}$$

$P_S = 98.86\ \text{kW}$

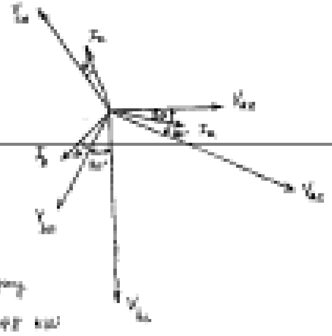
$Q_S = 78.92\ \text{kVAR}$

3-27

$$|I| = \frac{S}{\sqrt{3}\,V} = \frac{30{,}000}{\sqrt{3}\,(2400)} = 7.22\ A$$

$$P_a = V_{ac}\, I_a \cos\alpha \;\Big]^{V_{ac}}_{I_a}$$

$$P_b = V_{bc}\, I_b \cos\beta \;\Big]^{V_{bc}}_{I_b}$$



(a) $PF = 1.0\,;\ \theta = \cos^{-1} 1.0 = 0°$

$P_a = (2400)(7.22)\cos 30° = 15\ kW$

$P_b = (2400)(7.22)\cos 30° = 15\ kW$

(b) $PF = 0.2\,;\ \theta = \cos^{-1} 0.2 = 78.5°$ lagging

$P_a = (2400)(7.22)\cos(30° - 78.5°) = 11.48\ kW$

$P_b = (2400)(7.22)\cos(30 + 78.5) = -5.5\ kW$

(c) $PF = 0.5\,;\ \theta = \cos^{-1} 0.5 = 60°$ leading

$P_a = (2400)(7.22)\cos(30 + 60) = 0$

$P_b = (2400)(7.22)\cos(30 - 60) = 15\ kW$