3-19

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

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

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

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

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

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

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

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

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

$\mathbf{I}_{after} = \dfrac{26{,}000}{\sqrt{3}(250)(0.95)} \angle -\cos^{-1} 0.95 = 68.7 \angle -18.19°$

3-23

$S_1 = 15\ kVA$, $\mathbf{V}_L = 2400\angle 0^\circ$, $PF_1 = 0.8$ lagging

$P_2 = 20\ kW$, $\mathbf{V}_L = 2400\angle 0^\circ$, $PF_2 = 0.9$ leading

(a) $\mathbf{I}_1 = \dfrac{15{,}000}{\sqrt{3}(2400)}\angle -\cos^{-1}0.8 = 3.61\angle -36.9^\circ\ A$

$\mathbf{I}_2 = \dfrac{20{,}000}{\sqrt{3}(2400)(0.9)}\angle \cos^{-1}0.9 = 5.34\angle 25.8^\circ\ A$

(b) $P_1 = 15(0.8) = 12\ kW$

$Q_1 = 15 \sin 36.9^\circ = 9\ kVAR$

$P_2 = 20\ kW$

$Q_2 = -20 \tan 25.8^\circ = -9.7\ kVAR$

(c) $\mathbf{I}_T = \mathbf{I}_1 + \mathbf{I}_2 = 3.61\angle -36.9^\circ + 5.34\angle 25.8^\circ = 7.7\angle 1.2^\circ\ A$

(d) $P_T = P_1 + P_2 = 12 + 20 = 32\ kW$

$Q_T = Q_1 + Q_2 = 9 - 9.7 = -0.7\ kVAR$

(e) $PF = \cos 1.2^\circ = 0.999$ leading

3-25

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

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

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

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

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

(a) $$Z_1 = \frac{265.6 \angle 0^\circ}{72.46 \angle -30^\circ} = 3.66 \angle 30^\circ\ \Omega$$

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

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

(c) $$\mathbf{V}_B = \mathbf{V}_{ph} + Z_{fdr}\mathbf{I}_T = 265.6 \angle 0^\circ + (0.5 + j2.0)(104.7 \angle -9.1^\circ)$$

$$= 402.7 \angle 29.5^\circ\ V_{LN}$$

$$= 697.5 \angle 59.5^\circ\ V_{LL}$$

(d) $$S_B = \sqrt{3}\mathbf{V}_B \mathbf{I}_T^* = \sqrt{3}(697.5 \angle 29.5^\circ)(104.7 \angle -9.1^\circ)^*$$

$$= 126.5 \angle 38.6^\circ\ kVA$$

$$= 98.86 + j78.92\ kVA$$

$P_B = 98.86\ kW$

$Q_B = 78.92\ kVAR$

3-26

$Z_\Delta = 45\angle 60^\circ\ \Omega$; $Z_{fdr} = 1.2 + j1.6\ \Omega$

(a) $Z_Y = \frac{1}{3} Z_\Delta = 15\angle 60^\circ = 7.5 + j13\ \Omega$

$Z_T = Z_{fdr} + Z_Y = 7.5 + j13 + 1.2 + j1.6 = 8.7 + j14.6\ \Omega$

$$\mathbf{I} = \frac{\mathbf{V}_{ph}}{Z_T} = \frac{(208/\sqrt{3})\angle 0^\circ}{8.7 + j14.6} = 7.06\angle -59.2^\circ\ A$$

$$\mathbf{V}_{LOAD} = \mathbf{V}_{ph} - Z_{fdr}\mathbf{I} = 120\angle 0^\circ - (1.2 + j1.6)(7.06\angle -59.2^\circ)$$

$$= 120 + j0 - (14.04 - j1.493) = 106\angle 0.81^\circ\ V_{LN}$$

$$= 183.6\angle 30.81^\circ\ V_{LL}$$

(b) $Z_{C,\Delta} = 60\angle -90^\circ = -j60\ \Omega$

$Z_{C,Y} = \frac{1}{3} Z_{C,\Delta} = 20\angle -90^\circ = -j20\ \Omega$

$$Z_{eq} = \frac{(7.5 + j13)(-j20)}{7.5 + j13 - j20} = 28.5 + j6.6\ \Omega$$

$$\mathbf{I} = \frac{120\angle 0^\circ}{28.5 + j6.6 + 1.2 + j1.6} = \frac{120 + j0}{29.7 + j8.2} = 3.89\angle -15.4^\circ\ A$$

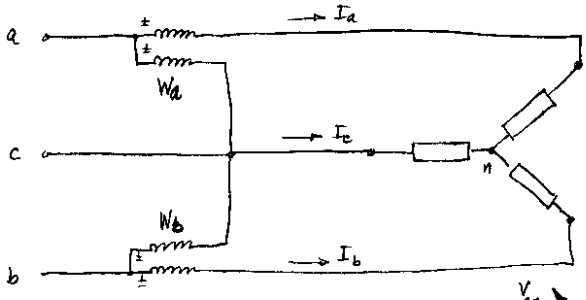
$$\mathbf{V}_{LOAD} = 120\angle 0 - (1.2 + j1.6)(3.89\angle -15.4^\circ)$$

$$= 120 + j0 - (6.16 + j4.76)$$

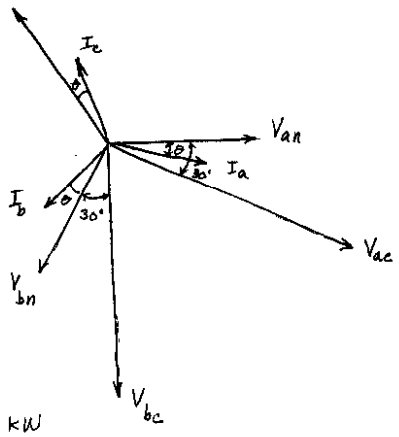
$$= 113.9\angle -2.4^\circ$$

$$= 197.3\angle 27.6^\circ$$

3-27



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



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

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

(b) 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

(c) 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

(d) 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