# 3-19

$S = 500$ MVA, $V_L = V_{ph} = 345$ kV, $\Delta$-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) $I_{ph} = 483.1 \angle -30^\circ$ 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

$$P_M = 40(0.65) = 26 \text{ kW}$$

$$\theta_M = \cos^{-1} 0.65 = 49.46^\circ$$

(a) $$Q_M = P_M \tan\theta_M = 26 \tan 49.46^\circ = 30.4 \text{ kVAR}$$

$$PF_{new} = 0.95$$

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

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

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

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

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

# 3-23

$S_1 = 15\ kVA$, $V_L = 2400\angle 0°$, $PF_1 = 0.8$ lagging

$P_2 = 20\ kW$, $V_L = 2400\angle 0°$, $PF_2 = 0.9$ leading

(a) $I_1 = \dfrac{15{,}000}{\sqrt{3}(2400)}\angle -\cos^{-1}0.8 = 3.61\angle -36.9°\ A$

$I_2 = \dfrac{20{,}000}{\sqrt{3}(2400)(0.9)}\angle \cos^{-1}0.9 = 5.34\angle 25.8°\ A$

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

$Q_1 = 15 \sin 36.9° = 9\ kVAR$

$P_2 = 20\ kW$

$Q_2 = -20 \tan 25.8° = -9.7\ kVAR$

(c) $I_T = I_1 + I_2 = 3.61\angle -36.9° + 5.34\angle 25.8° = 7.7\angle 1.2°\ A$

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

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

(e) $PF = \cos 1.2° = 0.999$ 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

$Z_{fdr} = 0.5 + j2.0\ \Omega$, $V_{ph} = \dfrac{460}{\sqrt{3}}\angle 0° = 265.6\angle 0°\ V_{LN}$

$I_1 = \dfrac{50{,}000\angle -\cos^{-1}0.866}{\sqrt{3}(460)(0.866)} = 72.46\angle -30°\ A$

$I_2 = \dfrac{36{,}000}{\sqrt{3}(460)}\angle \cos^{-1}0.9 = 45.18\angle 25.8°\ A$

(a) $Z_1 = \dfrac{265.6\angle 0°}{72.46\angle -30°} = 3.66\angle 30°\ \Omega$

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

(b) $I_T = I_1 + I_2 = 72.46\angle -30° + 45.18\angle 25.8° = 104.7\angle -9.1°$

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ntd.)

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

$= 402.7\angle 29.5°$ $V_{LN}$

$= 697.5\angle 59.5°$ $V_{LL}$

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

$= 126.5\angle 38.6°$ KVA

$= 98.86 + j78.92$ KVA

$P_B = 98.86$ kW

$Q_B = 78.92$ KVAR

# 3-26

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

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

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

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

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

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

$= 183.6\angle 30.81°$ $V_{LL}$

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

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

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

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

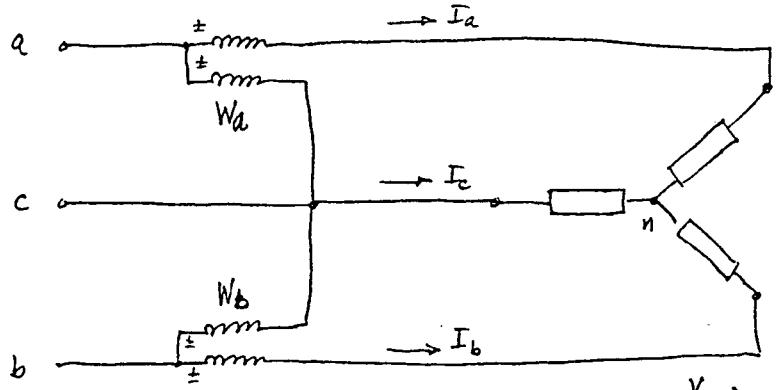
$\mathbf{V}_{LOAD} = 120\angle 0 - (1.2+j1.6)(3.89\angle -15.4°)$

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

$= 113.9\angle -2.4°$

$= 197.3\angle 27.6°$

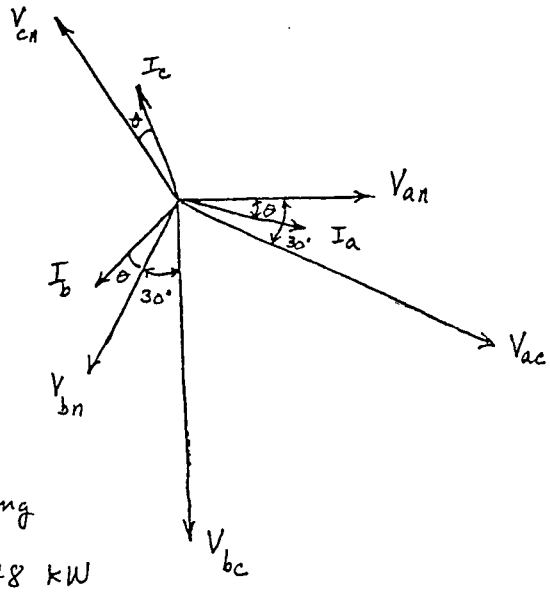
# 3-27




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

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

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




(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

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

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