SOLUTION OF HOMEWORK 1 FOR EE205

P 11.7 $Z_{ga} + Z_{la} + Z_{La} = 60 + j80\,\Omega$

$$Z_{gb} + Z_{lb} + Z_{Lb} = 40 + j30\Omega$$

$$Z_{gc} + Z_{lc} + Z_{Lc} = 20 + j15\Omega$$

$$\frac{\mathbf{V}_N - 240}{60 + j80} + \frac{\mathbf{V}_N - 240\underline{/120^\circ}}{40 + j30} + \frac{\mathbf{V}_N - 240\underline{/-120^\circ}}{20 + j15} + \frac{\mathbf{V}_N}{10} = 0$$

Solving for $\mathbf{V}_N$ yields

$$\mathbf{V}_N = 42.94\underline{/-156.32^\circ}\,\text{V}$$

$$\mathbf{I}_o = \frac{\mathbf{V}_N}{10} = 4.29\underline{/-156.32^\circ}\,\text{A}$$

P 11.11 **[a]** $\mathbf{I}_{\text{AB}} = \dfrac{480}{60 + j45} = 6.4\underline{/-36.87^\circ}\,\text{A}$

$$\mathbf{I}_{\text{BC}} = 6.4\underline{/-156.87^\circ}\,\text{A}$$

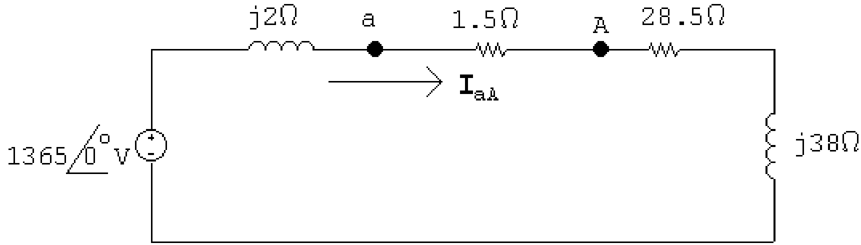
$$\mathbf{I}_{\text{CA}} = 6.4\underline{/83.13^\circ}\,\text{A}$$

[b] $\mathbf{I}_{\text{aA}} = \sqrt{3}\underline{/-30^\circ}\mathbf{I}_{\text{AB}} = 11.09\underline{/-66.87^\circ}\,\text{A}$

$$\mathbf{I}_{\text{bB}} = 11.09\underline{/173.13^\circ}\,\text{A}$$

$$\mathbf{I}_{\text{cC}} = 11.09\underline{/53.13^\circ}\,\text{A}$$

P 11.20 **[a]**



$$\mathbf{I}_{\text{aA}} = \frac{1365\angle 0^\circ}{30 + j40} = 27.3\angle -53.13^\circ \text{ A}$$

$$\mathbf{I}_{\text{CA}} = \frac{\mathbf{I}_{\text{aA}}}{\sqrt{3}}\angle 150^\circ = 15.76\angle 96.87^\circ \text{ A}$$

[b] $S_{g/\phi} = -1365\mathbf{I}^*_{\text{aA}} = -22{,}358.7 - j29{,}811.6 \text{ VA}$

$$\therefore \quad P_{\text{developed/phase}} = 22.359 \text{ kW}$$

$$P_{\text{absorbed/phase}} = |\mathbf{I}_{\text{aA}}|^2 28.5 = 21.241 \text{ kW}$$

$$\% \text{ delivered} = \frac{21.241}{22.359}(100) = 95\%$$

P 11.21 Let $p_{\rm a}$, $p_{\rm b}$, and $p_{\rm c}$ represent the instantaneous power of phases a, b, and c, respectively. Then assuming a positive phase sequence, we have

$$p_{\rm a} = v_{\rm an} i_{\rm aA} = [V_m \cos \omega t][I_m \cos(\omega t - \theta_\phi)]$$

$$p_{\rm b} = v_{\rm bn} i_{\rm bB} = [V_m \cos(\omega t - 120^\circ)][I_m \cos(\omega t - \theta_\phi - 120^\circ)]$$

$$p_{\rm c} = v_{\rm cn} i_{\rm cC} = [V_m \cos(\omega t + 120^\circ)][I_m \cos(\omega t - \theta_\phi + 120^\circ)]$$

The total instantaneous power is $p_T = p_{\rm a} + p_{\rm b} + p_{\rm c}$, so

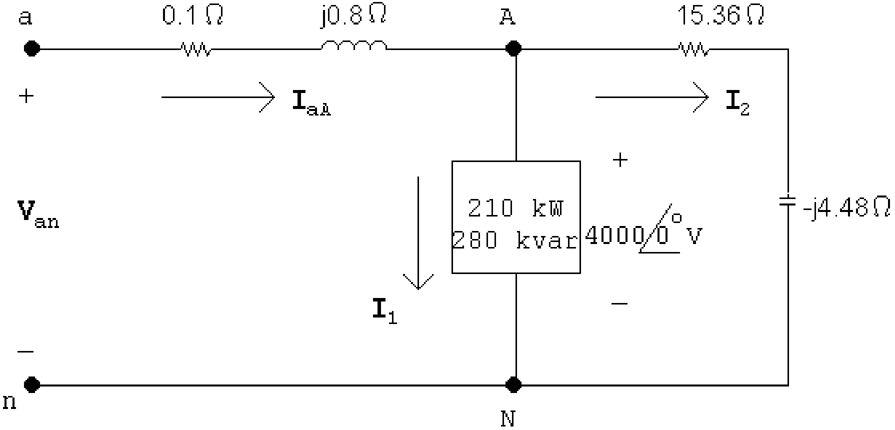
$$p_T = V_m I_m [\cos \omega t \cos(\omega t - \theta_\phi) + \cos(\omega t - 120^\circ) \cos(\omega t - \theta_\phi - 120^\circ)$$

$$+ \cos(\omega t + 120^\circ) \cos(\omega t - \theta_\phi + 120^\circ)]$$

Now simplify using trigonometric identities. In simplifying, collect the coefficients of $\cos(\omega t - \theta_\phi)$ and $\sin(\omega t - \theta_\phi)$. We get

$$\begin{aligned} p_T &= V_m I_m [\cos \omega t (1 + 2\cos^2 120^\circ) \cos(\omega t - \theta_\phi) \\ &\quad + 2 \sin \omega t \sin^2 120^\circ \sin(\omega t - \theta_\phi)] \\ &= 1.5 V_m I_m [\cos \omega t \cos(\omega t - \theta_\phi) + \sin \omega t \sin(\omega t - \theta_\phi)] \\ &= 1.5 V_m I_m \cos \theta_\phi \end{aligned}$$

P 11.24



$$4000\mathbf{I}_1^* = (210 + j280)10^3$$

$$\mathbf{I}_1^* = \frac{210}{4} + j\frac{280}{4} = 52.5 + j70\,\text{A}$$

$$\mathbf{I}_1 = 52.5 - j70\,\text{A}$$

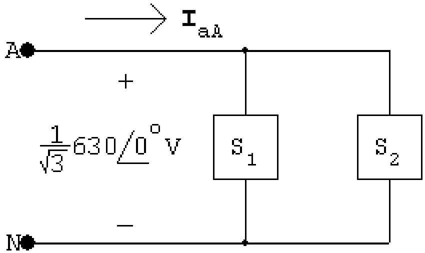
$$\mathbf{I}_2 = \frac{4000\underline{/0^\circ}}{15.36 - j4.48} = 240 + j70\,\text{A}$$

$$\therefore \quad \mathbf{I}_{\text{aA}} = \mathbf{I}_1 + \mathbf{I}_2 = 292.5 + j0\,\text{A}$$

$$\mathbf{V}_{\text{an}} = 4000 + j0 + 292.5(0.1 + j0.8) = 4036.04\underline{/3.32^\circ}\,\text{V}$$

$$|\mathbf{V}_{\text{ab}}| = \sqrt{3}|\mathbf{V}_{\text{an}}| = 6990.62\,\text{V}$$

P 11.27 **[a]**



$$S_{s/\phi} = \frac{1}{3}(60)(0.96 - j0.28) \times 10^3 = 19.2 - j5.6\,\text{kVA}$$

$$S_{1/\phi} = 15\,\text{kVA}$$

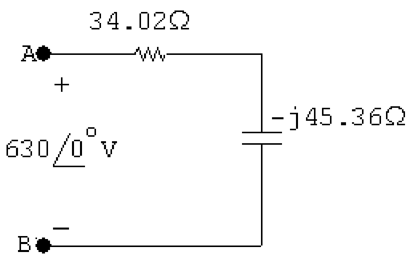
$$S_{2/\phi} = S_{s/\phi} - S_{1/\phi} = 4.2 - j5.6\,\text{kVA}$$

$$\therefore \quad \mathbf{I}_2^* = \frac{4200 - j5600}{630/\sqrt{3}} = 11.547 - j15.396\,\text{A}$$

$$\mathbf{I}_2 = 11.547 + j15.396\,\text{A}$$

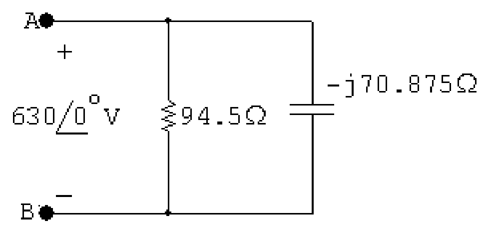
$$Z_y = \frac{630\angle 0^\circ/\sqrt{3}}{\mathbf{I}_2} = 11.34 - j15.12\,\Omega$$

$$Z_\Delta = 3Z_y = 34.02 - j45.36\,\Omega$$



[b] $R = \frac{(630/\sqrt{3})^2}{4200} = 31.5\,\Omega; \qquad R_\Delta = 3R = 94.5\,\Omega$

$$X_L = \frac{(630/\sqrt{3})^2}{-5600} = -23.625\,\Omega; \qquad X_\Delta = 3X_L = -70.875\,\Omega$$

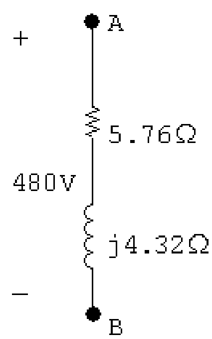


P 11.28 Assume a Δ-connect load (series):

$$S_\phi = \frac{1}{3}(96 \times 10^3)(0.8 + j0.6) = 25{,}600 + j19{,}200\,\text{VA}$$

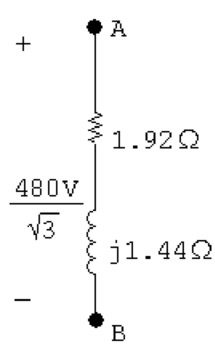
$$Z^*_{\Delta\phi} = \frac{|480|^2}{25{,}600 + j19{,}200} = 5.76 - j4.32\,\Omega$$

$$Z_{\Delta\phi} = 5.76 + 4.32\,\Omega$$



Now assume a Y-connected load (series):

$$Z_{Y\phi} = \frac{1}{3}Z_{\Delta\phi} = 1.92 + j1.44\,\Omega$$



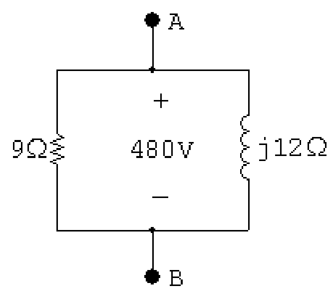
Now assume a Δ-connected load (parallel):

$$P_\phi = \frac{|480|^2}{R_\Delta}$$

$$R_{\Delta\phi} = \frac{|480|^2}{25{,}600} = 9\,\Omega$$

$$Q_\phi = \frac{|480|^2}{X_\Delta}$$

$$X_\Delta\phi = \frac{|480|^2}{19{,}200} = 12\,\Omega$$



Now assume a Y-connected load (parallel):

$$R_{Y\phi} = \frac{1}{3}R_{\Delta\phi} = 3\,\Omega$$

$$X_{Y\phi} = \frac{1}{3}X_{\Delta\phi} = 4\,\Omega$$