P 10.6 **[a]** Area under one cycle of v_g^2:

$$A = (5^2)(2)(30 \times 10^{-6}) + 2^2(2)(37.5 \times 10^{-6})$$
$$= 1800 \times 10^{-6}$$

Mean value of v_g^2:

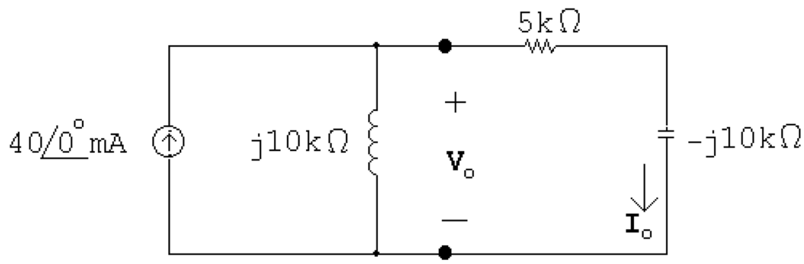
$$\text{M.V.} = \frac{A}{200 \times 10^{-6}} = \frac{1800 \times 10^{-6}}{200 \times 10^{-6}} = 9$$

$$\therefore \quad V_{\text{rms}} = \sqrt{9} = 3\,\text{V(rms)}$$

[b] $P = \dfrac{V_{\text{rms}}^2}{R} = \dfrac{3^2}{2.25} = 4\,\text{W}$

P 10.9 $\mathbf{I}_g = 40\underline{/0^\circ}\text{ mA}$

$$j\omega L = j10{,}000\,\Omega; \qquad \frac{1}{j\omega C} = -j10{,}000\,\Omega$$



$$\mathbf{I}_o = \frac{j10{,}000}{5000}(40\underline{/0^\circ}) = 80\underline{/90^\circ}\text{ mA}$$

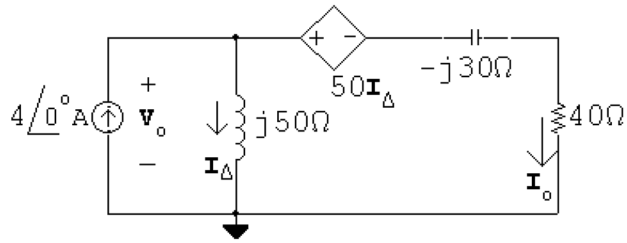
$$P = \frac{1}{2}|\mathbf{I}_o|^2(5000) = \frac{1}{2}(0.08)^2(5000) = 16\,\text{W}$$

$$Q = \frac{1}{2}|\mathbf{I}_o|^2(-10{,}000) = -32\,\text{VAR}$$

$$S = P + jQ = 16 - j32\,\text{VA}$$

$$|S| = 35.78\,\text{VA}$$

P 10.11 $j\omega L = j10^5(0.5\times 10^{-3}) = j50\,\Omega;\qquad \frac{1}{j\omega C} = \frac{1}{j10^5[(1/3)\times 10^{-6}]} = -j30\,\Omega$



$$-4 + \frac{\mathbf{V}_o}{j50} + \frac{\mathbf{V}_o - 50\mathbf{I}_\Delta}{40 - j30} = 0$$

$$\mathbf{I}_\Delta = \frac{\mathbf{V}_o}{j50}$$

Place the equations in standard form:

$$\mathbf{V}_o\left(\frac{1}{j50} + \frac{1}{40 - j30}\right) + \mathbf{I}_\Delta\left(\frac{-50}{40 - j30}\right) = 4$$

$$\mathbf{V}_o\left(\frac{1}{j50}\right) + \mathbf{I}_\Delta(-1) = 0$$

Solving,

$$\mathbf{V}_o = 200 - j400 \text{ V};\qquad \mathbf{I}_\Delta = -8 - j4 \text{ A}$$

$$\mathbf{I}_o = 4 - (-8 - j4) = 12 + j4 \text{ A}$$

$$P_{40\Omega} = \frac{1}{2}|\mathbf{I}_o|^2(40) = \frac{1}{2}(160)(40) = 3200\,\text{W}$$

P 10.13 $Z_\mathrm{f} = -j10{,}000\|20{,}000 = 4000 - j8000\,\Omega$

$$Z_\mathrm{i} = 2000 - j2000\,\Omega$$

$$\therefore \quad \frac{Z_\mathrm{f}}{Z_\mathrm{i}} = \frac{4000 - j8000}{2000 - j2000} = 3 - j1$$

$$\mathbf{V}_o = -\frac{Z_\mathrm{f}}{Z_\mathrm{i}}\mathbf{V}_g; \qquad \mathbf{V}_g = 1\underline{/0^\circ}\,\mathrm{V}$$

$$\mathbf{V}_o = (3 - j1)(1) = 3 - j1 = 3.16\underline{/-18.43^\circ}\,\mathrm{V}$$

$$P = \frac{1}{2}\frac{V_m^2}{R} = \frac{1}{2}\frac{(10)}{1000} = 5 \times 10^{-3} = 5\,\mathrm{mW}$$

P 10.14 **[a]** $P = \frac{1}{2}\frac{(240)^2}{480} = 60\,\text{W}$

$$-\frac{1}{\omega C} = \frac{-9\times 10^6}{(5000)(5)} = -360\,\Omega$$

$$Q = \frac{1}{2}\frac{(240)^2}{(-360)} = -80\,\text{VAR}$$

$$p_{\text{max}} = P + \sqrt{P^2 + Q^2} = 60 + \sqrt{(60)^2 + (80)^2} = 160\,\text{W(del)}$$

[b] $p_{\text{min}} = 60 - \sqrt{60^2 + 80^2} = -40\,\text{W(abs)}$

[c] $P = 60\,\text{W}$ from (a)

[d] $Q = -80\,\text{VAR}$ from (a)

[e] generate, because $Q < 0$

[f] pf $= \cos(\theta_v - \theta_i)$

$$\mathbf{I} = \frac{240}{480} + \frac{240}{-j360} = 0.5 + j0.67 = 0.83\underline{/53.13^\circ}\,\text{A}$$

$\therefore$ pf $= \cos(0 - 53.13^\circ) = 0.6$ leading

[g] rf $= \sin(-53.13^\circ) = -0.8$

P 10.17 **[a]** $Z_1 = 240 + j70 = 250\underline{/16.26^\circ}\,\Omega$

$$\text{pf } = \cos(16.26^\circ) = 0.96 \text{ lagging}$$

$$\text{rf } = \sin(16.26^\circ) = 0.28$$

$$Z_2 = 160 - j120 = 200\underline{/-36.87^\circ}\,\Omega$$

$$\text{pf } = \cos(-36.87^\circ) = 0.80 \text{ leading}$$

$$\text{rf } = \sin(-36.87^\circ) = -0.60$$

$$Z_3 = 30 - j40 = 50\underline{/-53.13^\circ}\,\Omega$$

$$\text{pf } = \cos(-53.13^\circ) = 0.6 \text{ leading}$$

$$\text{rf } = \sin(-53.13^\circ) = -0.8$$

[b] $Y = Y_1 + Y_2 + Y_3$

$$Y_1 = \frac{1}{250\underline{/16.26^\circ}}; \qquad Y_2 = \frac{1}{200\underline{/-36.87^\circ}}; \qquad Y_3 = \frac{1}{50\underline{/-53.13^\circ}}$$

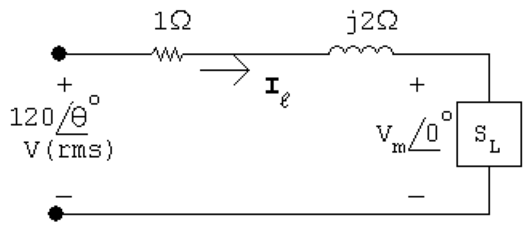
$$Y = 19.84 + j17.88\,\text{mS}$$

$$Z = \frac{1}{Y} = 37.44\underline{/-42.03^\circ}\,\Omega$$

$$\text{pf } = \cos(-42.03^\circ) = 0.74 \text{ leading}$$

$$\text{rf } = \sin(-42.03^\circ) = -0.67$$

P 10.29 **[a]** Let $\mathbf{V}_\text{L} = V_m\underline{/0^\circ}$:



$$S_\text{L} = 600(0.8 + j0.6) = 480 + j360\,\text{VA}$$

$$\mathbf{I}_\ell^* = \frac{480}{V_m} + j\frac{360}{V_m}; \qquad \mathbf{I}_\ell = \frac{480}{V_m} - j\frac{360}{V_m}$$

$$120\underline{/\theta} = V_m + \left(\frac{480}{V_m} - j\frac{360}{V_m}\right)(1 + j2)$$

$$120V_m\underline{/\theta} = V_m^2 + (480 - j360)(1 + j2) = V_m^2 + 1200 + j600$$

$$120V_m\cos\theta = V_m^2 + 1200; \qquad 120V_m\sin\theta = 600$$

$$(120)^2V_m^2 = (V_m^2 + 1200)^2 + 600^2$$

$$14{,}400V_m^2 = V_m^4 + 2400V_m^2 + 18\times 10^5$$

or

$$V_m^4 - 12{,}000V_m^2 + 18\times 10^5 = 0$$

Solving,

$V_m = 108.85$ V and $V_m = 12.326$ V

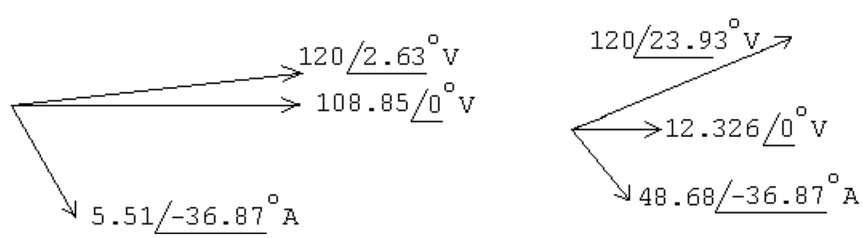
If $V_m = 108.85$ V:

$$\sin\theta = \frac{600}{(108.85)(120)} = 0.045935; \qquad \therefore \quad \theta = 2.63^\circ$$

If $V_m = 12.326$ V:

$$\sin\theta = \frac{600}{(12.326)(120)} = 0.405647; \qquad \therefore \quad \theta = 23.93^\circ$$

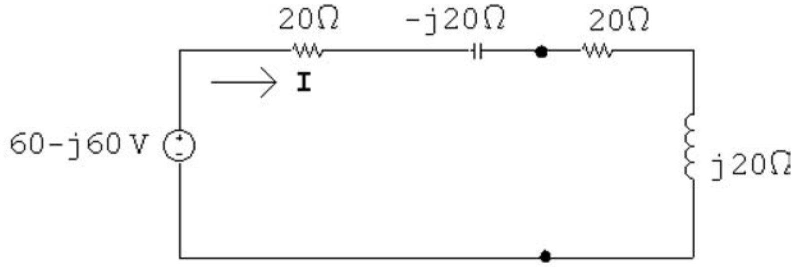
[b]



P 10.33 **[a]** $Z_{\rm Th} = j40\|40 - j40 = 20 - j20$

$$\therefore \quad Z_{\rm L} = Z^*_{\rm Th} = 20 + j20\,\Omega$$

[b] $\mathbf{V}_{\rm Th} = \dfrac{40}{40 + j40}(120) = 60 - j60\,\text{V}$



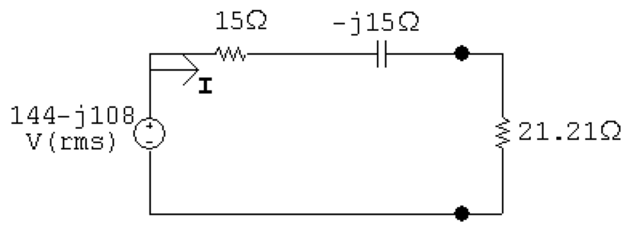
$$\mathbf{I} = \frac{60 - j60}{40} = 1.5 - j1.5\,\text{A}$$

$$P_{\rm load} = \frac{1}{2}|\mathbf{I}|^2(20) = 45\,\text{W}$$

P 10.35 **[a]** $Z_{\rm Th} = [(3 + j4) \| - j8] + 7.32 - j17.24 = 15 - j15\,\Omega$

$\therefore \quad R = |Z_{\rm Th}| = 21.21\,\Omega$

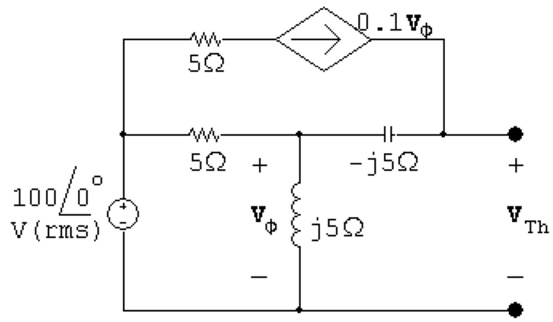
[b] $\mathbf{V}_{\rm Th} = \frac{-j8}{3 - j4}(112.5) = 144 - j108$ V(rms)



$$\mathbf{I} = \frac{144 - j108}{35.21 - j15} = 4.45 - j1.14$$

$$P = |\mathbf{I}|^2(21.21) = 447.35\,\text{W}$$

P 10.37 **[a]** Open circuit voltage:

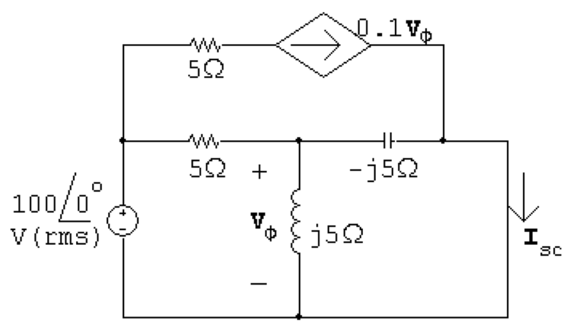


$$\frac{\mathbf{V}_\phi - 100}{5} + \frac{\mathbf{V}_\phi}{j5} - 0.1\mathbf{V}_\phi = 0$$

$$\therefore \quad \mathbf{V}_\phi = 40 + j80\,\text{V(rms)}$$

$$\mathbf{V}_{\text{Th}} = \mathbf{V}_\phi + 0.1\mathbf{V}_\phi(-j5) = \mathbf{V}_\phi(1 - j0.5) = 80 + j60\,\text{V(rms)}$$

Short circuit current:



$$\mathbf{I}_{\text{sc}} = 0.1\mathbf{V}_\phi + \frac{\mathbf{V}_\phi}{-j5} = (0.1 + j0.2)\mathbf{V}_\phi$$

$$\frac{\mathbf{V}_\phi - 100}{5} + \frac{\mathbf{V}_\phi}{j5} + \frac{\mathbf{V}_\phi}{-j5} = 0$$

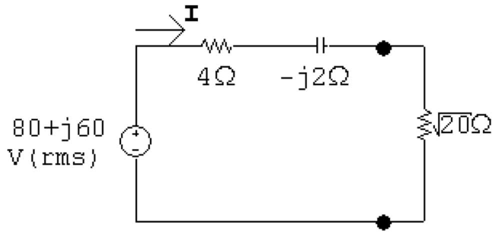
$$\therefore \quad \mathbf{V}_\phi = 100\,\text{V(rms)}$$

$$\mathbf{I}_{\text{sc}} = (0.1 + j0.2)(100) = 10 + j20\,\text{A(rms)}$$

$$Z_{\text{Th}} = \frac{\mathbf{V}_{\text{Th}}}{\mathbf{I}_{\text{sc}}} = \frac{80 + j60}{10 + j20} = 4 - j2\,\Omega$$

$$\therefore \quad R_o = |Z_{\text{Th}}| = 4.47\,\Omega$$

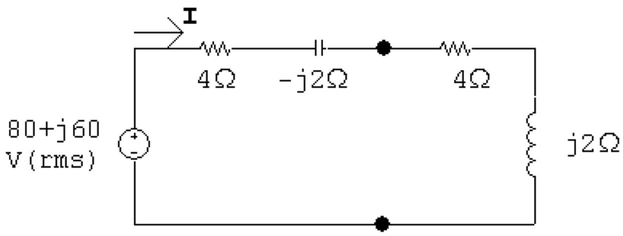
[b]



$$\mathbf{I} = \frac{80 + j60}{4 + \sqrt{20} - j2} = 7.36 + j8.82\,\text{A(rms)}$$

$$P = (11.49)^2(\sqrt{20}) = 590.17\,\text{W}$$

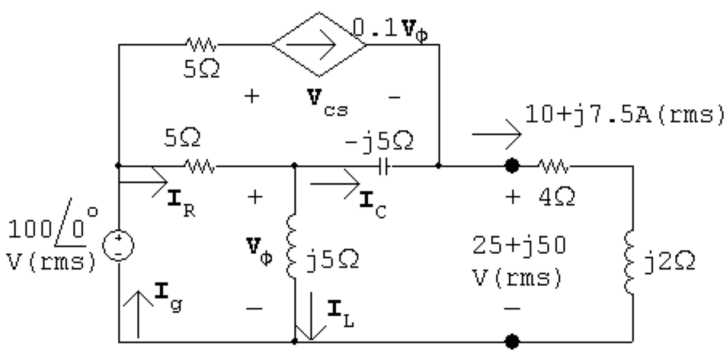
[c]



$$\mathbf{I} = \frac{80 + j60}{8} = 10 + j7.5\,\text{A(rms)}$$

$$P = (10^2 + 7.5^2)(4) = 625\,\text{W}$$

[d]



$$\frac{\mathbf{V}_\phi - 100}{5} + \frac{\mathbf{V}_\phi}{j5} + \frac{\mathbf{V}_\phi - (25 + j50)}{-j5} = 0$$

$$\mathbf{V}_\phi = 50 + j25\,\text{V(rms)}$$

$$0.1\mathbf{V}_\phi = 5 + j2.5$$

$$5 + j2.5 + \mathbf{I}_C = 10 + j7.5$$

$$\mathbf{I}_C = 5 + j5\,\text{A(rms)}$$

$$\mathbf{I}_L = \frac{\mathbf{V}_\phi}{j5} = 5 - j10\,\text{A(rms)}$$

$$\mathbf{I}_R = \mathbf{I}_C + \mathbf{I}_L = 10 - j5\,\text{A(rms)}$$

$$\mathbf{I}_g = \mathbf{I}_R + 0.1\mathbf{V}_\phi = 15 - j2.5\,\text{A(rms)}$$

$S_g = -100\mathbf{I}_g^* = -1500 - j250\,\text{VA}$

$100 = 5(5 + j2.5) + \mathbf{V}_{\text{cs}} + 25 + j50 \quad \therefore \quad \mathbf{V}_{\text{cs}} = 50 - j62.5\,\text{V(rms)}$

$S_{\text{cs}} = (50 - j62.5)(5 - j2.5) = 93.75 - j437.5\,\text{VA}$

Thus,

$\sum P_{\text{dev}} = 1500$

% delivered to $R_o = \dfrac{625}{1500}(100) = 41.67\%$