P 9.1 [a] $\omega = 2\pi f = 800\,\text{rad/s}, \qquad f = \dfrac{\omega}{2\pi} = 127.32\,\text{Hz}$

[b] $T = 1/f = 7.85\,\text{ms}$

[c] $I_m = 125\,\text{mA}$

[d] $i(0) = 125\cos(36.87^\circ) = 100\,\text{mA}$

[e] $\phi = 36.87^\circ; \qquad \phi = \dfrac{36.87^\circ(2\pi)}{360^\circ} = 0.6435\ \text{rad}$

[f] $i = 0$ when $800t + 36.87^\circ = 90^\circ$. Now resolve the units:

$$(800\ \text{rad/s})t = \frac{53.13^\circ}{57.3^\circ/\text{rad}} = 0.927\,\text{rad}, \qquad t = 1.16\,\text{ms}$$

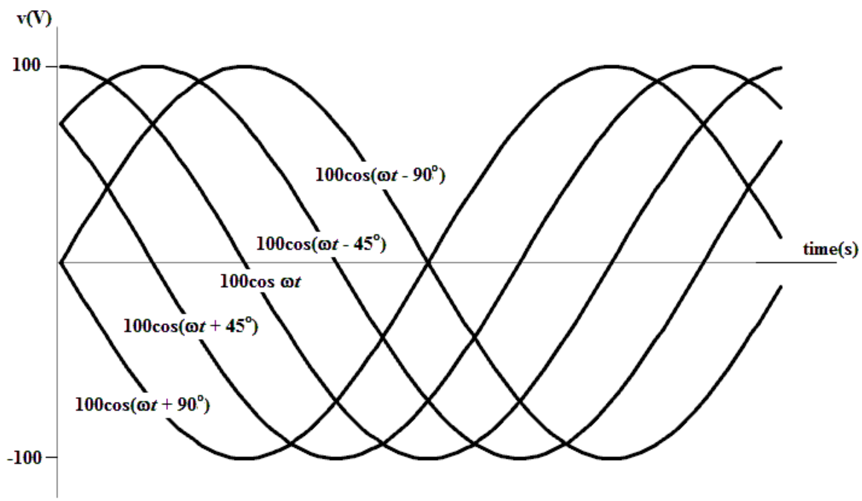
[g] $(di/dt) = (-0.125)800\sin(800t + 36.87^\circ)$

$$(di/dt) = 0 \quad \text{when} \quad 800t + 36.87^\circ = 180^\circ$$

$$\text{or} \qquad 800t = \frac{143.13^\circ}{57.3^\circ/\text{rad}} = 2.498\,\text{rad}$$

Therefore $t = 3.12\,\text{ms}$

P 9.2



[a] Right as ϕ becomes more negative

[b] Left

P 9.5 **[a]** $\frac{T}{2} = 25 - 5 = 20\,\text{ms}; \qquad T = 40\,\text{ms}$

$$f = \frac{1}{T} = \frac{1}{40 \times 10^{-3}} = 25\,\text{Hz}$$

[b] $i = I_m \sin(\omega t + \theta)$

$$\omega = 2\pi f = 50\pi \text{ rad/s}$$

$$50\pi(5 \times 10^{-3}) + \theta = 0; \qquad \therefore \quad \theta = \frac{-\pi}{4} \text{ rad} = -45^\circ$$

$$i = I_m \sin[50\pi t - 45^\circ]$$

$$0.5 = I_m \sin -45^\circ; \qquad I_m = -70.71\,\text{mA}$$

$$i = -70.71 \sin[50\pi t - 45^\circ] = 70.71 \cos[50\pi t + 45^\circ]\,\text{mA}$$

P 9.6 $\quad V_m = \sqrt{2} V_{\text{rms}} = \sqrt{2}(240) = 339.41\,\text{V}$

P 9.7 $\quad V_{\text{rms}} = \sqrt{\frac{1}{T} \int_0^{T/2} V_m^2 \sin^2 \frac{2\pi}{T} t\, dt}$

$$\int_0^{T/2} V_m^2 \sin^2\left(\frac{2\pi}{T} t\right) dt = \frac{V_m^2}{2} \int_0^{T/2} \left(1 - \cos \frac{4\pi}{T} t\right) dt = \frac{V_m^2 T}{4}$$

Therefore $\quad V_{\text{rms}} = \sqrt{\frac{1}{T} \frac{V_m^2 T}{4}} = \frac{V_m}{2}$

P 9.11 [a] $\mathbf{Y} = 30\underline{/-160^\circ} + 15\underline{/70^\circ} = 29.38\underline{/170.56^\circ}$

$$y = 28.38\cos(200t + 170.56^\circ)$$

[b] $\mathbf{Y} = 90\underline{/-110^\circ} + 60\underline{/-70^\circ} = 141.33\underline{/-94.16^\circ}$

$$y = 141.33\cos(50t - 94.16^\circ)$$

[c] $\mathbf{Y} = 50\underline{/-60^\circ} + 25\underline{/20^\circ} - 75\underline{/-30^\circ} = 16.7\underline{/170.52^\circ}$

$$y = 16.7\cos(5000t + 170.52^\circ)$$

[d] $\mathbf{Y} = 10\underline{/30^\circ} + 10\underline{/-90^\circ} + 10\underline{/150^\circ} = 0$

$$y = 0$$

P 9.12 [a] 400 Hz

[b] $\theta_v = 0^\circ$

$$\mathbf{I} = \frac{100\underline{/0^\circ}}{j\omega L} = \frac{100}{\omega L}\underline{/-90^\circ}; \qquad \theta_i = -90^\circ$$

[c] $\dfrac{100}{\omega L} = 20; \qquad \omega L = 5\,\Omega$

[d] $L = \dfrac{5}{800\pi} = 1.99\,\text{mH}$

[e] $Z_L = j\omega L = j5\,\Omega$

P 9.13 [a] $\omega = 2\pi f = 160\pi \times 10^3 = 502.65\,\text{krad/s} = 502{,}654.82\,\text{rad/s}$

[b] $\mathbf{I} = \dfrac{25 \times 10^{-3}\underline{/0^\circ}}{1/j\omega C} = j\omega C(25 \times 10^{-3})\underline{/0^\circ} = 25 \times 10^{-3}\omega C\underline{/90^\circ}$

$$\therefore \quad \theta_i = 90^\circ$$

[c] $628.32 \times 10^{-6} = 25 \times 10^{-3}\,\omega C$

$$\frac{1}{\omega C} = \frac{25 \times 10^{-3}}{628.32 \times 10^{-6}} = 39.79\,\Omega, \quad \therefore \quad X_C = -39.79\,\Omega$$

[d] $C = \dfrac{1}{39.79(\omega)} = \dfrac{1}{(39.79)(160\pi \times 10^3)}$

$$C = 0.05 \times 10^{-6} = 0.05\,\mu\text{F}$$

[e] $Z_c = j\left(\dfrac{-1}{\omega C}\right) = -j39.79\,\Omega$

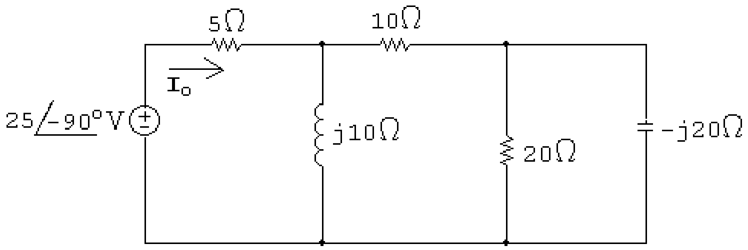
P 9.22 $Z_{\text{ab}} = 5 + j8 + 10 \| -j20 + (8 + j16) \| (40 - j80)$

$$= 5 + j8 + 8 - j4 + 12 + j16 = 25 + j20\,\Omega = 32.02\underline{/38.66^\circ}\,\Omega$$

P 9.30 $\mathbf{V}_s = 25\underline{/-90^\circ}\,\text{V}$

$$\frac{1}{j\omega C} = -j20\,\Omega$$

$$j\omega L = j10\,\Omega$$

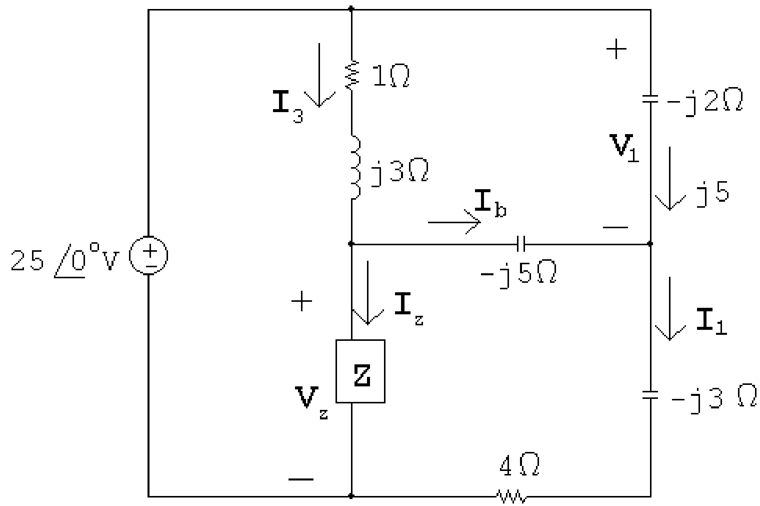


$$Z_{\text{eq}} = 5 + j10 \| (10 + 20 \| -j20) = 10 + j10\,\Omega$$

$$\mathbf{I}_o = \frac{\mathbf{V}_o}{Z_{\text{eq}}} = \frac{25\underline{/-90^\circ}}{10 + j10} = -1.25 - j1.25 = 1.77\underline{/-135^\circ}\,\text{A}$$

$$i_o = 1.77\cos(4000t - 135^\circ)\,\text{A}$$

P 9.32



$$\mathbf{V}_1 = j5(-j2) = 10\,\mathrm{V}$$

$$-25 + 10 + (4 - j3)\mathbf{I}_1 = 0 \quad \therefore \quad \mathbf{I}_1 = \frac{15}{4 - j3} = 2.4 + j1.8\,\mathrm{A}$$

$$\mathbf{I}_\mathrm{b} = \mathbf{I}_1 - j5 = (2.4 + j1.8) - j5 = 2.4 - j3.2\,\mathrm{A}$$

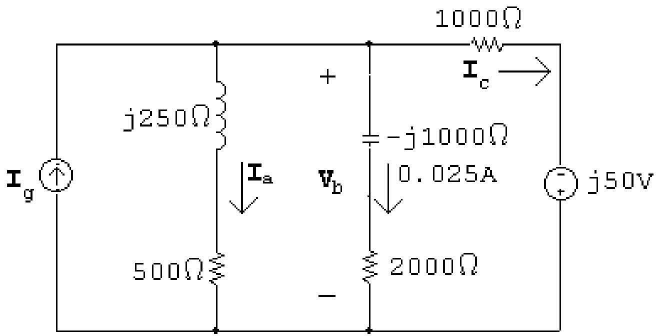
$$\mathbf{V}_Z = -j5\mathbf{I}_2 + (4 - j3)\mathbf{I}_1 = -j5(2.4 - j3.2) + (4 - j3)(2.4 + j1.8) = -1 - j12\,\mathrm{V}$$

$$-25 + (1 + j3)\mathbf{I}_3 + (-1 - j12) = 0 \quad \therefore \quad \mathbf{I}_3 = 6.2 - j6.6\,\mathrm{A}$$

$$\mathbf{I}_Z = \mathbf{I}_3 - \mathbf{I}_2 = (6.2 - j6.6) - (2.4 - j3.2) = 3.8 - j3.4\,\mathrm{A}$$

$$Z = \frac{\mathbf{V}_Z}{\mathbf{I}_Z} = \frac{-1 - j12}{3.8 - j3.4} = 1.42 - j1.88\,\Omega$$

P 9.36 [**a**]



$$\mathbf{V}_{\rm b} = (2000 - j1000)(0.025) = 50 - j25\,\text{V}$$

$$\mathbf{I}_{\rm a} = \frac{50 - j25}{500 + j250} = 60 - j80\,\text{mA} = 100\underline{/-53.13^\circ}\,\text{mA}$$

$$\mathbf{I}_{\rm c} = \frac{50 - j25 + j50}{1000} = 50 + j25\,\text{mA} = 55.9\underline{/26.57^\circ}\,\text{mA}$$

$$\mathbf{I}_g = \mathbf{I}_{\rm a} + \mathbf{I}_{\rm b} + \mathbf{I}_{\rm c} = 135 - j55\,\text{mA} = 145.77\underline{/-22.17^\circ}\,\text{mA}$$

[b] $i_{\rm a} = 100\cos(1500t - 53.13^\circ)\,\text{mA}$

$i_{\rm c} = 55.9\cos(1500t + 26.57^\circ)\,\text{mA}$

$i_g = 145.77\cos(1500t - 22.17^\circ)\,\text{mA}$

P 9.37 [a] In order for v_g and i_g to be in phase, the impedance to the right of the $500\,\Omega$ resistor must be purely real:

$$Z_{\rm eq} = j\omega L \| (R + 1/\omega C) = \frac{j\omega L(R + 1/j\omega C)}{j\omega L + R + 1/j\omega C}$$

$$= \frac{j\omega L(j\omega RC + 1)}{j\omega RC - \omega^2 LC + 1}$$

$$= \frac{(-\omega^2 RLC + j\omega L)(1 - \omega^2 LC - j\omega RC)}{(1 - \omega^2 LC + j\omega RC)(1 - \omega^2 LC - j\omega RC)}$$

The denominator of the above expression is purely real. Now set the imaginary part of the numerator in that expression to zero and solve for ω:

$$\omega L(1 - \omega^2 LC) + \omega^3 R^2 lC^2 = 0$$

So $$\omega^2 = \frac{1}{LC - R^2C^2} = \frac{1}{(0.2)(10^{-6}) - 200^2(10^{-6})^2} = 6{,}250{,}000$$

$$\therefore \qquad \omega = 2500 \text{ rad/s} \qquad \text{and} \qquad f = 397.9 \text{ Hz}$$

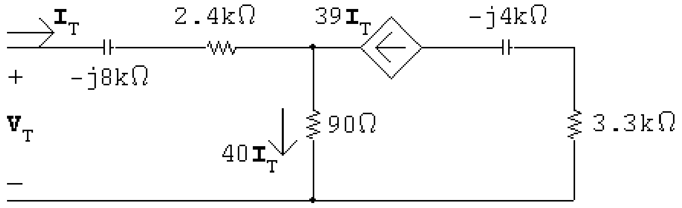
[b] $Z_{\rm eq} = 500 + j500 \| (200 - j400) = 1500\,\Omega$

$$\mathbf{I}_g = \frac{90/0^\circ}{1500} = 60/0^\circ\,\text{mA}$$

$i_g(t) = 60\cos 2500t\,\text{mA}$

P 9.53 $$\frac{1}{\omega C_1} = \frac{10^9}{50{,}000(2.5)} = 8\,\text{k}\Omega$$

$$\frac{1}{\omega C_2} = \frac{10^9}{50{,}000(5)} = 4\,\text{k}\Omega$$



$$\mathbf{V}_T = (2400 - j8000)\mathbf{I}_T + 40\mathbf{I}_T(90)$$

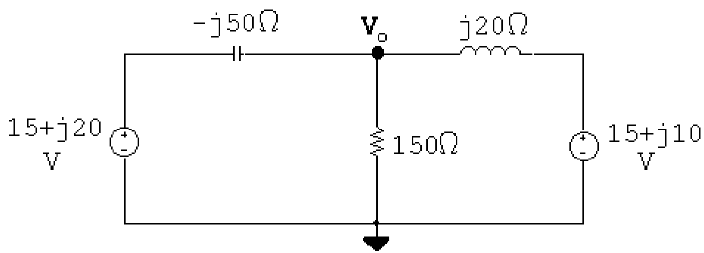
$$Z_{\text{Th}} = \frac{\mathbf{V}_T}{\mathbf{I}_T} = 6000 - j8000\,\Omega$$

P 9.57 $j\omega L = j(400)(50 \times 10^{-3}) = j20\,\Omega$

$$\frac{1}{j\omega C} = \frac{-j}{(400)(50 \times 10^{-6})} = -j50\,\Omega$$

$$\mathbf{V}_{g1} = 25\underline{/53.13^\circ} = 15 + j20\,\text{V}$$

$$\mathbf{V}_{g2} = 18.03\underline{/33.69^\circ} = 15 + j10\,\text{V}$$



$$\frac{\mathbf{V}_o - (15 + j20)}{-j50} + \frac{\mathbf{V}_o}{150} + \frac{\mathbf{V}_o - (15 + j10)}{j20} = 0$$

Solving,

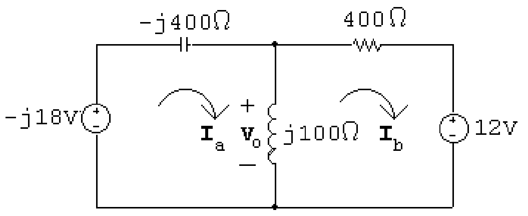
$$\mathbf{V}_o = 15\underline{/0^\circ}$$

$$v_o(t) = 15 \cos 400t\,\text{V}$$

P 9.63 $\mathbf{V}_\mathrm{a} = -j18\,\mathrm{V}; \qquad \mathbf{V}_\mathrm{b} = 12\,\mathrm{V}$

$$j\omega L = j(4000)(25 \times 10^{-3}) = j100\Omega$$

$$\frac{-j}{\omega C} = \frac{-j}{4000(625 \times 10^{-6})} = -j400\,\Omega$$



$$-j18 = -j300\mathbf{I}_\mathrm{a} - j100\mathbf{I}_\mathrm{b}$$

$$-12 = -j100\mathbf{I}_\mathrm{a} + (400 + j100)\mathbf{I}_\mathrm{b}$$

Solving,

$$\mathbf{I}_\mathrm{a} = 67.5 - j7.5\,\mathrm{mA}; \qquad \mathbf{I}_\mathrm{b} = -22.5 + j22.5\,\mathrm{mA}$$

$$\mathbf{V}_o = j100(\mathbf{I}_\mathrm{a} - \mathbf{I}_\mathrm{b}) = 3 + j9 = 9.49\underline{/71.57^\circ}\,\mathrm{A}$$

$$v_o(t) = 9.49\cos(4000t + 71.57^\circ)\,\mathrm{A}$$