EENG382 QZ03 – AUTHOR'S SOLUTIONS

NOTE: I have not yet verified that the author's solutions are, in fact, correct.

Prob 16.22

P 16.22 **[a]** The current has half-wave symmetry. Therefore,

$$a_v = 0; \qquad a_k = b_k = 0, \quad k \text{ even}$$

For k odd,

$$a_k = \frac{4}{T}\int_0^{T/2}\left(I_m - \frac{2I_m}{T}t\right)\cos k\omega_o t\,dt \qquad T/2$$

$$= \frac{4}{T}\int_0^{T/2} I_m \cos k\omega_0 t\,dt - \frac{8I_m}{T^2}\int_0^{T/2} t\cos k\omega_0 t\,dt \qquad 0$$

$$= \frac{4I_m}{T}\frac{\sin k\omega_0 t}{k\omega_0}\Big|_0^{T/2} - \frac{8I_m}{T^2}\left[\frac{\cos k\omega_o t}{k^2\omega_0^2} + \frac{t}{k\omega_0}\sin k\omega_0 T\right]_0^{T/2}$$

$$= 0 - \frac{8I_m}{T^2}\left[\frac{\cos k\pi}{k^2\omega_0^2} - \frac{1}{k^2\omega_0^2}\right]$$

$$= \left(\frac{8I_m}{T^2}\right)\left(\frac{1}{k^2\omega_0^2}\right)(1-\cos k\pi)$$

$$= \frac{4I_m}{\pi^2 k^2} = \frac{20}{k^2}, \quad \text{for } k \text{ odd}$$

$$b_k = \frac{4}{T}\int_0^{T/2}\left(I_m - \frac{2I_m}{T}t\right)\sin k\omega_o t\,dt$$

$$= \frac{4I_m}{T}\int_0^{T/2}\sin k\omega_0 t\,dt - \frac{8I_m}{T^2}\int_0^{T/2} t\sin k\omega_0 t\,dt$$

$$= \frac{4I_m}{T}\left[\frac{-\cos k\omega_0 t}{k\omega_0}\right]_0^{T/2} - \frac{8I_m}{T^2}\left[\frac{\sin k\omega_o t}{k^2\omega_0^2} - \frac{t}{k\omega_0}\cos k\omega_0 T\right]$$

$$= \frac{4I_m}{T}\left[\frac{1-\cos k\pi}{k\omega_0}\right] - \frac{8I_m}{T^2}\left[\frac{-T\cos k\pi}{2k\omega_0}\right]$$

$$= \frac{8I_m}{k\omega_0 T}\left[1 + \frac{1}{2}\cos k\pi\right]$$

$$= \frac{2I_m}{\pi k} = \frac{10\pi}{k}, \quad \text{for } k \text{ odd}$$

Prob 16.22 (Cont'd)

$$a_k - jb_k = \frac{20}{k^2} - j\frac{10\pi}{k} = \frac{10}{k}\left(\frac{2}{k} - j\pi\right) = \frac{10}{k^2}\sqrt{\pi^2 k^2 + 4}\underline{/-\theta_k}$$

where $\quad \tan\theta_k = \dfrac{\pi k}{2}$

$$i(t) = 10\sum_{n=1,3,5,\ldots}^{\infty} \frac{\sqrt{(n\pi)^2 + 4}}{n^2}\cos(n\omega_0 t - \theta_n), \qquad \theta_n = \tan^{-1}\frac{n\pi}{2}$$

[b] $A_1 = 10\sqrt{4+\pi^2} \cong 37.24\,\text{A} \qquad \tan\theta_1 = \dfrac{\pi}{2} \qquad \theta_1 \cong 57.52^\circ$

$$A_3 = \frac{10}{9}\sqrt{4+9\pi^2} \cong 10.71\,\text{A} \qquad \tan\theta_3 = \frac{3\pi}{2} \qquad \theta_3 \cong 78.02^\circ$$

$$A_5 = \frac{10}{25}\sqrt{4+25\pi^2} \cong 6.33\,\text{A} \qquad \tan\theta_5 = \frac{5\pi}{2} \qquad \theta_5 \cong 82.74^\circ$$

$$A_7 = \frac{10}{49}\sqrt{4+49\pi^2} \cong 4.51\,\text{A} \qquad \tan\theta_7 = \frac{7\pi}{2} \qquad \theta_7 \cong 84.80^\circ$$

$$A_9 = \frac{10}{81}\sqrt{4+81\pi^2} \cong 3.50\,\text{A} \qquad \tan\theta_9 = \frac{9\pi}{2} \qquad \theta_9 \cong 85.95^\circ$$

$$i(t) \cong 37.24\cos(\omega_o t - 57.52^\circ) + 10.71\cos(3\omega_o t - 78.02^\circ)$$
$$+6.33\cos(5\omega_o t - 82.74^\circ) + 4.51\cos(7\omega_o t - 84.80^\circ)$$
$$+3.50\cos(9\omega_o t - 85.95^\circ) + \ldots$$

$$i(T/4) \cong 37.24\cos(90 - 57.52^\circ) + 10.71\cos(270 - 78.02^\circ)$$
$$+6.33\cos(450 - 82.74^\circ) + 4.51\cos(630 - 84.80^\circ)$$
$$+3.50\cos(810 - 85.95^\circ) \cong 26.23\,\text{A}$$

Actual value:

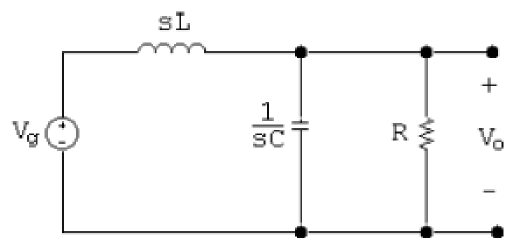
$$i\left(\frac{T}{4}\right) = \frac{1}{2}(5\pi^2) \cong 24.67\,\text{A}$$

Prob 16.35

P 16.35 $v_g = 10 - \frac{80}{\pi^2} \sum_{n=1,3,5,\ldots}^{\infty} \frac{1}{n^2} \cos n\omega_o t \text{ V}$

$$\omega_o = \frac{2\pi}{T} = \frac{2\pi}{4\pi} \times 10^3 = 500 \text{ rad/s}$$

$$v_g = 10 - \frac{80}{\pi^2} \cos 500t - \frac{80}{9\pi^2} \cos 1500t + \ldots$$



$$\frac{V_o - V_g}{sL} + sCV_o + \frac{V_o}{R} = 0$$

$$V_o(RLCs^2 + Ls + R) = RV_g$$

$$H(s) = \frac{V_o}{V_g} = \frac{1/LC}{s^2 + s/RC + 1/LC}$$

$$\frac{1}{LC} = \frac{10^6}{(0.1)(10)} = 10^6$$

$$\frac{1}{RC} = \frac{10^6}{(50\sqrt{2})(10)} = 1000\sqrt{2}$$

$$H(s) = \frac{10^6}{s^2 + 1000\sqrt{2}s + 10^6}$$

Prob 16.35 (Cont'd)

$$H(j\omega) = \frac{10^6}{10^6 - \omega^2 + j1000\omega\sqrt{2}}$$

$$H(j0) = 1$$

$$H(j500) = 0.9701\underline{/-43.31^\circ}$$

$$H(j1500) = 0.4061\underline{/-120.51^\circ}$$

$$v_o = 10(1) + \frac{80}{\pi^2}(0.9701)\cos(500t - 43.31^\circ)$$

$$+\frac{80}{9\pi^2}(0.4061)\cos(1500t - 120.51^\circ) + \dots$$

$$v_o = 10 + 7.86\cos(500t - 43.31^\circ) + 0.3658\cos(1500t - 120.51^\circ) + \dots$$

$$V_{\text{rms}} \cong \sqrt{10^2 + \left(\frac{7.86}{\sqrt{2}}\right)^2 + \left(\frac{0.3658}{\sqrt{2}}\right)^2} = 11.44\,\text{V}$$

$$P \cong \frac{V_{\text{rms}}^2}{50\sqrt{2}} = 1.85\,\text{W}$$

Note – the higher harmonics are severely attenuated and can be ignored. For example, the 5th harmonic component of v_o is

$$v_{o5} = (0.1580)\left(\frac{80}{25\pi^2}\right)\cos(2500t - 146.04^\circ) = 0.0512\cos(2500t - 146.04^\circ)\,\text{V}$$

Prob 16.47

P 16.47 **[a]** $C_o = a_v = \frac{(1/2)(T/2)V_m}{T} = \frac{V_m}{4}$

$$C_n = \frac{1}{T}\int_0^{T/2} \frac{2V_m}{T} t e^{-jn\omega_o t}\,dt$$

$$= \frac{2V_m}{T^2}\left[\frac{e^{-jn\omega_o t}}{-n^2\omega_o^t}(-jn\omega_o t - 1)\right]_0^{T/2}$$

$$= \frac{V_m}{2n^2\pi^2}[e^{-jn\pi}(-jn\pi + 1) - 1]$$

Since $e^{-jn\pi} = \cos n\pi$ we can write

$$C_n = \frac{V_m}{2\pi^2 n^2}(\cos n\pi - 1) + j\frac{V_m}{2n\pi}\cos n\pi$$

[b] $C_o = \frac{54}{4} = 13.5\,\text{V}$

$$C_{-1} = \frac{-54}{\pi^2} + j\frac{27}{\pi} = 10.19\underline{/122.48^\circ}\,\text{V}$$

$$C_1 = 10.19\underline{/-122.48^\circ}\,\text{V}$$

$$C_{-2} = -j\frac{13.5}{\pi} = 4.30\underline{/-90^\circ}\,\text{V}$$

$$C_2 = 4.30\underline{/90^\circ}\,\text{V}$$

$$C_{-3} = \frac{-6}{\pi^2} + j\frac{9}{\pi} = 2.93\underline{/101.98^\circ}\,\text{V}$$

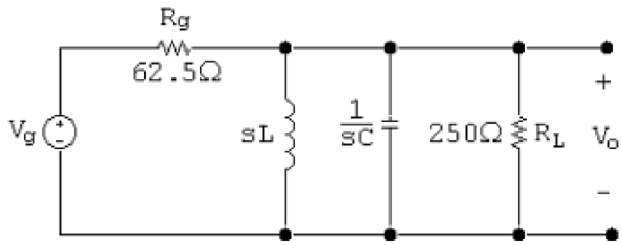
$$C_3 = 2.93\underline{/-101.98^\circ}\,\text{V}$$

$$C_{-4} = -j\frac{6.75}{\pi} = 2.15\underline{/-90^\circ}\,\text{V}$$

$$C_4 = 2.15\underline{/90^\circ}\,\text{V}$$

Prob 16.47 (Cont'd)

[c]



$$\frac{V_o}{250} + \frac{V_o}{sL} + V_o sC + \frac{V_o - V_g}{62.5} = 0$$

$$\therefore \qquad (250LCs^2 + 5sL + 250)V_o = 4sLV_g$$

$$\frac{V_o}{V_g} = H(s) = \frac{(4/250C)s}{s^2 + 1/50C + 1/LC}$$

$$H(s) = \frac{16{,}000s}{s^2 + 2 \times 10^4 s + 4 \times 10^{10}}$$

$$\omega_o = \frac{2\pi}{T} = \frac{2\pi}{10\pi} \times 10^6 = 2 \times 10^5 \text{ rad/s}$$

$$H(j0) = 0$$

$$H(j2 \times 10^5 k) = \frac{j8k}{100(1 - k^2) + j10k}$$

Therefore,

$H_{-1} = 0.8\underline{/0^\circ}$; $\qquad H_1 = 0.8\underline{/0^\circ}$

$H_{-2} = \dfrac{-j16}{-300 - j20} = 0.0532\underline{/86.19^\circ}$; $\qquad H_2 = 0.0532\underline{/-86.19^\circ}$

$H_{-3} = \dfrac{-j24}{-800 - j30} = 0.0300\underline{/87.85^\circ}$; $\qquad H_2 = 0.0300\underline{/-87.85^\circ}$

$H_{-4} = \dfrac{-j32}{-1500 - j40} = 0.0213\underline{/88.47^\circ}$; $\qquad H_2 = 0.0213\underline{/-88.47^\circ}$

Prob 16.47 (Cont'd)

The output voltage coefficients:

$$C_0 = 0$$

$$C_{-1} = (10.19\underline{/122.48^\circ})(0.8\underline{/0^\circ}) = 8.15\underline{/122.48^\circ}\,\text{V}$$

$$C_1 = 8.15\underline{/-122.48^\circ}\,\text{V}$$

$$C_{-2} = (4.30\underline{/-90^\circ})(0.05\underline{/86.19^\circ}) = 0.2287\underline{/-3.81^\circ}\,\text{V}$$

$$C_2 = 0.2287\underline{/3.81^\circ}\,\text{V}$$

$$C_{-3} = (2.93\underline{/101.98^\circ})(0.03\underline{/87.85^\circ}) = 0.0878\underline{/-170.17^\circ}\,\text{V}$$

$$C_3 = 0.0878\underline{/170.17^\circ}\,\text{V}$$

$$C_{-4} = (2.15\underline{/-90^\circ})(0.02\underline{/88.47^\circ}) = 0.0458\underline{/-1.53^\circ}\,\text{V}$$

$$C_4 = 0.0458\underline{/1.53^\circ}\,\text{V}$$

[d] $$V_{\text{rms}} \cong \sqrt{C_o^2 + 2\sum_{n=1}^{4}|C_n|^2} \cong \sqrt{2\sum_{n=1}^{4}|C_n|^2}$$

$$\cong \sqrt{2(8.15^2 + 0.2287^2 + 0.0878^2 + 0.0458^2} \cong 11.53\,\text{V}$$

$$P = \frac{(11.53)^2}{250} = 531.95\,\text{mW}$$

Prob 17.1

P 17.1 **[a]** $F(\omega) = \int_{-\tau/2}^{\tau/2} \frac{2A}{\tau} t e^{-j\omega t}\, dt$

$$= \frac{2A}{\tau}\left[\frac{e^{-j\omega t}}{-\omega^2}(-j\omega t - 1)\right]_{-\tau/2}^{\tau/2}$$

$$= \frac{2A}{\omega^2\tau}\left[e^{-j\omega\tau/2}\left(\frac{j\omega\tau}{2}+1\right) - e^{j\omega\tau/2}\left(\frac{-j\omega\tau}{2}+1\right)\right]$$

$$F(\omega) = \frac{2A}{\omega^2\tau}\left[e^{-j\omega\tau/2} - e^{j\omega\tau/2} + j\frac{\omega\tau}{2}\left(e^{-j\omega\tau/2} + e^{j\omega\tau/2}\right)\right]$$

$$F(\omega) = j\frac{2A}{\tau}\left[\frac{\omega\tau\cos(\omega\tau/2) - 2\sin(\omega\tau/2)}{\omega^2}\right]$$

[b] Using L'Hopital's rule,

$$F(0) = \lim_{\omega\to 0} 2A\left[\frac{\omega\tau(\tau/2)[-\sin(\omega\tau/2)] + \tau\cos(\omega\tau/2) - 2(\tau/2)\cos(\omega\tau/2)}{2\omega\tau}\right]$$

$$= \lim_{\omega\to 0} 2A\left[\frac{-\omega\tau(\tau/2)\sin(\omega\tau/2)}{2\omega\tau}\right]$$

$$= \lim_{\omega\to 0} 2A\left[\frac{-\tau\sin(\omega\tau/2)}{4}\right] = 0$$

$$\therefore \quad F(0) = 0$$

Prob 17.1 (Cont'd)

[c] When $A = 1$ and $\tau = 1$

$$F(\omega) = j2\left[\frac{\omega\cos(\omega/2) - 2\sin(\omega/2)}{\omega^2}\right]$$

$$|F(\omega)| = \left|\frac{2\omega\cos(\omega/2) - 4\sin(\omega/2)}{\omega^2}\right|$$

$$F(0) = 0$$

$$|F(2)| = \left|\frac{4\cos 1 - 4\sin 1}{4}\right| = 0.30$$

$$|F(4)| = \left|\frac{8\cos 2 - 4\sin 2}{16}\right| = 0.44$$

$$|F(6)| = \left|\frac{12\cos 3 - 4\sin 3}{36}\right| = 0.35$$

$$|F(8)| = \left|\frac{16\cos 4 - 4\sin 4}{64}\right| = 0.12$$

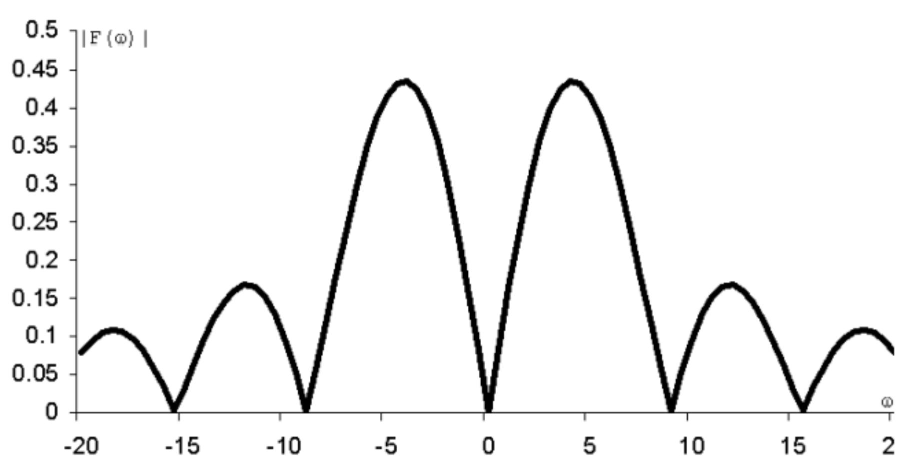
$$|F(9)| = \left|\frac{18\cos 4.5 - 4\sin 4.5}{81}\right| \cong 0$$

$$|F(10)| = \left|\frac{20\cos 5 - 4\sin 5}{100}\right| = 0.10$$

$$|F(12)| = \left|\frac{24\cos 6 - 4\sin 6}{144}\right| = 0.17$$

$$|F(14)| = \left|\frac{28\cos 7 - 4\sin 7}{196}\right| = 0.09$$

$$|F(15.5)| = \left|\frac{31\cos 7.75 - 4\sin 7.75}{240.25}\right| \cong 0$$



Prob 17.2

P 17.2 **[a]** $F(\omega) = A + \frac{2A}{\omega_o}\omega, \quad -\omega_o/2 \le \omega \le 0$

$$F(\omega) = A - \frac{2A}{\omega_o}\omega, \quad 0 \le \omega \le \omega_o/2$$

$$F(\omega) = 0 \qquad \text{elsewhere}$$

$$f(t) = \frac{1}{2\pi}\int_{-\omega_o/2}^{0}\left(A + \frac{2A}{\omega_o}\omega\right)e^{jt\omega}\,d\omega$$

$$+\frac{1}{2\pi}\int_{0}^{\omega_o/2}\left(A - \frac{2A}{\omega_o}\omega\right)e^{jt\omega}\,d\omega$$

$$f(t) = \frac{1}{2\pi}\left[\int_{-\omega_o/2}^{0} Ae^{jt\omega}\,d\omega + \int_{-\omega_o/2}^{0}\frac{2A}{\omega_o}\omega e^{jt\omega}\,d\omega\right.$$

$$\left.+\int_{0}^{\omega_o/2} Ae^{jt\omega}\,d\omega - \int_{0}^{\omega_o/2}\frac{2A}{\omega_o}\omega e^{jt\omega}\,d\omega\right]$$

$$= \frac{1}{2\pi}[\text{ Int1 } + \text{ Int2 } + \text{ Int3 } - \text{ Int4 }]$$

$$\text{Int1 } = \int_{-\omega_o/2}^{0} Ae^{jt\omega}\,d\omega = \frac{A}{jt}(1 - e^{-jt\omega_o/2})$$

$$\text{Int2 } = \int_{-\omega_o/2}^{0}\frac{2A}{\omega_o}\omega e^{jt\omega}\,d\omega = \frac{2A}{\omega_o t^2}(1 - j\frac{t\omega_o}{2}e^{-jt\omega_o/2} - e^{-jt\omega_o/2})$$

$$\text{Int3 } = \int_{0}^{\omega_o/2} Ae^{jt\omega}\,d\omega = \frac{A}{jt}(e^{jt\omega_o/2} - 1)$$

$$\text{Int4 } = \int_{0}^{\omega_o/2}\frac{2A}{\omega_o}\omega e^{jt\omega}\,d\omega = \frac{2A}{\omega_o t^2}(-j\frac{t\omega_o}{2}e^{jt\omega_o/2} + e^{jt\omega_o/2} - 1)$$

$$\text{Int1 } + \text{ Int3 } = \frac{2A}{t}\sin(\omega_o t/2)$$

$$\text{Int2 } - \text{ Int4 } = \frac{4A}{\omega_o t^2}[1 - \cos(\omega_o t/2)] - \frac{2A}{t}\sin(\omega_o t/2)$$

$$\therefore \qquad f(t) = \frac{1}{2\pi}\left[\frac{4A}{\omega_o t^2}\left(1 - \cos(\omega_o t/2)\right)\right]$$

$$= \frac{2A}{\pi\omega_o t^2}\left[2\sin^2(\omega_o t/4)\right]$$

$$= \frac{4\omega_o A}{\pi\omega_o^2 t^2}\sin^2(\omega_o t/4)$$

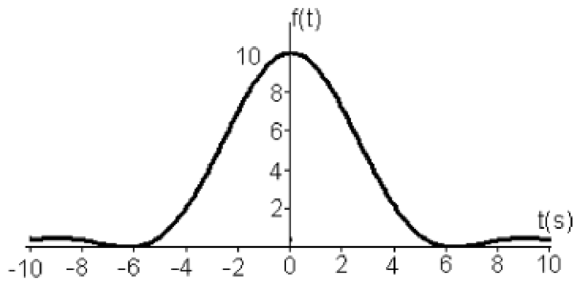
$$= \frac{\omega_o A}{4\pi}\left[\frac{\sin(\omega_o t/4)}{(\omega_o t/4)}\right]^2$$

Prob 17.2 (Cont'd)

$$[\mathbf{b}]\ f(0) = \frac{\omega_o A}{4\pi}(1)^2 = 79.58 \times 10^{-3}\omega_o A$$

$$[\mathbf{c}]\ A = 20\pi; \qquad \omega_o = 2 \text{ rad/s}$$

$$f(t) = 10\left[\frac{\sin(t/2)}{(t/2)}\right]^2$$



Prob 17.3

$$\text{P 17.3} \quad [\mathbf{a}]\ F(\omega) = \int_{-2}^{2}\left[A\sin\left(\frac{\pi}{2}\right)t\right]e^{-j\omega t}\,dt = \frac{-j4\pi A}{\pi^2 - 4\omega^2}\sin 2\omega$$

$$[\mathbf{b}]\ F(\omega) = \int_{-\tau/2}^{0}\left(\frac{2A}{\tau}t + A\right)e^{-j\omega t}\,dt + \int_{0}^{\tau/2}\left(\frac{-2A}{\tau}t + A\right)e^{-j\omega t}\,dt$$

$$= \frac{4A}{\omega^2\tau}\left[1 - \cos\left(\frac{\omega\tau}{2}\right)\right]$$

Prob 17.26

P 17.26 **[a]** $\frac{V_o}{V_g} = H(s) = \frac{4/s}{0.5 + 0.01s + 4/s}$

$$H(s) = \frac{400}{s^2 + 50s + 400} = \frac{400}{(s+10)(s+40)}$$

$$H(j\omega) = \frac{400}{(j\omega + 10)(j\omega + 40)}$$

$$V_g(\omega) = \frac{6}{j\omega}$$

$$V_o(\omega) = V_g(\omega)H(j\omega) = \frac{2400}{j\omega(j\omega + 10)(j\omega + 40)}$$

$$V_o(\omega) = \frac{K_1}{j\omega} + \frac{K_2}{j\omega + 10} + \frac{K_3}{j\omega + 40}$$

$$K_1 = \frac{2400}{400} = 6; \qquad K_2 = \frac{2400}{(-10)(30)} = -8$$

$$K_3 = \frac{2400}{(-40)(-30)} = 2$$

$$V_o(\omega) = \frac{6}{j\omega} - \frac{8}{j\omega + 10} + \frac{2}{j\omega + 40}$$

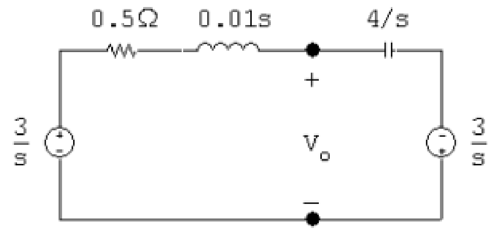
$$v_o(t) = 3\mathrm{sgn}(t) - 8e^{-10t}u(t) + 2e^{-40t}u(t)\,\mathrm{V}$$

[b] $v_o(0^-) = -3\,\mathrm{V}$

[c] $v_o(0^+) = 3 - 8 + 2 = -3\,\mathrm{V}$

Prob 17.26 (Cont'd)

[d] For $t \geq 0^+$:



$$\frac{V_o - 3/s}{0.5 + 0.01s} + \frac{(V_o + 3/s)s}{4} = 0$$

$$V_o\left[\frac{100}{s+50} + \frac{s}{4}\right] = \frac{300}{s(s+50)} - 0.75$$

$$V_o = \frac{1200 - 3s^2 - 150s}{s(s+10)(s+40)} = \frac{K_1}{s} + \frac{K_2}{s+10} + \frac{K_3}{s+40}$$

$$K_1 = \frac{1200}{400} = 3; \qquad K_2 = \frac{1200 - 300 + 1500}{(-10)(30)} = -8$$

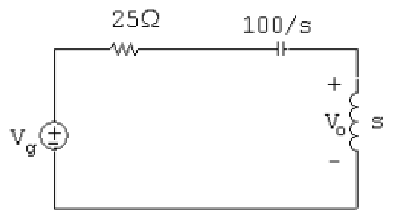
$$K_3 = \frac{1200 - 4800 + 6000}{(-40)(-30)} = 2$$

$$v_o(t) = (3 - 8e^{-10t} + 2e^{-40t})u(t)\,\text{V}$$

[e] Yes.

Prob 17.35

P 17.35 [a]



$$V_o = \frac{V_g s}{25 + (100/s) + s} = \frac{V_g s^2}{s^2 + 25s + 100}$$

$$H(s) = \frac{V_o}{V_g} = \frac{s^2}{(s+5)(s+20)}; \qquad H(j\omega) = \frac{(j\omega)^2}{(j\omega+5)(j\omega+20)}$$

$$v_g = 25i_g = 450e^{10t}u(-t) - 450e^{-10t}u(t)\,\text{V}$$

$$V_g = \frac{450}{-j\omega+10} - \frac{450}{j\omega+10}$$

$$V_o(\omega) = H(j\omega)V_g = \frac{450(j\omega)^2}{(-j\omega+10)(j\omega+5)(j\omega+20)}$$

$$+\frac{-450(j\omega)^2}{(j\omega+10)(j\omega+5)(j\omega+20)}$$

$$= \frac{K_1}{-j\omega+10} + \frac{K_2}{j\omega+5} + \frac{K_3}{j\omega+20} + \frac{K_4}{j\omega+5} + \frac{K_5}{j\omega+10} + \frac{K_6}{j\omega+20}$$

$$K_1 = \frac{450(100)}{(15)(30)} = 100 \qquad K_4 = \frac{-450(25)}{(5)(15)} = -150$$

$$K_2 = \frac{450(25)}{(15)(15)} = 50 \qquad K_5 = \frac{-450(100)}{(-5)(10)} = 900$$

$$K_3 = \frac{450(400)}{(30)(-15)} = -400 \qquad K_6 = \frac{-450(400)}{(-15)(-10)} = -1200$$

$$V_o(\omega) = \frac{100}{-j\omega+10} + \frac{-100}{j\omega+5} + \frac{-1600}{j\omega+20} + \frac{900}{j\omega+10}$$

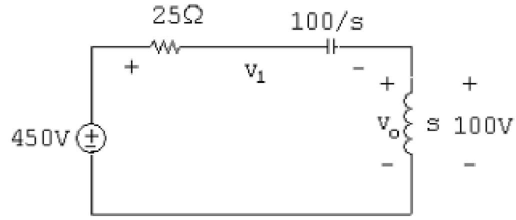
$$v_o = 100e^{10t}u(-t) + [900e^{-10t} - 100e^{-5t} - 1600e^{-20t}]u(t)\,\text{V}$$

Prob 17.35 (Cont'd)

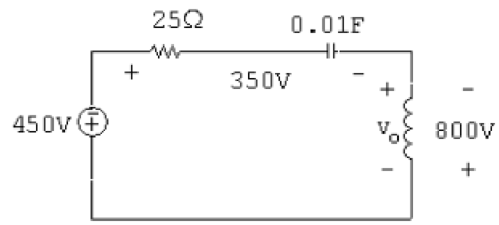
[b] $v_o(0^-) = 100\,\text{V}$

[c] $v_o(0^+) = 900 - 100 - 1600 = -800\,\text{V}$

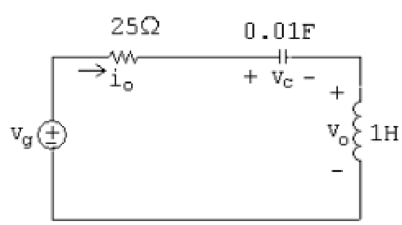
[d] At $t = 0^-$ the circuit is



Therefore, the solution predicts $v_1(0^-)$ will be 350 V.
Now $v_1(0^+) = v_1(0^-)$ because the inductor will not let the current in the $25\,\Omega$ resistor change instantaneously, and the capacitor will not let the voltage across the 0.01 F capacitor change instantaneously.
At $t = 0^+$ the circuit is



From the circuit at $t = 0^+$ we see that v_o must be -800 V, which is consistent with the solution for v_o obtained in part (a).
It is informative to solve for either the current in the circuit or the voltage across the capacitor and note the solutions for i_o and v_C are consistent with the solution for v_o



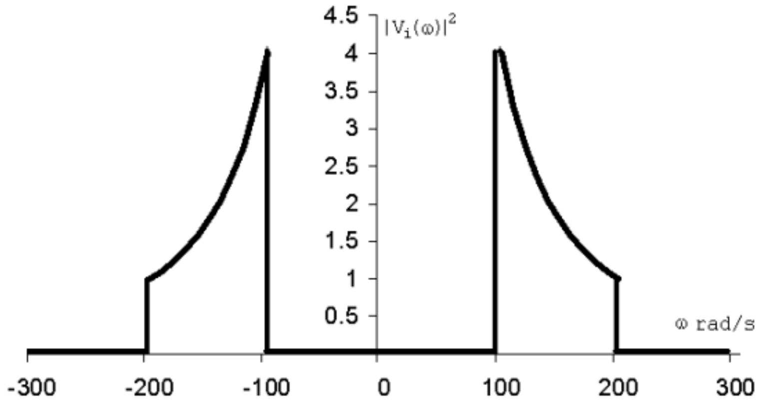
The solutions are

$$i_o = 10e^{10t}u(-t) + [20e^{-5t} + 80e^{-20t} - 90e^{-10t}]u(t)\,\text{A}$$

$$v_C = 100e^{10t}u(-t) + [900e^{-10t} - 400e^{-5t} - 400e^{-20t}]u(t)\,\text{V}$$

Prob 17.41

P 17.41 **[a]** $|V_i(\omega)|^2 = \dfrac{4\times10^4}{\omega^2}$; $|V_i(100)|^2 = \dfrac{4\times10^4}{100^2} = 4$; $|V_i(200)|^2 = \dfrac{4\times10^4}{200^2} = 1$



[b] $V_o = \dfrac{V_i R}{R + (1/sC)} = \dfrac{sRCV_i}{RCs + 1}$

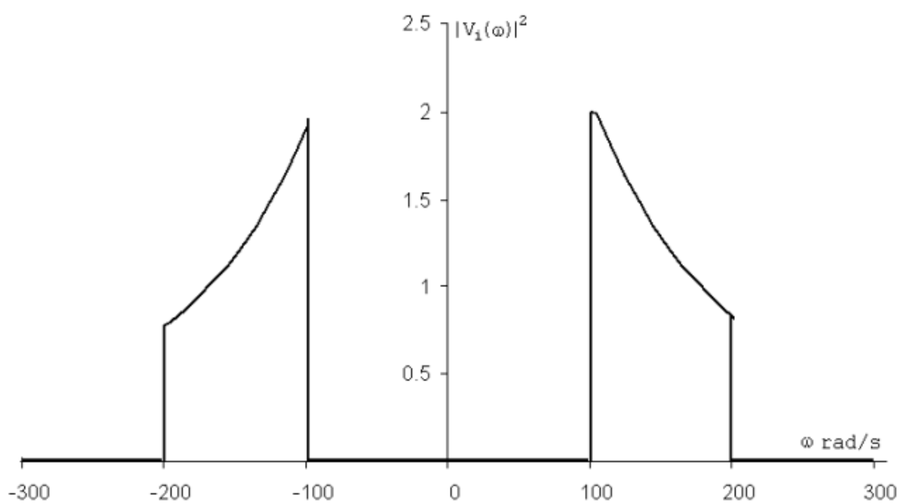
$$H(s) = \frac{V_o}{V_i} = \frac{s}{s + (1/RC)}; \qquad \frac{1}{RC} = \frac{10^6 10^{-3}}{(0.5)(20)} = \frac{1000}{10} = 100$$

$$H(j\omega) = \frac{j\omega}{j\omega + 100}$$

$$|V_o(\omega)| = \frac{200}{|\omega|}\cdot\frac{|\omega|}{\sqrt{\omega^2 + 10^4}} = \frac{200}{\sqrt{\omega^2 + 10^4}}$$

$$|V_o(\omega)|^2 = \frac{4\times10^4}{\omega^2 + 10^4}, \quad 100 \le \omega \le 200 \text{ rad/s}; \quad |V_o(\omega)|^2 = 0, \quad \text{elsewhe}$$

$$|V_o(100)|^2 = \frac{4\times10^4}{10^4 + 10^4} = 2; \qquad |V_o(200)|^2 = \frac{4\times10^4}{5\times10^4} = 0.8$$



Prob 17.41 (Cont'd)

$$[\mathbf{c}]\ \ W_{1\Omega} = \frac{1}{\pi}\int_{100}^{200} \frac{4\times 10^4}{\omega^2}\,d\omega = \frac{4\times 10^4}{\pi}\left[-\frac{1}{\omega}\right]_{100}^{200}$$

$$= \frac{4\times 10^4}{\pi}\left[\frac{1}{100} - \frac{1}{200}\right] = \frac{200}{\pi} \cong 63.66\,\mathrm{J}$$

$$[\mathbf{d}]\ \ W_{1\Omega} = \frac{1}{\pi}\int_{100}^{200} \frac{4\times 10^4}{\omega^2 + 10^4}\,d\omega = \frac{4\times 10^4}{\pi}\cdot \tan^{-1}\frac{\omega}{100}\Big|_{100}^{200}$$

$$= \frac{400}{\pi}[\tan^{-1}2 - \tan^{-1}1] \cong 40.97\,\mathrm{J}$$