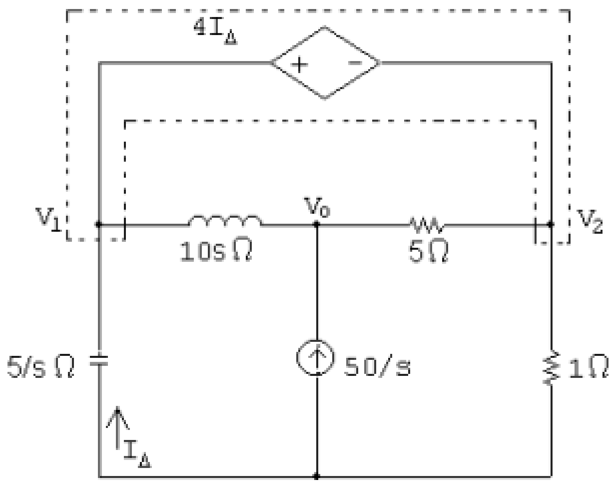
EENG382 QZ02 – AUTHOR'S SOLUTIONS

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

Prob 13.30

P 13.30 [a]



At V_o :

$$\frac{V_o - V_1}{10s} - \frac{50}{s} + \frac{V_o - V_2}{5} = 0$$

$$\therefore \qquad V_o(2s+1) - 2sV_2 - V_1 = 500$$

Supernode:

$$\frac{V_1 s}{5} + \frac{V_1 - V_o}{10s} + \frac{V_2}{1} + \frac{V_2 - V_1}{5} = 0$$

$$\therefore \qquad -V_o(2s+1) + 12sV_2 + (2s^2+1)V_1 = 0$$

Prob 13.30 (Cont'd)

Constraint:

$$V_1 - V_2 = 4I_\Delta = 4\left(-\frac{V_1 s}{5}\right)$$

$$\therefore \qquad V_2 = (0.8s + 1)V_1$$

Simplifying:

$$V_o(2s + 1) - V_1(1.6s^2 + 2s + 1) = 500$$

$$-V_o(2s + 1) - V_1(11.6s^2 + 12s + 1) = 0$$

$$\Delta = \begin{vmatrix} 2s + 1 & -(1.6s^2 + 2s + 1) \\ -(2s + 1) & (11.6s^2 + 12s + 1) \end{vmatrix} = 20(s^2 + 1.5s + 0.5)$$

$$N_o = \begin{vmatrix} 500 & -(1.6s^2 + 2s + 1) \\ 0 & (11.6s^2 + 12s + 1) \end{vmatrix} = 500(11.6s^2 + 12s + 1)$$

$$V_o = \frac{N_o}{\Delta} = \frac{25(11.6s^2 + 12s + 1)}{s(s + 0.5)(s + 1)}$$

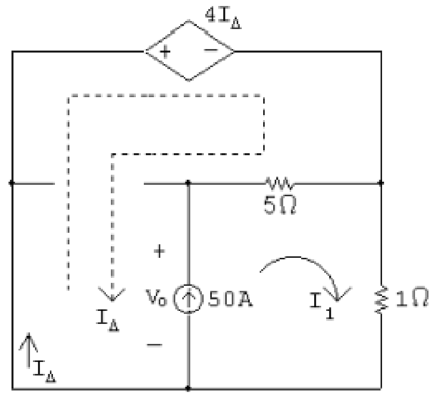
[b] $v_o(0^+) = \lim_{s\to\infty} sV_o = 25(11.6) = 290\,\text{V}$

$$v_o(\infty) = \lim_{s\to 0} sV_o = \frac{25}{0.5} = 50\,\text{V}$$

[c] At $t = 0^+$ the circuit is

Prob 13.30 (Cont'd)

[**c**] At $t = 0^+$ the circuit is



$$4I_\Delta + 1I_1 = 0; \quad I_1 - I_\Delta = 50$$

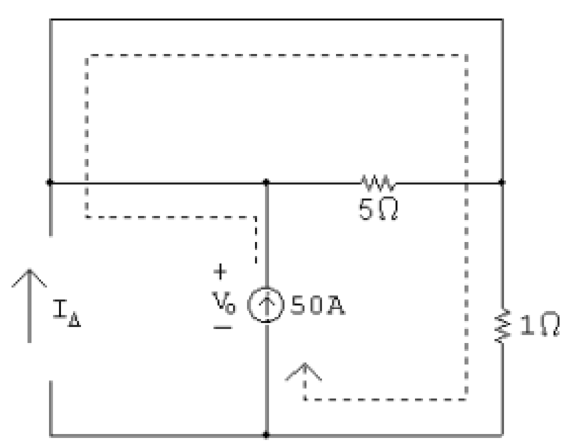
$$\therefore \quad 4I_\phi + 50 + I_\Delta = 0; \qquad 5I_\Delta = -50$$

$$\therefore \quad I_\Delta = I_o(0^+) = -10\,\text{A}$$

$$\text{Also} \quad I_1 = 50 - 10 = 40\,\text{A}$$

$$V_o(0^+) = 5(I_1 - I_\Delta) + 1I_1 = 6I_1 - 5I_\Delta = 240 - 5(-10) = 290\,\text{V} \ \text{(checks)}$$

At $t = \infty$ the circuit is



$$V_o(\infty) = 50(1) = 50\,\text{V(checks)}$$

Prob 13.30 (Cont'd)

$$[\mathbf{d}]\ V_o = \frac{25(11.6s^2 + 12s + 1)}{s(s + 0.5)(s + 1)} = \frac{K_1}{s} + \frac{K_2}{s + 0.5} + \frac{K_3}{s + 1}$$

$$K_1 = \frac{25}{(0.5)(1)} = 50; \qquad K_2 = \frac{-52.5}{(-0.5)(0.5)} = 210$$

$$K_3 = \frac{15}{(-1)(-0.5)} = 30$$

$$V_o = \frac{50}{s} + \frac{210}{s + 0.5} + \frac{30}{s + 1}$$

$$v_o(t) = (50 + 210e^{-0.5t} + 30e^{-t})u(t)\,\mathrm{V}$$

$$v_o(\infty) = 50\,\mathrm{V}(\text{checks})$$

$$v_o(0^+) = 50 + 210 + 30 = 290\,\mathrm{V}(\text{checks})$$

Prob 13.54

P 13.54 **[a]** $Z_i = 1000 + \frac{5\times 10^6}{s} = \frac{1000(s+5000)}{s}$

$$Z_f = \frac{40\times 10^6}{s}\|40{,}000 = \frac{40\times 10^6}{s+1000}$$

$$H(s) = -\frac{Z_f}{Z_i} = \frac{-40\times 10^6/(s+1000)}{1000(s+5000)/s} = \frac{-40{,}000s}{(s+1000)(s+5000)}$$

[b] Zero at $z_1 = 0$; Poles at $-p_1 = -1000$ rad/s and $-p_2 = -5000$ rad/s

Prob 13.64

P 13.64 **[a]** From Problem 13.50(a)

$$H(s) = \frac{250}{s+250}$$

$$h(\lambda) = 250e^{-250\lambda}$$

$0 \le t \le 4\,\text{ms}$:

$$v_o = \int_0^t 16(250)e^{-250\lambda}\,d\lambda = 16(1-e^{-250t})\,\text{V}$$

$4\,\text{ms} \le t \le \infty$:

$$v_o = \int_{t-0.004}^t 16(250)e^{-250\lambda}\,d\lambda = 16(e-1)e^{-250t}\,\text{V}$$

[b]

Prob 14.4

P 14.4 **[a]** $\omega_c = \dfrac{1}{RC} = \dfrac{1}{(10^3)(100 \times 10^{-9})} = 10\,\text{krad/s}$

$$f_c = \frac{\omega_c}{2\pi} = 1591.55\,\text{Hz}$$

[b] $H(j\omega) = \dfrac{\omega_c}{s + \omega_c} = \dfrac{10{,}000}{s + 10{,}000}$

$$H(j\omega) = \frac{10{,}000}{10{,}000 + j\omega}$$

$$H(j\omega_c) = \frac{10{,}000}{10{,}000 + j10{,}000} = 0.7071\underline{/-45^\circ}$$

$$H(j0.1\omega_c) = \frac{10{,}000}{10{,}000 + j1000} = 0.9950\underline{/-5.71^\circ}$$

$$H(j10\omega_c) = \frac{10{,}000}{10{,}000 + j100{,}000} = 0.0995\underline{/-84.29^\circ}$$

[c] $v_o(t)|_{\omega_c} = 200(0.7071)\cos(10{,}000t - 45^\circ)$

$$= 141.42\cos(10{,}000t - 45^\circ)\,\text{mV}$$

$$v_o(t)|_{0.1\omega_c} = 200(0.9950)\cos(1000t - 5.71^\circ)$$

$$= 199.01\cos(1000t - 5.71^\circ)\,\text{mV}$$

$$v_o(t)|_{10\omega_c} = 200(0.0995)\cos(100{,}000t - 84.29^\circ)$$

$$= 19.90\cos(100{,}000t - 84.29^\circ)\,\text{mV}$$

Prob 14.32

P 14.32 **[a]** $\omega_o^2 = \frac{1}{LC} = \frac{1}{(5 \times 10^{-3})(200 \times 10^{-12})} = 10^{12}$

$\omega_o = 1\,\text{Mrad/s}$

[b] $\beta = \frac{R + R_L}{R_L} \cdot \frac{1}{RC} = \left(\frac{500 \times 10^3}{400 \times 10^3}\right)\left(\frac{1}{(100 \times 10^3)(200 \times 10^{-12})}\right) = 62.5\,\text{krad/s}$

[c] $Q = \frac{\omega_o}{\beta} = \frac{10^6}{62.5 \times 10^3} = 16$

[d] $H(j\omega_o) = \frac{R_L}{R + R_L} = 0.8\underline{/0^\circ}$

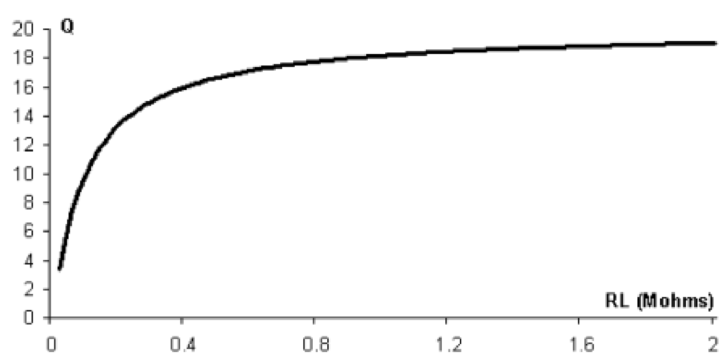
$\therefore \quad v_o(t) = 250(0.8)\cos(10^6 t) = 200\cos 10^6 t\,\text{mV}$

[e] $\beta = \left(1 + \frac{R}{R_L}\right)\frac{1}{RC} = \left(1 + \frac{100}{R_L}\right)(50 \times 10^3)\ \text{rad/s}$

$\omega_o = 10^6\ \text{rad/s}$

$Q = \frac{\omega_o}{\beta} = \frac{20}{1 + (100/R_L)}$ where R_L is in kilohms

[f]



Prob 14.35

P 14.35 **[a]** $\omega_o^2 = \dfrac{1}{LC} = \dfrac{1}{(50 \times 10^{-6})(20 \times 10^{-9})} = 10^{12}$

$\therefore \quad \omega_o = 1\,\text{Mrad/s}$

[b] $f_o = \dfrac{\omega_o}{2\pi} = 159.15\,\text{kHz}$

[c] $Q = \omega_o RC = (10^6)(750)(20 \times 10^{-9}) = 15$

[d] $\omega_{c1} = \omega_o \left[-\dfrac{1}{2Q} + \sqrt{1 + \left(\dfrac{1}{2Q}\right)^2} \right] = 10^6 \left[-\dfrac{1}{30} + \sqrt{1 + \dfrac{1}{900}} \right]$

$= 967.22\,\text{krad/s}$

[e] $f_{c1} = \dfrac{\omega_{c1}}{2\pi} = 153.94\,\text{kHz}$

[f] $\omega_{c2} = \omega_o \left[\dfrac{1}{2Q} + \sqrt{1 + \left(\dfrac{1}{2Q}\right)^2} \right] = 10^6 \left[\dfrac{1}{30} + \sqrt{1 + \dfrac{1}{900}} \right]$

$= 1.03\,\text{Mrad/s}$

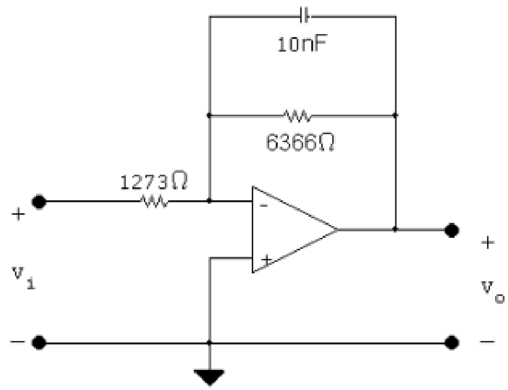
[g] $f_{c2} = \dfrac{\omega_{c1}}{2\pi} = 164.55\,\text{kHz}$

[h] $\beta = f_{c2} - f_{c1} = 10.61\,\text{kHz}$

Prob 15.4

P 15.4 [**a**] $\omega_c = \frac{1}{R_2 C}$ so $R_2 = \frac{1}{\omega_c C} = \frac{1}{2\pi(2500)(10 \times 10^{-9})} = 6366\,\Omega$

$$K = \frac{R_2}{R_1} \quad \text{so} \quad R_1 = \frac{R_2}{K} = \frac{6366}{5} = 1273\,\Omega$$



[**b**] Both the cutoff frequency and the passband gain are changed.

Prob 15.25

P 15.25 From the solution to Problem 14.35, $\omega_o = 10^6$ rad/s and $\beta = 2\pi(10.61)$ krad/s. Calculate the scale factors:

$$k_f = \frac{\omega_o'}{\omega_o} = \frac{50 \times 10^3}{10^6} = 0.05$$

$$k_m = \frac{k_f L'}{L} = \frac{0.05(200 \times 10^{-6})}{50 \times 10^{-6}} = 0.2$$

Thus,

$$R' = k_m R = (0.2)(750) = 150\,\Omega \qquad C' = \frac{C}{k_m k_f} = \frac{20 \times 10^{-9}}{(0.2)(0.05)} = 2\,\mu\text{F}$$

Calculate the bandwidth:

$$\beta' = k_f \beta = (0.05)[2\pi(10.6 \times 10^3)] = 3330 \text{ rad/s}$$

To check, calculate the quality factor:

$$Q = \frac{\omega_o}{\beta} = \frac{10^6}{2\pi(10.61 \times 10^3)} = 15$$

$$Q' = \frac{\omega_o'}{\beta'} = \frac{50 \times 10^3}{3330} = 15 \text{ (checks)}$$

Prob 15.60

P 15.60 **[a]** $\omega_o = 2000\pi$ rad/s

$$\therefore \qquad k_f = \frac{\omega_o'}{\omega_o} = 2000\pi$$

$$k_m = \frac{C}{C'k_f} = \frac{1}{(15\times 10^{-9})(2000\pi)} = \frac{10^5}{3\pi}$$

$$R' = k_m R = \frac{10^5}{3\pi}(1) = 10{,}610\,\Omega \qquad \text{so} \qquad R'/2 = 5305\,\Omega$$

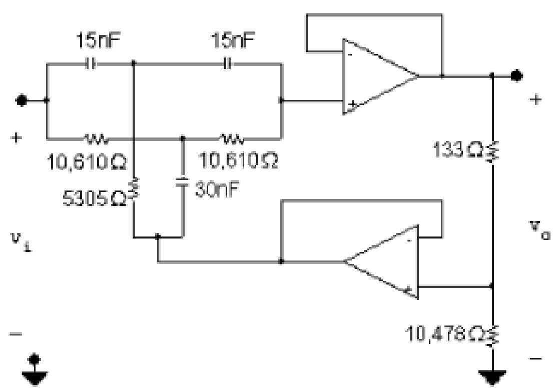
$$\sigma = 1 - \frac{1}{4Q} = 1 - \frac{1}{4(20)} = 0.9875$$

$$\sigma R' = 10{,}478\,\Omega; \qquad (1-\sigma)R' = 133\,\Omega$$

$$C' = 15\,\text{nF}$$

$$2C' = 30\,\text{nF}$$

[b]



[c] $k_f = 2000\pi$

$$H(s) = \frac{(s/2000\pi)^2 + 1}{(s/2000\pi)^2 + \frac{1}{20}(s/2000\pi) + 1}$$

$$= \frac{s^2 + 4\times 10^6\pi^2}{s^2 + 100\pi s + 4\times 10^6\pi^2}$$