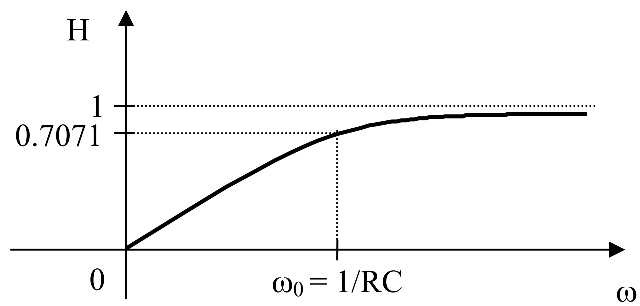
Chapter 14, Solution 1.

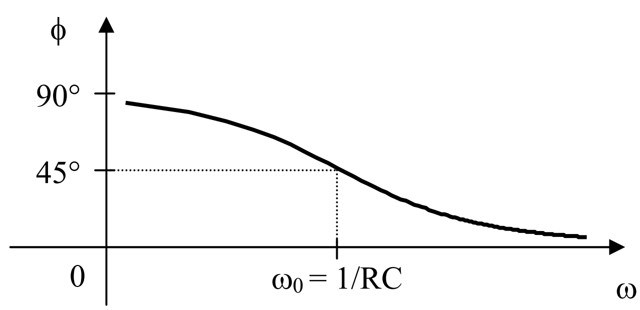
$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{R}{R + 1/j\omega C} = \frac{j\omega RC}{1 + j\omega RC}$$

$$\mathbf{H}(\omega) = \frac{j\omega/\omega_0}{1 + j\omega/\omega_0}, \qquad \text{where } \omega_0 = \frac{1}{RC}$$

$$H = |\mathbf{H}(\omega)| = \frac{\omega/\omega_0}{\sqrt{1 + (\omega/\omega_0)^2}} \qquad \phi = \angle\mathbf{H}(\omega) = \frac{\pi}{2} - \tan^{-1}\left(\frac{\omega}{\omega_0}\right)$$

This is a highpass filter. The frequency response is the same as that for P.P.14.1 except that $\omega_0 = 1/RC$. Thus, the sketches of H and ϕ are shown below.



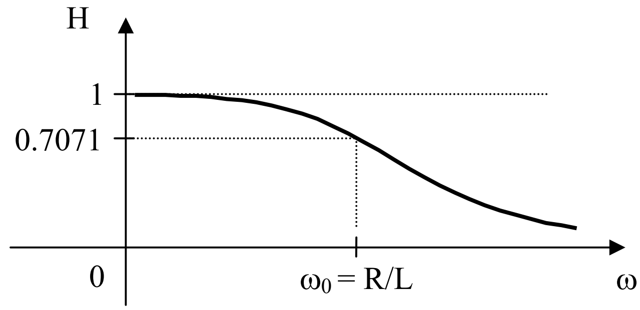


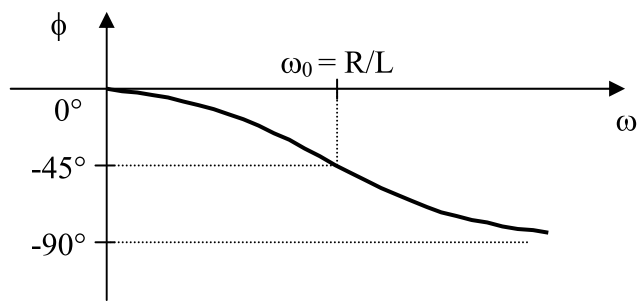
Chapter 14, Solution 2.

$$\mathbf{H}(\omega) = \frac{R}{R + j\omega L} = \frac{1}{1 + j\omega L/R} = \underline{\frac{\mathbf{1}}{\mathbf{1 + j\omega/\omega_0}}}, \qquad \text{where } \underline{\boldsymbol{\omega_0} = \frac{\mathbf{R}}{\mathbf{L}}}$$

$$H = \left|\mathbf{H}(\omega)\right| = \frac{1}{\sqrt{1 + (\omega/\omega_0)^2}} \qquad \phi = \angle\mathbf{H}(\omega) = -\tan^{-1}\left(\frac{\omega}{\omega_0}\right)$$

The frequency response is identical to the response in Example 14.1 except that $\omega_0 = R/L$. Hence the response is shown below.



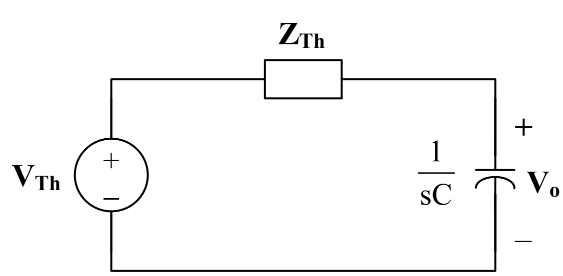


Chapter 14, Solution 3.

(a) The Thevenin impedance across the second capacitor where $\mathbf{V}_o$ is taken is

$$\mathbf{Z}_{Th} = R + R \,||\, 1/sC = R + \frac{R}{1 + sRC}$$

$$\mathbf{V}_{Th} = \frac{1/sC}{R + 1/sC}\mathbf{V}_i = \frac{\mathbf{V}_i}{1 + sRC}$$



$$\mathbf{V}_o = \frac{1/sC}{\mathbf{Z}_{Th} + 1/sC} \cdot \mathbf{V}_{Th} = \frac{\mathbf{V}_i}{(1+sRC)(1+sC\mathbf{Z}_{Th})}$$

$$\mathbf{H}(s) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{1}{(1+sC\mathbf{Z}_{Th})(1+sRC)} = \frac{1}{(1+sRC)(1+sRC+sRC/(1+sRC))}$$

$$\mathbf{H}(s) = \underline{\frac{\mathbf{1}}{\mathbf{s^2R^2C^2 + 3sRC + 1}}}$$

(b) $\quad RC = (40\times10^3)(2\times10^{-6}) = 80\times10^{-3} = 0.08$

There are no zeros and the poles are at

$$s_1 = \frac{-0.383}{RC} = \underline{\mathbf{-4.787}}$$

$$s_2 = \frac{-2.617}{RC} = \underline{\mathbf{-32.712}}$$

Chapter 14, Solution 4.

(a) $\quad R \parallel \dfrac{1}{j\omega C} = \dfrac{R}{1+j\omega RC}$

$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{\dfrac{R}{1+j\omega RC}}{j\omega L + \dfrac{R}{1+j\omega RC}} = \frac{R}{R + j\omega L(1+j\omega RC)}$$

$$\mathbf{H}(\omega) = \underline{\frac{\mathbf{R}}{\mathbf{-\omega^2 RLC + R + j\omega L}}}$$

(b) $\quad \mathbf{H}(\omega) = \dfrac{R + j\omega L}{R + j\omega L + 1/j\omega C} = \dfrac{j\omega C(R + j\omega L)}{1 + j\omega C(R + j\omega L)}$

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

Chapter 14, Solution 5.

(a) $$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{1/j\omega C}{R + j\omega L + 1/j\omega C}$$

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

(b) $$R \parallel \frac{1}{j\omega C} = \frac{R}{1 + j\omega RC}$$

$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{j\omega L}{j\omega L + R/(1 + j\omega RC)} = \frac{j\omega L\,(1 + j\omega RC)}{R + j\omega L\,(1 + j\omega RC)}$$

$$\mathbf{H}(\omega) = \underline{\frac{\mathbf{j\omega L - \omega^2 RLC}}{\mathbf{R + j\omega L - \omega^2 RLC}}}$$

Chapter 14, Solution 6.

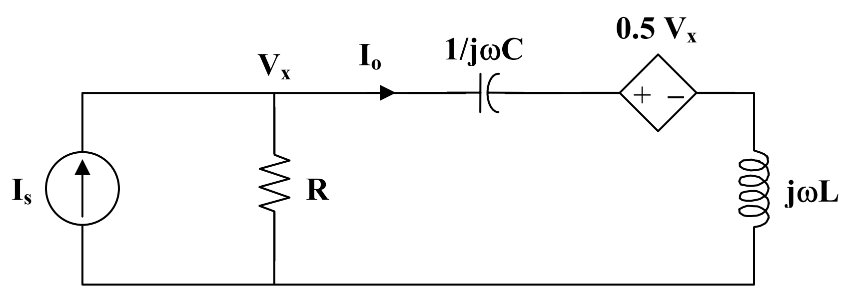
(a) Using current division,

$$\mathbf{H}(\omega) = \frac{\mathbf{I}_o}{\mathbf{I}_i} = \frac{R}{R + j\omega L + 1/j\omega C}$$

$$\mathbf{H}(\omega) = \frac{j\omega RC}{1 + j\omega RC - \omega^2 LC} = \frac{j\omega(20)(0.25)}{1 + j\omega(20)(0.25) - \omega^2 (10)(0.25)}$$

$$\mathbf{H}(\omega) = \underline{\frac{\mathbf{j\omega 5}}{\mathbf{1 + j\omega 5 - 2.5\omega^2}}}$$

(b) We apply nodal analysis to the circuit below.



$$\mathbf{I}_s = \frac{\mathbf{V}_x}{R} + \frac{\mathbf{V}_x - 0.5\mathbf{V}_x}{j\omega L + 1/j\omega C}$$

But $\quad \mathbf{I}_o = \dfrac{0.5\,\mathbf{V}_x}{j\omega L + 1/j\omega C} \longrightarrow \mathbf{V}_x = 2\,\mathbf{I}_o\,(j\omega L + 1/j\omega C)$

$$\frac{\mathbf{I}_s}{\mathbf{V}_x} = \frac{1}{R} + \frac{0.5}{j\omega L + 1/j\omega C}$$

$$\frac{\mathbf{I}_s}{2\,\mathbf{I}_o\,(j\omega L + 1/j\omega C)} = \frac{1}{R} + \frac{1}{2\,(j\omega L + 1/j\omega C)}$$

$$\frac{\mathbf{I}_s}{\mathbf{I}_o} = \frac{2\,(j\omega L + 1/j\omega C)}{R} + 1$$

$$\mathbf{H}(\omega) = \frac{\mathbf{I}_o}{\mathbf{I}_s} = \frac{1}{1 + 2\,(j\omega L + 1/j\omega C)/R} = \frac{j\omega RC}{j\omega RC + 2\,(1 - \omega^2 LC)}$$

$$\mathbf{H}(\omega) = \frac{j\omega}{j\omega + 2\,(1 - \omega^2\, 0.25)}$$

$$\mathbf{H}(\omega) = \underline{\frac{\mathbf{j\omega}}{\mathbf{2 + j\omega - 0.5\omega^2}}}$$

Chapter 14, Solution 7.

(a)
$$0.05 = 20\log_{10} H$$
$$2.5\times 10^{-3} = \log_{10} H$$
$$H = 10^{2.5\times 10^{-3}} = \underline{\mathbf{1.005773}}$$

(b)
$$-6.2 = 20\log_{10} H$$
$$-0.31 = \log_{10} H$$
$$H = 10^{-0.31} = \underline{\mathbf{0.4898}}$$

(c)
$$104.7 = 20\log_{10} H$$
$$5.235 = \log_{10} H$$
$$H = 10^{5.235} = \underline{\mathbf{1.718\times 10^5}}$$

Chapter 14, Solution 8.

(a) $H = 0.05$

$H_{dB} = 20\log_{10} 0.05 = \underline{\mathbf{-26.02}}$, $\phi = \underline{\mathbf{0°}}$

(b) $H = 125$

$H_{dB} = 20\log_{10} 125 = \underline{\mathbf{41.94}}$, $\phi = \underline{\mathbf{0°}}$

(c) $H(1) = \dfrac{j10}{2 + j} = 4.472\angle 63.43°$

$H_{dB} = 20\log_{10} 4.472 = \underline{\mathbf{13.01}}$, $\phi = \underline{\mathbf{63.43°}}$

(d) $H(1) = \dfrac{3}{1+j} + \dfrac{6}{2+j} = 3.9 - j1.7 = 4.254\angle -23.55°$

$H_{dB} = 20\log_{10} 4.254 = \underline{\mathbf{12.577}}$, $\phi = \underline{\mathbf{-23.55°}}$

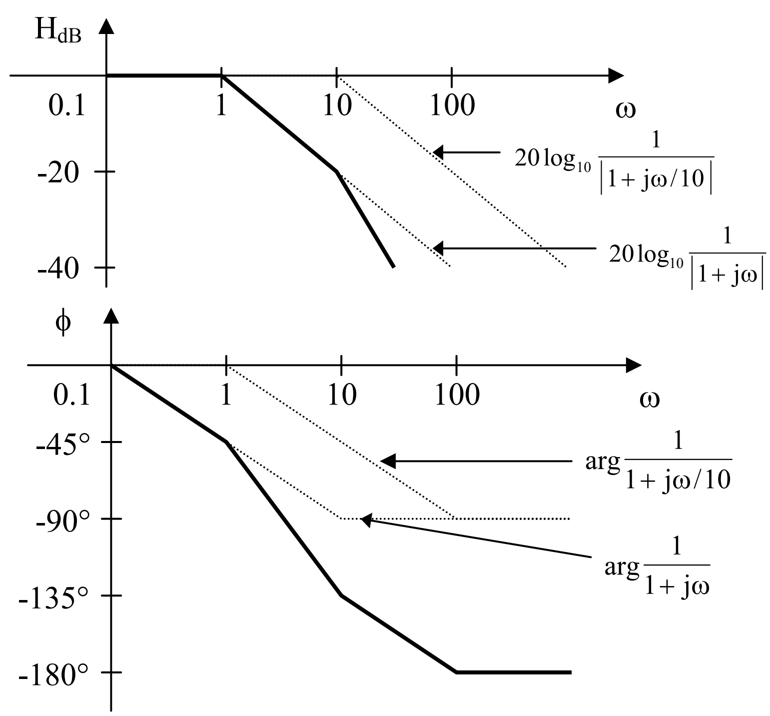
Chapter 14, Solution 9.

$$\mathbf{H}(\omega) = \frac{1}{(1 + j\omega)(1 + j\omega/10)}$$

$$H_{dB} = -20\log_{10}\left|1 + j\omega\right| - 20\log_{10}\left|1 + j\omega/10\right|$$

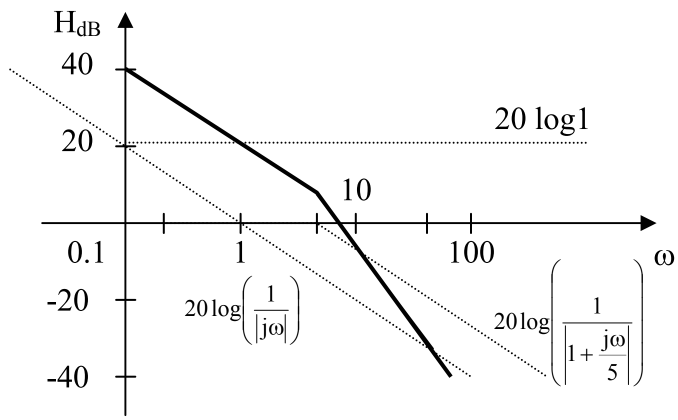
$$\phi = -\tan^{-1}(\omega) - \tan^{-1}(\omega/10)$$

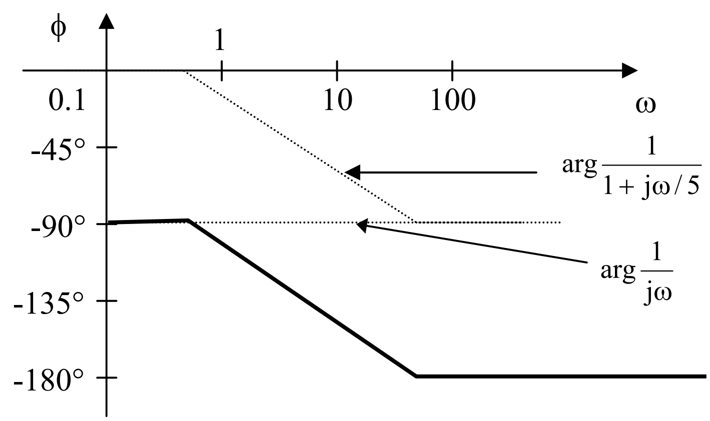
<u>The magnitude and phase plots are shown below</u>.



Chapter 14, Solution 10.

$$H(j\omega) = \frac{50}{j\omega(5 + j\omega)} = \frac{10}{1 j\omega\left(1 + \frac{j\omega}{5}\right)}$$





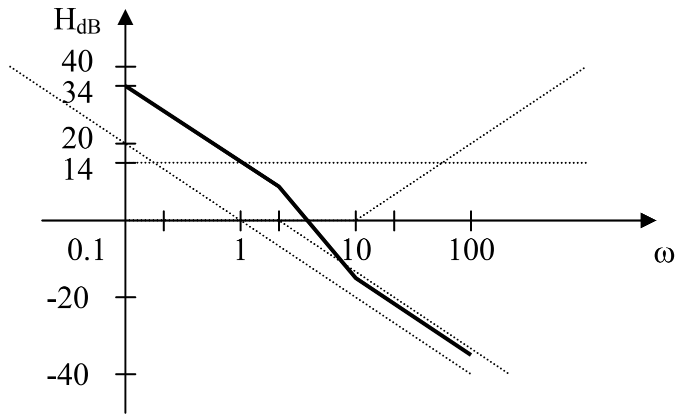
Chapter 14, Solution 11.

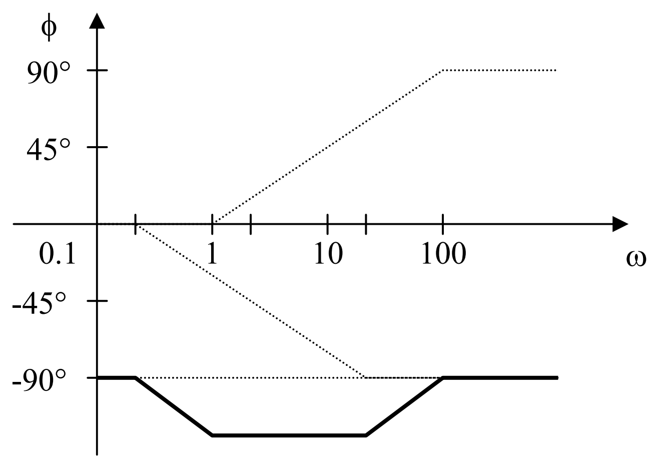
$$\mathbf{H}(\omega) = \frac{5(1 + j\omega/10)}{j\omega(1 + j\omega/2)}$$

$$H_{dB} = 20\log_{10} 5 + 20\log_{10}\left|1 + j\omega/10\right| - 20\log_{10}\left|j\omega\right| - 20\log_{10}\left|1 + j\omega/2\right|$$

$$\phi = -90° + \tan^{-1}\omega/10 - \tan^{-1}\omega/2$$

<u>The magnitude and phase plots are shown below</u>.

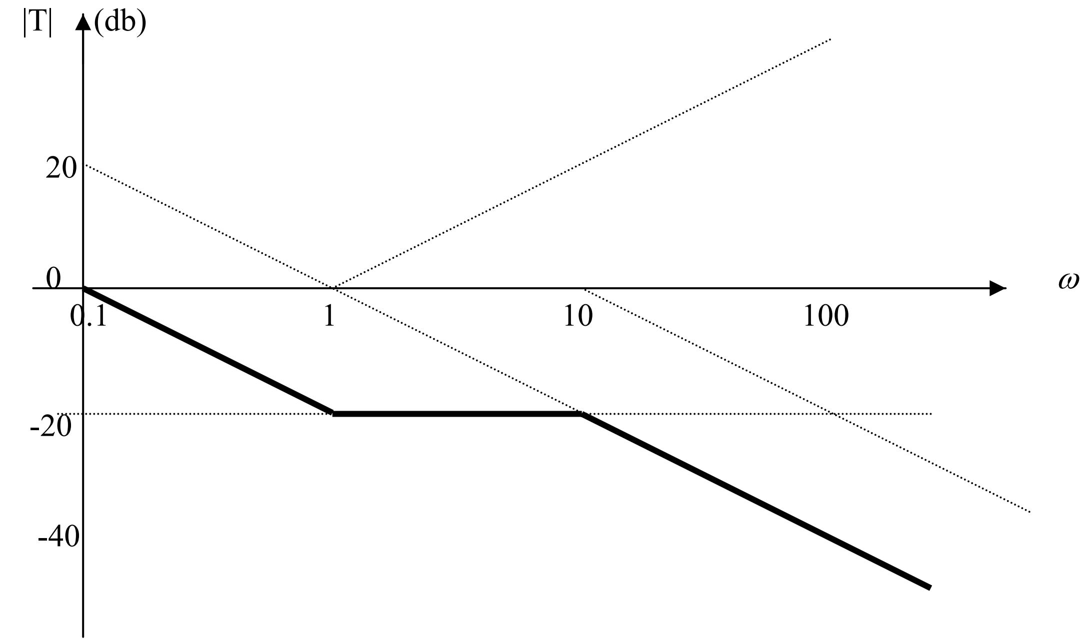


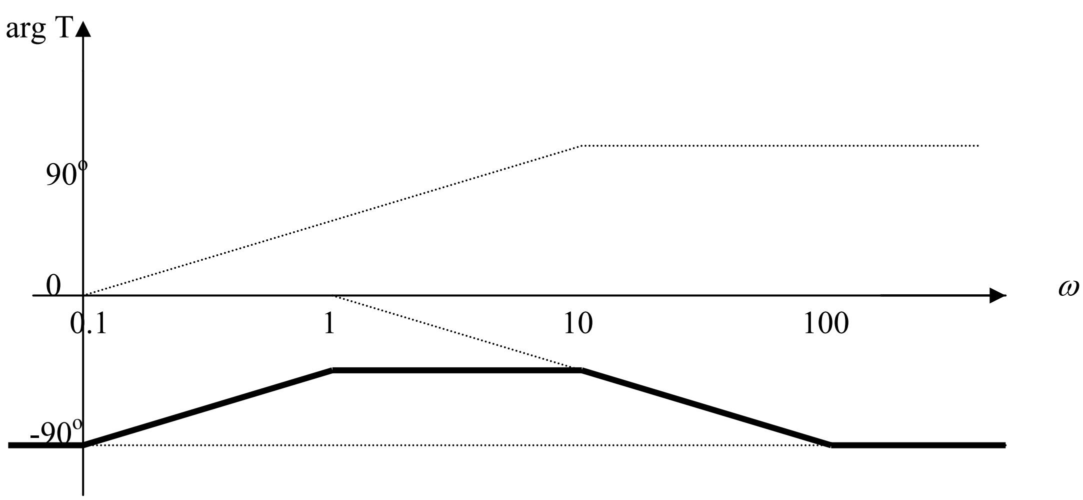


Chapter 14, Solution 12.

$$T(w) = \frac{0.1(1 + j\omega)}{j\omega(1 + j\omega/10)}, \qquad 20\log 0.1 = -20$$

The plots are shown below.



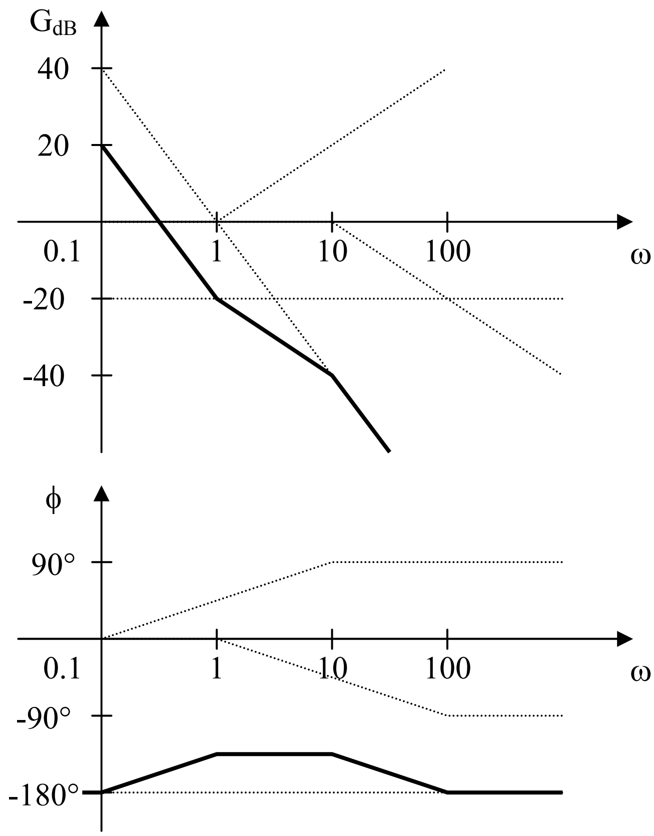


Chapter 14, Solution 13.

$$\mathbf{G}(\omega) = \frac{1 + j\omega}{(j\omega)^2 (10 + j\omega)} = \frac{(1/10)(1 + j\omega)}{(j\omega)^2 (1 + j\omega/10)}$$

$$G_{dB} = -20 + 20\log_{10}|1 + j\omega| - 40\log_{10}|j\omega| - 20\log_{10}|1 + j\omega/10|$$
$$\phi = -180° + \tan^{-1}\omega - \tan^{-1}\omega/10$$

__The magnitude and phase plots are shown below__.



Chapter 14, Solution 14.

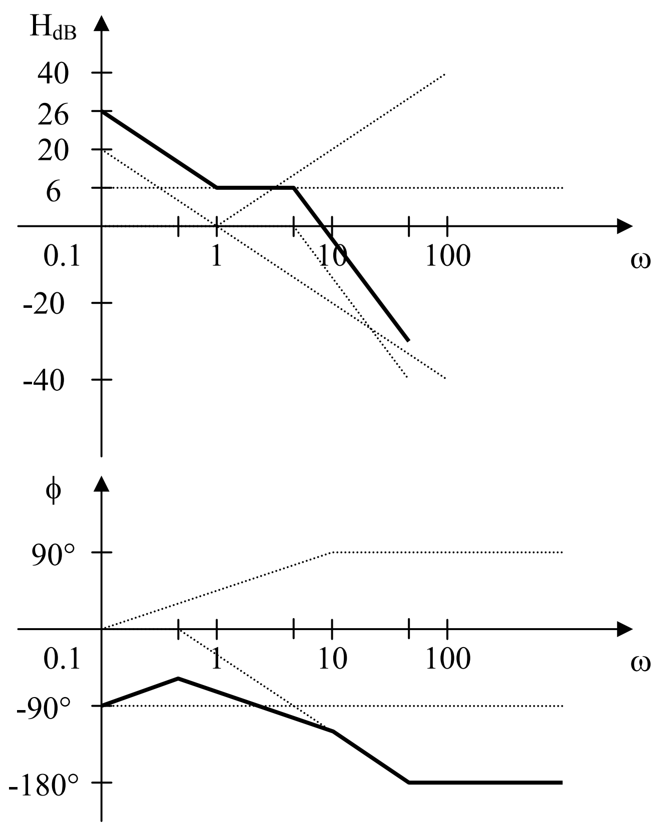
$$\mathbf{H}(\omega) = \frac{50}{25} \frac{1 + j\omega}{j\omega\left(1 + \frac{j\omega 10}{25} + \left(\frac{j\omega}{5}\right)^2\right)}$$

$$H_{dB} = 20\log_{10} 2 + 20\log_{10}\left|1 + j\omega\right| - 20\log_{10}\left|j\omega\right|$$

$$- 20\log_{10}\left|1 + j\omega 2/5 + (j\omega/5)^2\right|$$

$$\phi = -90° + \tan^{-1}\omega - \tan^{-1}\left(\frac{\omega 10/25}{1 - \omega^2/5}\right)$$

__The magnitude and phase plots are shown below__.



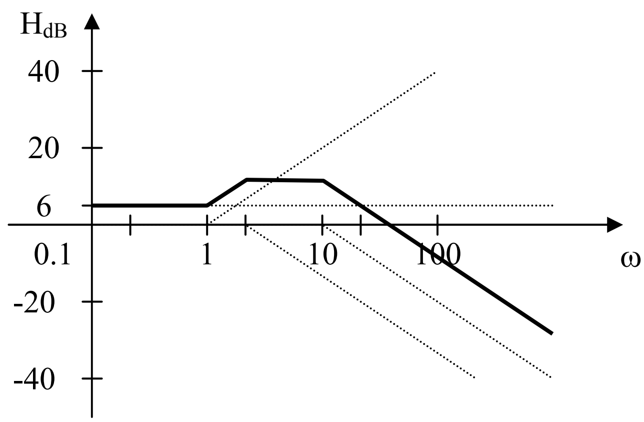
Chapter 14, Solution 15.

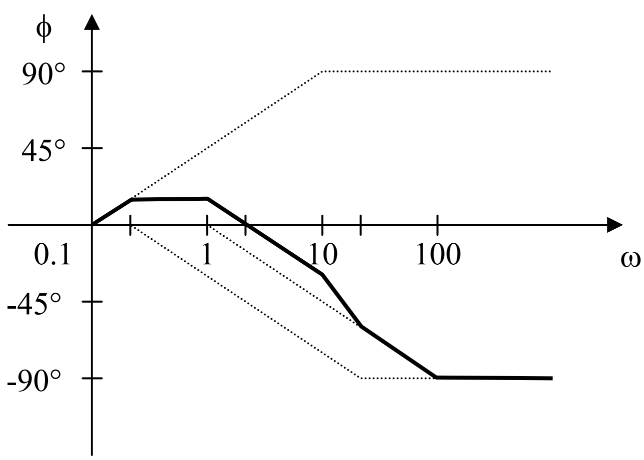
$$\mathbf{H}(\omega) = \frac{40(1+j\omega)}{(2+j\omega)(10+j\omega)} = \frac{2(1+j\omega)}{(1+j\omega/2)(1+j\omega/10)}$$

$$H_{dB} = 20\log_{10} 2 + 20\log_{10}\left|1+j\omega\right| - 20\log_{10}\left|1+j\omega/2\right| - 20\log_{10}\left|1+j\omega/10\right|$$

$$\phi = \tan^{-1}\omega - \tan^{-1}\omega/2 - \tan^{-1}\omega/10$$

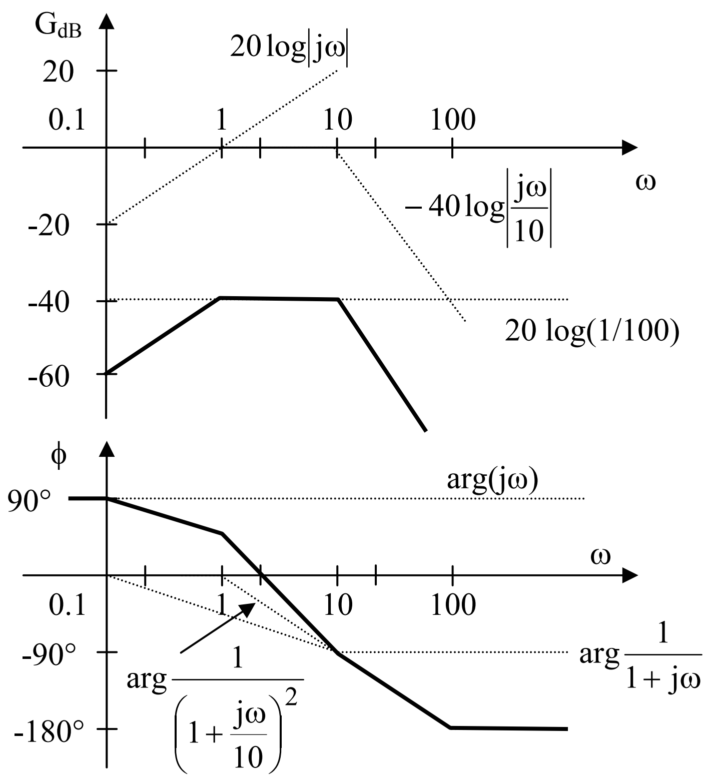
<u>**The magnitude and phase plots are shown below**</u>.





Chapter 14, Solution 16.

$$G(\omega) = \frac{j\omega}{100(1+j\omega)\left(1+\frac{j\omega}{10}\right)^2}$$



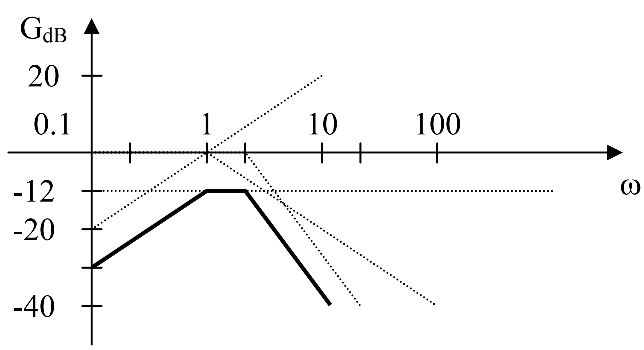
Chapter 14, Solution 17.

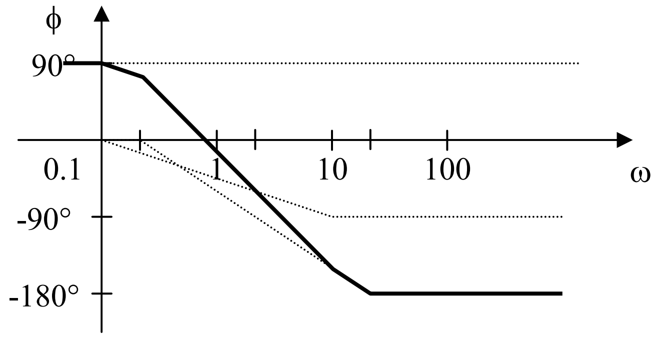
$$\mathbf{G}(\omega) = \frac{(1/4)\, j\omega}{(1 + j\omega)(1 + j\omega/2)^2}$$

$$G_{dB} = -20\log_{10} 4 + 20\log_{10}|\, j\omega| - 20\log_{10}|1 + j\omega| - 40\log_{10}|1 + j\omega/2\,|$$

$$\phi = -90° - \tan^{-1}\omega - 2\tan^{-1}\omega/2$$

__**The magnitude and phase plots are shown below**__.





Chapter 14, Solution 18.

$$\mathbf{G}(\omega) = \frac{4(1 + j\omega/2)^2}{50\, j\omega(1 + j\omega/5)(1 + j\omega/10)}$$

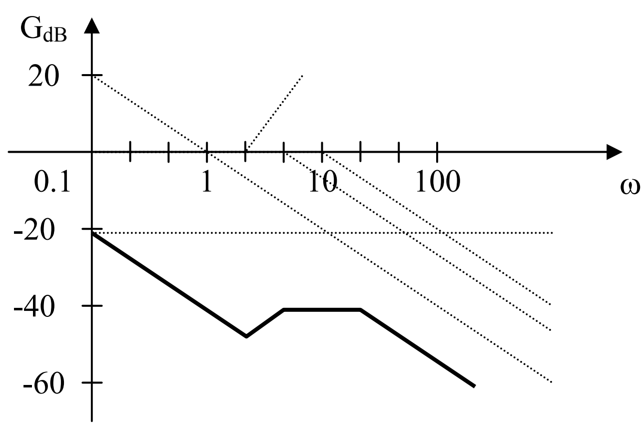
$$G_{dB} = 20\log_{10} 4/50 + 40\log_{10}\left|1 + j\omega/2\right| - 20\log_{10}\left|j\omega\right|$$

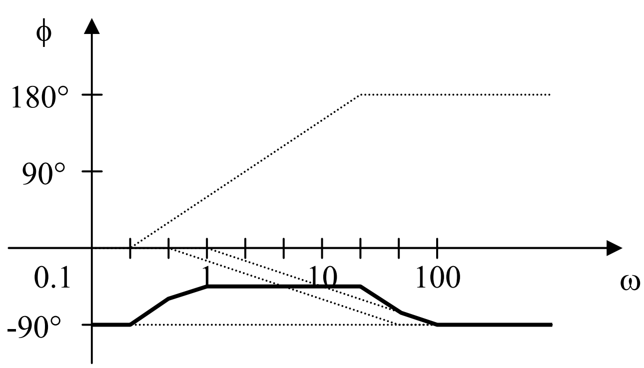
$$- 20\log_{10}\left|1 + j\omega/5\right| - 20\log_{10}\left|1 + j\omega/10\right|$$

where $20\log_{10} 4/50 = \text{-}21.94$

$$\phi = \text{-}90° + 2\tan^{-1}\omega/2 - \tan^{-1}\omega/5 - \tan^{-1}\omega/10$$

<u>The magnitude and phase plots are shown below</u>.





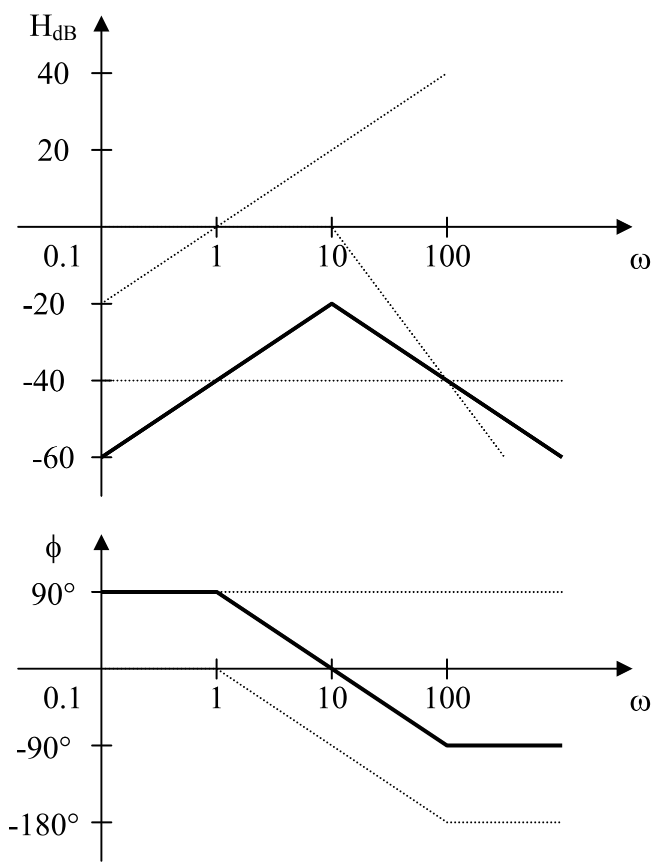
Chapter 14, Solution 19.

$$\mathbf{H}(\omega) = \frac{j\omega}{100(1 + j\omega/10 - \omega^2/100)}$$

$$H_{dB} = 20\log_{10}\left|j\omega\right| - 20\log_{10}100 - 20\log_{10}\left|1 + j\omega/10 - \omega^2/100\right|$$

$$\phi = 90° - \tan^{-1}\left(\frac{\omega/10}{1 - \omega^2/100}\right)$$

<u>**The magnitude and phase plots are shown below**</u>.



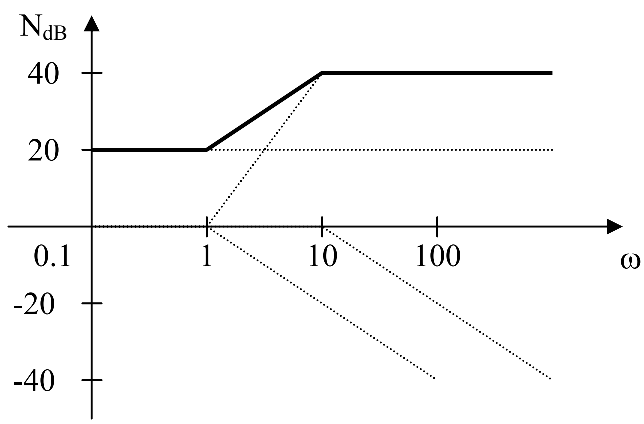
Chapter 14, Solution 20.

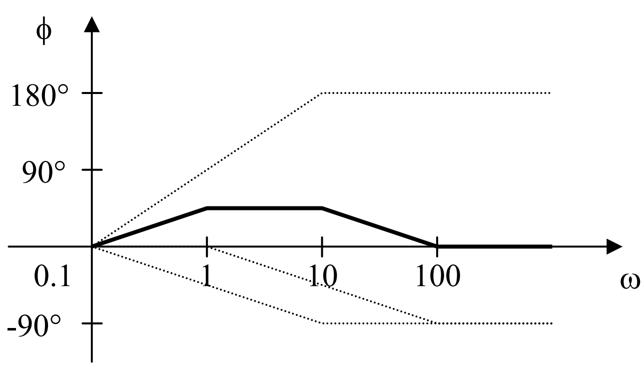
$$\mathbf{N}(\omega) = \frac{10\,(1 + j\omega - \omega^2)}{(1 + j\omega)(1 + j\omega/10)}$$

$$N_{dB} = 20 - 20\log_{10}\left|1 + j\omega\right| - 20\log_{10}\left|1 + j\omega/10\right| + 20\log_{10}\left|1 + j\omega - \omega^2\right|$$

$$\phi = \tan^{-1}\left(\frac{\omega}{1 - \omega^2}\right) - \tan^{-1}\omega - \tan^{-1}\omega/10$$

The magnitude and phase plots are shown below.





Chapter 14, Solution 21.

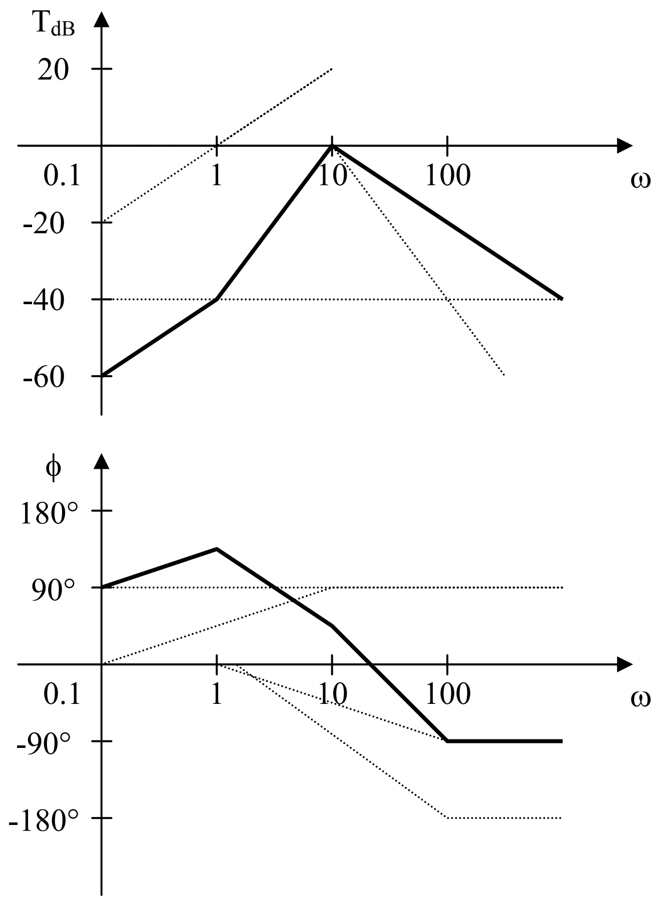
$$\mathbf{T}(\omega) = \frac{j\omega(1 + j\omega)}{100\,(1 + j\omega/10)(1 + j\omega/10 - \omega^2/100)}$$

$$T_{dB} = 20\log_{10}\left|j\omega\right| + 20\log_{10}\left|1 + j\omega\right| - 20\log_{10}100$$

$$-20\log_{10}\left|1+j\omega/10\right|-20\log_{10}\left|1+j\omega/10-\omega^2/100\right|$$

$$\phi = 90° + \tan^{-1}\omega - \tan^{-1}\omega/10 - \tan^{-1}\left(\frac{\omega/10}{1-\omega^2/100}\right)$$

<u>The magnitude and phase plots are shown below</u>.



Chapter 14, Solution 22.

$$20 = 20\log_{10} k \longrightarrow k = 10$$

A zero of slope $+20\ \text{dB/dec}$ at $\omega = 2 \longrightarrow 1 + j\omega/2$

A pole of slope $-20\ \text{dB/dec}$ at $\omega = 20 \longrightarrow \dfrac{1}{1+j\omega/20}$

A pole of slope -20 dB/dec at $\omega = 100 \longrightarrow \dfrac{1}{1 + j\omega/100}$

Hence,

$$\mathbf{H}(\omega) = \frac{10(1 + j\omega/2)}{(1 + j\omega/20)(1 + j\omega/100)}$$

$$\mathbf{H}(\omega) = \underline{\mathbf{\frac{10^4\,(2 + j\omega)}{(20 + j\omega)(100 + j\omega)}}}$$

Chapter 14, Solution 23.

A zero of slope $+20$ dB/dec at the origin $\longrightarrow j\omega$

A pole of slope -20 dB/dec at $\omega = 1 \longrightarrow \dfrac{1}{1 + j\omega/1}$

A pole of slope -40 dB/dec at $\omega = 10 \longrightarrow \dfrac{1}{(1 + j\omega/10)^2}$

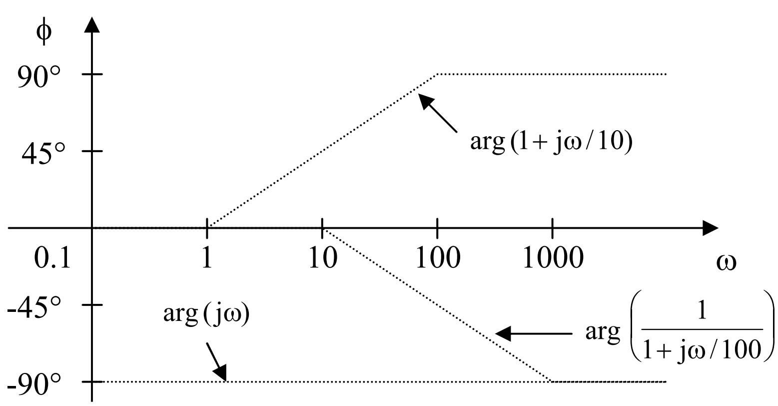
Hence,

$$\mathbf{H}(\omega) = \frac{j\omega}{(1 + j\omega)(1 + j\omega/10)^2}$$

$$\mathbf{H}(\omega) = \underline{\mathbf{\frac{100\,j\omega}{(1 + j\omega)(10 + j\omega)^2}}}$$

Chapter 14, Solution 24.

The phase plot is decomposed as shown below.



$$\mathbf{G}(\omega) = \frac{k'(1 + j\omega/10)}{j\omega(1 + j\omega/100)} = \frac{k'(10)(10 + j\omega)}{j\omega(100 + j\omega)}$$

where k' is a constant since $\arg k' = 0$.

Hence, $\quad \mathbf{G}(\omega) = \underline{\frac{\mathbf{k\,(10 + j\omega)}}{\mathbf{j\omega(100 + j\omega)}}}$, $\quad$ where $\underline{\mathbf{k = 10k'}\ \textbf{ is constant}}$

Chapter 14, Solution 25.

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(40 \times 10^{-3})(1 \times 10^{-6})}} = 5\ \text{krad/s}$$

$$\mathbf{Z}(\omega_0) = R = \underline{\mathbf{2\ k\Omega}}$$

$$\mathbf{Z}(\omega_0/4) = R + j\left(\frac{\omega_0}{4}L - \frac{4}{\omega_0 C}\right)$$

$$\mathbf{Z}(\omega_0/4) = 2000 + j\left(\frac{5 \times 10^3}{4} \cdot 40 \times 10^{-3} - \frac{4}{(5 \times 10^3)(1 \times 10^{-6})}\right)$$

$$\mathbf{Z}(\omega_0/4) = 2000 + j(50 - 4000/5)$$

$$\mathbf{Z}(\omega_0/4) = \underline{\mathbf{2 - j0.75\ k\Omega}}$$

$$\mathbf{Z}(\omega_0/2) = R + j\left(\frac{\omega_0}{2}L - \frac{2}{\omega_0 C}\right)$$

$$\mathbf{Z}(\omega_0/2) = 2000 + j\left(\frac{(5 \times 10^3)}{2}(40 \times 10^{-3}) - \frac{2}{(5 \times 10^3)(1 \times 10^{-6})}\right)$$

$$\mathbf{Z}(\omega_0/4) = 2000 + j(100 - 2000/5)$$

$$\mathbf{Z}(\omega_0/2) = \underline{\mathbf{2 - j0.3\ k\Omega}}$$

$$\mathbf{Z}(2\omega_0) = R + j\left(2\omega_0 L - \frac{1}{2\omega_0 C}\right)$$

$$\mathbf{Z}(2\omega_0) = 2000 + j\left((2)(5\times10^3)(40\times10^{-3}) - \frac{1}{(2)(5\times10^3)(1\times10^{-6})}\right)$$

$$\mathbf{Z}(2\omega_0) = \underline{\mathbf{2 + j0.3\ k\Omega}}$$

$$\mathbf{Z}(4\omega_0) = \mathrm{R} + j\left(4\omega_0 \mathrm{L} - \frac{1}{4\omega_0 \mathrm{C}}\right)$$

$$\mathbf{Z}(4\omega_0) = 2000 + j\left((4)(5\times10^3)(40\times10^{-3}) - \frac{1}{(4)(5\times10^3)(1\times10^{-6})}\right)$$

$$\mathbf{Z}(4\omega_0) = \underline{\mathbf{2 + j0.75\ k\Omega}}$$

Chapter 14, Solution 26.

(a) $$f_o = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{5x10^{-9}\,x10x10^{-3}}} = \underline{22.51\,\text{kHz}}$$

(b) $$B = \frac{R}{L} = \frac{100}{10x10^{-3}} = \underline{10\,\text{krad/s}}$$

(c) $$Q = \frac{\omega_o L}{R} = \frac{1}{\sqrt{LC}}\frac{L}{R} = \frac{10^6}{\sqrt{50}}\frac{10x10^{-3}}{0.1x10^3} = \underline{14.142}$$

Chapter 14, Solution 27.

At resonance,

$$\mathbf{Z} = \mathrm{R} = 10\,\Omega, \qquad \omega_0 = \frac{1}{\sqrt{\mathrm{LC}}}$$

$$\mathrm{B} = \frac{\mathrm{R}}{\mathrm{L}} \qquad \text{and} \qquad \mathrm{Q} = \frac{\omega_0}{\mathrm{B}} = \frac{\omega_0 \mathrm{L}}{\mathrm{R}}$$

Hence,

$$\mathrm{L} = \frac{\mathrm{RQ}}{\omega_0} = \frac{(10)(80)}{50} = 16\ \mathrm{H}$$

$$C = \frac{1}{\omega_0^2 L} = \frac{1}{(50)^2(16)} = 25\ \mu F$$

$$B = \frac{R}{L} = \frac{10}{16} = 0.625\ \text{rad/s}$$

Therefore,

$R = \underline{\mathbf{10\ \Omega}}$, $L = \underline{\mathbf{16\ H}}$, $C = \underline{\mathbf{25\ \mu F}}$, $B = \underline{\mathbf{0.625\ rad/s}}$

Chapter 14, Solution 28.

Let $R = 10\ \Omega$.

$$L = \frac{R}{B} = \frac{10}{20} = 0.5\ H$$

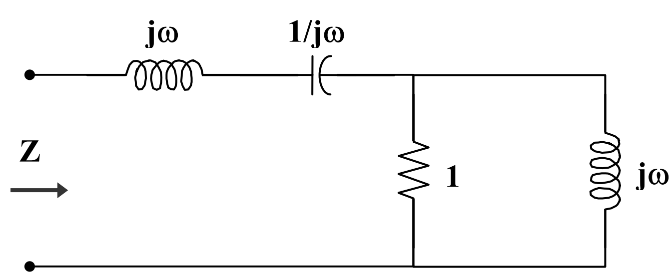
$$C = \frac{1}{\omega_0^2 L} = \frac{1}{(1000)^2(0.5)} = 2\ \mu F$$

$$Q = \frac{\omega_0}{B} = \frac{1000}{20} = 50$$

Therefore, if $R = 10\ \Omega$ then

$L = \underline{\mathbf{0.5\ H}}$, $C = \underline{\mathbf{2\ \mu F}}$, $Q = \underline{\mathbf{50}}$

Chapter 14, Solution 29.



$$\mathbf{Z} = j\omega + \frac{1}{j\omega} + \frac{j\omega}{1 + j\omega}$$

$$\mathbf{Z} = j\left(\omega - \frac{1}{\omega}\right) + \frac{\omega^2 + j\omega}{1+\omega^2}$$

Since $v(t)$ and $i(t)$ are in phase,

$$\text{Im}(\mathbf{Z}) = 0 = \omega - \frac{1}{\omega} + \frac{\omega}{1+\omega^2}$$

$$\omega^4 + \omega^2 - 1 = 0$$

$$\omega^2 = \frac{-1 \pm \sqrt{1+4}}{2} = 0.618$$

$$\omega = \underline{\mathbf{0.7861\ rad/s}}$$

Chapter 14, Solution 30.

Select $R = 10\,\Omega$.

$$L = \frac{R}{\omega_0 Q} = \frac{10}{(10)(20)} = 0.05\text{ H} = 5\text{ mH}$$

$$C = \frac{1}{\omega_0^2 L} = \frac{1}{(100)(0.05)} = 0.2\text{ F}$$

$$B = \frac{1}{RC} = \frac{1}{(10)(0.2)} = 0.5\text{ rad/s}$$

Therefore, if $R = 10\,\Omega$ then

$L = \underline{\mathbf{5\ mH}}$, $C = \underline{\mathbf{0.2\ F}}$, $B = \underline{\mathbf{0.5\ rad/s}}$

Chapter 14, Solution 31.

$$X_L = \omega L \longrightarrow L = \frac{X_L}{\omega}$$

$$B = \frac{R}{L} = \frac{\omega R}{X_L} = \frac{2\pi x 10 x 10^6 x 5.6 x 10^3}{40 x 10^3} = \underline{8.796 x 10^6\text{ rad/s}}$$

Chapter 14, Solution 32.

Since $Q > 10$,

$$\omega_1 = \omega_0 - \frac{B}{2}, \qquad \omega_2 = \omega_0 + \frac{B}{2}$$

$$B = \frac{\omega_0}{Q} = \frac{6\times10^6}{120} = \underline{\mathbf{50\ krad/s}}$$

$$\omega_1 = 6 - 0.025 = \underline{\mathbf{5.975\times10^6\ rad/s}}$$

$$\omega_2 = 6 + 0.025 = \underline{\mathbf{6.025\times10^6\ rad/s}}$$

Chapter 14, Solution 33.

$$Q = \omega_o RC \quad \longrightarrow \quad C = \frac{Q}{2\pi f_o R} = \frac{80}{2\pi x 5.6x10^6 x 40x10^3} = \underline{56.84\ \ pF}$$

$$Q = \frac{R}{\omega_o L} \quad \longrightarrow \quad L = \frac{R}{2\pi f_o Q} = \frac{40x10^3}{2\pi x 5.6x10^6 x 80} = \underline{14.21\ \ \mu H}$$

Chapter 14, Solution 34.

(a) $$\omega_o = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8x10^{-3} x 60x10^{-6}}} = \underline{1.443\ krad/s}$$

(b) $$B = \frac{1}{RC} = \frac{1}{5x10^3 x 60x10^{-6}} = \underline{3.33\ rad/s}$$

(c) $$Q = \omega_o RC = 1.443x10^3 x 5x10^3 x 60x10^{-6} = \underline{432.9}$$

Chapter 14, Solution 35.

At resonance,

$$\mathbf{Y} = \frac{1}{R} \longrightarrow R = \frac{1}{Y} = \frac{1}{25 \times 10^{-3}} = \underline{\mathbf{40\ \Omega}}$$

$$Q = \omega_0 RC \longrightarrow C = \frac{Q}{\omega_0 R} = \frac{80}{(200 \times 10^3)(40)} = \underline{\mathbf{10\ \mu F}}$$

$$\omega_0 = \frac{1}{\sqrt{LC}} \longrightarrow L = \frac{1}{\omega_0^2 C} = \frac{1}{(4 \times 10^{10})(10 \times 10^{-6})} = \underline{\mathbf{2.5\ \mu H}}$$

$$B = \frac{\omega_0}{Q} = \frac{200 \times 10^3}{80} = \underline{\mathbf{2.5\ krad/s}}$$

$$\omega_1 = \omega_0 - \frac{B}{2} = 200 - 2.5 = \underline{\mathbf{197.5\ krad/s}}$$

$$\omega_1 = \omega_0 + \frac{B}{2} = 200 + 2.5 = \underline{\mathbf{202.5\ krad/s}}$$

Chapter 14, Solution 36.

$$\omega_0 = \frac{1}{\sqrt{LC}} = 5000\ \text{rad/s}$$

$$\mathbf{Y}(\omega_0) = \frac{1}{R} \longrightarrow \mathbf{Z}(\omega_0) = R = \underline{\mathbf{2\ k\Omega}}$$

$$\mathbf{Y}(\omega_0/4) = \frac{1}{R} + j\left(\frac{\omega_0}{4}C - \frac{4}{\omega_0 L}\right) = 0.5 - j18.75\ \text{kS}$$

$$\mathbf{Z}(\omega_0/4) = \frac{1}{0.0005 - j0.01875} = \underline{\mathbf{1.4212 + j53.3\ \Omega}}$$

$$\mathbf{Y}(\omega_0/2) = \frac{1}{R} + j\left(\frac{\omega_0}{2}C - \frac{2}{\omega_0 L}\right) = 0.5 - j7.5\ \text{kS}$$

$$\mathbf{Z}(\omega_0/2) = \frac{1}{0.0005 - j0.0075} = \underline{\mathbf{8.85 + j132.74\ \Omega}}$$

$$\mathbf{Y}(2\omega_0) = \frac{1}{R} + j\left(2\omega_0 L - \frac{1}{2\omega_0 C}\right) = 0.5 + j7.5\ \text{kS}$$

$$\mathbf{Z}(2\omega_0) = \underline{\mathbf{8.85 - j132.74\ \Omega}}$$

$$\mathbf{Y}(4\omega_0) = \frac{1}{R} + j\left(4\omega_0 L - \frac{1}{4\omega_0 C}\right) = 0.5 + j18.75\ \text{kS}$$

$$\mathbf{Z}(4\omega_0) = \underline{\mathbf{1.4212 - j53.3\ \Omega}}$$

Chapter 14, Solution 37.

$$Z = j\omega L // (R + \frac{1}{j\omega C}) = \frac{j\omega L(R + \frac{1}{j\omega C})}{R + \frac{1}{j\omega C} + j\omega L} = \frac{\left(\frac{L}{C} + j\omega LR\right)\left(R + j(\omega L - \frac{1}{\omega C})\right)}{R^2 + (\omega L - \frac{1}{\omega C})^2}$$

$$\text{Im}(Z) = \frac{\omega LR^2 + \frac{L}{C}\left(\omega L - \frac{1}{\omega C}\right)}{R^2 + (\omega L - \frac{1}{\omega C})^2} = 0 \qquad \longrightarrow \qquad \omega^2(R^2C^2 + LC) = 1$$

Thus,

$$\underline{\omega = \frac{1}{\sqrt{LC + R^2C^2}}}$$

Chapter 14, Solution 38.

$$Y\frac{1}{R + j\omega L} + j\omega C = j\omega C + \frac{R - j\omega L}{R^2 + \omega^2 L^2}$$

At resonance, $\text{Im}(\mathbf{Y}) = 0$, i.e.

$$\omega_0 C - \frac{\omega_0 L}{R^2 + \omega_0^2 L^2} = 0$$

$$R^2 + \omega_0^2 L^2 = \frac{L}{C}$$

$$\omega_0 = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} = \sqrt{\frac{1}{(40 \times 10^{-3})(10 \times 10^{-6})} - \left(\frac{50}{40 \times 10^{-3}}\right)^2}$$

$$\omega_0 = \underline{\mathbf{4841\ rad/s}}$$

Chapter 14, Solution 39.

(a) $B = \omega_2 - \omega_1 = 2\pi(f_2 - f_1) = 2\pi(90 - 86)x10^3 = 8\pi krad/s$

$$\omega_o = \frac{1}{2}(\omega_1 + \omega_2) = 2\pi(88)x10^3 = 176\pi$$

$$B = \frac{1}{RC} \longrightarrow C = \frac{1}{BR} = \frac{1}{8\pi x10^3 x2x10^3} = \underline{19.89nF}$$

(b) $\omega_o = \frac{1}{\sqrt{LC}} \longrightarrow L = \frac{1}{\omega^2{}_o C} = \frac{1}{(176\pi)^2 x19.89x10^{-9}} = \underline{164.4H}$

(c) $\omega_o = 176\pi = \underline{552.9krad/s}$

(d) $B = 8\pi = \underline{25.13krad/s}$

(e) $Q = \frac{\omega_o}{B} = \frac{176\pi}{8\pi} = \underline{22}$

Chapter 14, Solution 40.

(a) L = 5 + 10 = 15 mH

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{15x10^{-3} x20x10^{-6}}} = \underline{\mathbf{1.8257\ k\ rad/sec}}$$

$$Q = \omega_0 RC = 1.8257x10^3 x25x10^3 x20x10^{-6} = \underline{\mathbf{912.8}}$$

$$B = \frac{1}{RC} = \frac{1}{25x10^3 20x10^{-6}} = \underline{\mathbf{2\ rad}}$$

(b) To increase B by 100% means that B' = 4.

$$C' = \frac{1}{RB'} = \frac{1}{25x10^3 x4} = \underline{\mathbf{10\ \mu F}}$$

Since $C' = \dfrac{C_1 C_2}{C_1 + C_2} = 10\mu F$ and C_1 = 20 μF, we then obtain C_2 = 20 μF.

Therefore, to increase the bandwidth, we merely **add another 20 μF in series with the first one**.

Chapter 14, Solution 41.

(a) This is a series RLC circuit.

$$R = 2 + 6 = 8\,\Omega, \qquad L = 1\,H, \qquad C = 0.4\,F$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.4}} = \underline{\mathbf{1.5811\ rad/s}}$$

$$Q = \frac{\omega_0 L}{R} = \frac{1.5811}{8} = \underline{\mathbf{0.1976}}$$

$$B = \frac{R}{L} = \underline{\mathbf{8\ rad/s}}$$

(b) This is a parallel RLC circuit.

$$3\ \mu F \text{ and } 6\ \mu F \longrightarrow \frac{(3)(6)}{3+6} = 2\ \mu F$$

$$C = 2\ \mu F, \qquad R = 2\ k\Omega, \qquad L = 20\ mH$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(2\times10^{-6})(20\times10^{-3})}} = \underline{\mathbf{5\ krad/s}}$$

$$Q = \frac{R}{\omega_0 L} = \frac{2\times10^3}{(5\times10^3)(20\times10^{-3})} = \underline{\mathbf{20}}$$

$$B = \frac{1}{RC} = \frac{1}{(2\times10^3)(2\times10^{-6})} = \underline{\mathbf{250\ krad/s}}$$

Chapter 14, Solution 42.

(a) $\mathbf{Z}_{in} = (1/j\omega C) \,||\, (R + j\omega L)$

$$\mathbf{Z}_{in} = \frac{\dfrac{R + j\omega L}{j\omega C}}{R + j\omega L + \dfrac{1}{j\omega C}} = \frac{R + j\omega L}{1 - \omega^2 LC + j\omega RC}$$

$$\mathbf{Z}_{in} = \frac{(R + j\omega L)(1 - \omega^2 LC - j\omega RC)}{(1 - \omega^2 LC)^2 + \omega^2 R^2 C^2}$$

At resonance, $\text{Im}(\mathbf{Z}_{in}) = 0$, i.e.

$$0 = \omega L(1 - \omega^2 LC) - \omega R^2 C$$
$$\omega^2 LC = L - R^2 C$$

$$\omega_0 = \sqrt{\frac{L - R^2 C}{LC}} = \underline{\sqrt{\frac{\mathbf{1}}{\mathbf{C}} - \frac{\mathbf{R^2}}{\mathbf{L}}}}$$

(b) $\mathbf{Z}_{in} = j\omega L \,||\, (R + 1/j\omega C)$

$$\mathbf{Z}_{in} = \frac{j\omega L\,(R + 1/j\omega C)}{R + j\omega L + 1/j\omega C} = \frac{j\omega L\,(1 + j\omega RC)}{(1 - \omega^2 LC) + j\omega RC}$$

$$\mathbf{Z}_{in} = \frac{(-\omega^2 RLC + j\omega L)[(1 - \omega^2 LC) - j\omega RC]}{(1 - \omega^2 LC)^2 + \omega^2 R^2 C^2}$$

At resonance, $\text{Im}(\mathbf{Z}_{in}) = 0$, i.e.

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

$$\omega^2 (LC - R^2C^2) = 1$$

$$\omega_0 = \underline{\frac{\mathbf{1}}{\sqrt{\mathbf{LC - R^2C^2}}}}$$

(c) $\mathbf{Z}_{in} = R \parallel (j\omega L + 1/j\omega C)$

$$\mathbf{Z}_{in} = \frac{R\,(j\omega L + 1/j\omega C)}{R + j\omega L + 1/j\omega C} = \frac{R\,(1 - \omega^2 LC)}{(1 - \omega^2 LC) + j\omega RC}$$

$$\mathbf{Z}_{in} = \frac{R\,(1 - \omega^2 LC)[(1 - \omega^2 LC) - j\omega RC]}{(1 - \omega^2 LC)^2 + \omega^2 R^2 C^2}$$

At resonance, $\text{Im}(\mathbf{Z}_{in}) = 0$, i.e.

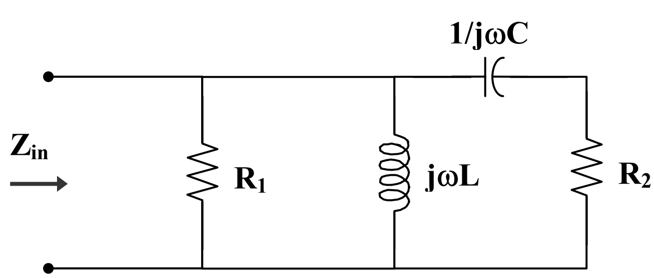
$$0 = R\,(1 - \omega^2 LC)\,\omega RC$$

$$1 - \omega^2 LC = 0$$

$$\omega_0 = \underline{\frac{\mathbf{1}}{\sqrt{\mathbf{LC}}}}$$

Chapter 14, Solution 43.

Consider the circuit below.



(a) $\mathbf{Z}_{in} = (R_1 \parallel j\omega L) \parallel (R_2 + 1/j\omega C)$

$$\mathbf{Z}_{in} = \left(\frac{R_1 j\omega L}{R_1 + j\omega L}\right) \parallel \left(R_2 + \frac{1}{j\omega C}\right)$$

$$\mathbf{Z}_{in} = \frac{\dfrac{j\omega R_1 L}{R_1 + j\omega L} \cdot \left(R_2 + \dfrac{1}{j\omega C} \right)}{R_2 + \dfrac{1}{j\omega C} + \dfrac{jR_1 \omega L}{R_1 + j\omega L}}$$

$$\mathbf{Z}_{in} = \frac{j\omega R_1 L\,(1 + j\omega R_2 C)}{(R_1 + j\omega L)(1 + j\omega R_2 C) - \omega^2 LCR_1}$$

$$\mathbf{Z}_{in} = \frac{-\omega^2 R_1 R_2 LC + j\omega R_1 L}{R_1 - \omega^2 LCR_1 - \omega^2 LCR_2 + j\omega(L + R_1 R_2 C)}$$

$$\mathbf{Z}_{in} = \frac{(-\omega^2 R_1 R_2 LC + j\omega R_1 L)[R_1 - \omega^2 LCR_1 - \omega^2 LCR_2 - j\omega(L + R_1 R_2 C)]}{(R_1 - \omega^2 LCR_1 - \omega^2 LCR_2)^2 + \omega^2 (L + R_1 R_2 C)^2}$$

At resonance, $\mathrm{Im}(\mathbf{Z}_{in}) = 0$, i.e.

$$0 = \omega^3 R_1 R_2 LC\,(L + R_1 R_2 C) + \omega R_1 L\,(R_1 - \omega^2 LCR_1 - \omega^2 LCR_2)$$
$$0 = \omega^3 R_1^2 R_2^2 LC^2 + R_1^2 \omega L - \omega^3 R_1^2 L^2 C$$
$$0 = \omega^2 R_2^2 C^2 + 1 - \omega^2 LC$$
$$\omega^2\,(LC - R_2^2 C^2) = 1$$

$$\omega_0 = \frac{1}{\sqrt{LC - R_2^2 C^2}}$$

$$\omega_0 = \frac{1}{\sqrt{(0.02)(9\times10^{-6}) - (0.1)^2 (9\times10^{-6})^2}}$$
$$\omega_0 = \underline{\mathbf{2.357\ krad/s}}$$

(b) At $\omega = \omega_0 = 2.357\ \text{krad/s}$,

$$j\omega L = j(2.357\times10^3)(20\times10^{-3}) = j47.14$$

$$R_1 \parallel j\omega L = \frac{j47.14}{1 + j47.14} = 0.9996 + j0.0212$$

$$R_2 + \frac{1}{j\omega C} = 0.1 + \frac{1}{j(2.357\times10^3)(9\times10^{-6})} = 0.1 - j47.14$$

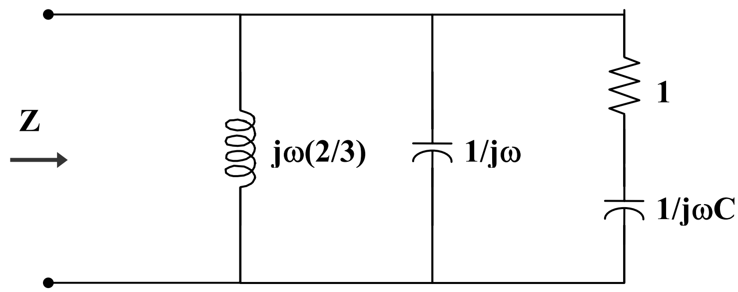
$$\mathbf{Z}_{in}(\omega_0) = (R_1 \parallel j\omega L) \parallel (R_2 + 1/j\omega C)$$

$$\mathbf{Z}_{in}(\omega_0) = \frac{(0.9996 + j0.0212)(0.1 - j47.14)}{(0.9996 + j0.0212) + (0.1 - j47.14)}$$

$$\mathbf{Z}_{in}(\omega_0) = \underline{\mathbf{1\,\Omega}}$$

Chapter 14, Solution 44.

We find the input impedance of the circuit shown below.



$$\frac{1}{\mathbf{Z}} = \frac{3}{j\omega 2} + j\omega + \frac{1}{1 + 1/j\omega C}, \qquad \omega = 1$$

$$\frac{1}{\mathbf{Z}} = -j1.5 + j + \frac{jC}{1 + jC} = -j0.5 + \frac{C^2 + jC}{1 + C^2}$$

$v(t)$ and $i(t)$ are in phase when $\mathbf{Z}$ is purely real, i.e.

$$0 = -0.5 + \frac{C}{1 + C^2} \longrightarrow (C - 1)^2 = 1 \qquad \text{or} \qquad C = \underline{\mathbf{1\,F}}$$

$$\frac{1}{\mathbf{Z}} = \frac{C^2}{1 + C^2} = \frac{1}{2} \longrightarrow \mathbf{Z} = 2\,\Omega$$

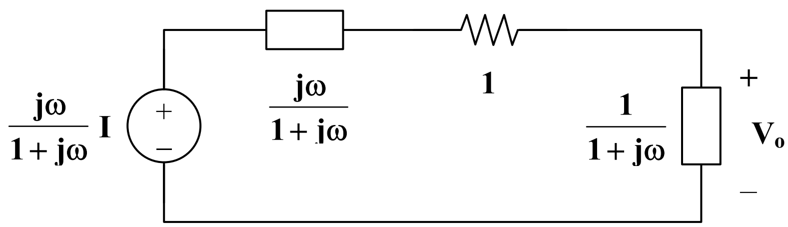
$$\mathbf{V} = \mathbf{Z}\mathbf{I} = (2)(10) = 20$$

$$v(t) = 20\sin(t)\text{ V}, \qquad \text{i.e.} \qquad V_o = \underline{\mathbf{20\ V}}$$

Chapter 14, Solution 45.

(a) $1 \,||\, j\omega = \dfrac{j\omega}{1+j\omega}, \qquad 1 \,||\, \dfrac{1}{j\omega} = \dfrac{1/j\omega}{1+1/j\omega} = \dfrac{1}{1+j\omega}$

Transform the current source gives the circuit below.



$$\mathbf{V}_o = \frac{\dfrac{1}{1+j\omega}}{1+\dfrac{1}{1+j\omega}+\dfrac{j\omega}{1+j\omega}} \cdot \frac{j\omega}{1+j\omega}\,\mathbf{I}$$

$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{I}} = \underline{\boldsymbol{\frac{j\omega}{2(1+j\omega)^2}}}$$

(b) $\mathbf{H}(1) = \dfrac{1}{2(1+j)^2}$

$$\left|\mathbf{H}(1)\right| = \frac{1}{2(\sqrt{2})^2} = \underline{\mathbf{0.25}}$$

Chapter 14, Solution 46.

(a) This is an RLC series circuit.

$$\omega_o = \frac{1}{\sqrt{LC}} \longrightarrow C = \frac{1}{\omega^2{}_o L} = \frac{1}{(2\pi x15x10^3)^2 x10x10^{-3}} = \underline{11.26\text{nF}}$$

(b) $Z = R,\ I = V/Z = 120/20 = \underline{\mathbf{6\ A}}$

(c) $Q = \dfrac{\omega_o L}{R} = \dfrac{2\pi x15x10^3 x10x10^{-3}}{20} = 15\pi = \underline{47.12}$

Chapter 14, Solution 47.

$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{R}{R + j\omega L} = \frac{1}{1 + j\omega L/R}$$

$H(0) = 1$ and $H(\infty) = 0$ showing that this circuit is a lowpass filter.

At the corner frequency, $\left|H(\omega_c)\right| = \frac{1}{\sqrt{2}}$, i.e.

$$\frac{1}{\sqrt{2}} = \frac{1}{\sqrt{1 + \left(\frac{\omega_c L}{R}\right)^2}} \longrightarrow 1 = \frac{\omega_c L}{R} \qquad \text{or} \qquad \omega_c = \frac{R}{L}$$

Hence,

$$\omega_c = \frac{R}{L} = 2\pi f_c$$

$$f_c = \frac{1}{2\pi} \cdot \frac{R}{L} = \frac{1}{2\pi} \cdot \frac{10 \times 10^3}{2 \times 10^{-3}} = \underline{\mathbf{796\ kHz}}$$

Chapter 14, Solution 48.

$$\mathbf{H}(\omega) = \frac{R \,\|\, \frac{1}{j\omega C}}{j\omega L + R \,\|\, \frac{1}{j\omega C}}$$

$$\mathbf{H}(\omega) = \frac{\frac{R/j\omega C}{R + 1/j\omega C}}{j\omega L + \frac{R/j\omega C}{R + 1/j\omega C}}$$

$$\mathbf{H}(\omega) = \underline{\frac{\mathbf{R}}{\mathbf{R} + \mathbf{j\omega L} - \omega^2 \mathbf{RLC}}}$$

$H(0) = 1$ and $H(\infty) = 0$ showing that **<u>this circuit is a lowpass filter</u>**.

Chapter 14, Solution 49.

At dc, $H(0) = \frac{4}{2} = 2$.

Hence, $\left| H(\omega) \right| = \frac{1}{\sqrt{2}} H(0) = \frac{2}{\sqrt{2}}$

$$\frac{2}{\sqrt{2}} = \frac{4}{\sqrt{4 + 100\omega_c^2}}$$

$$4 + 100\omega_c^2 = 8 \quad \longrightarrow \quad \omega_c = 0.2$$

$$H(2) = \frac{4}{2 + j20} = \frac{2}{1 + j10}$$

$$\left| H(2) \right| = \frac{2}{\sqrt{101}} = 0.199$$

In dB, $20\log_{10}\left| H(2) \right| = \underline{\mathbf{-14.023}}$

$\arg H(2) = \text{-}\tan^{-1} 10 = \underline{\mathbf{- 84.3°}}$

Chapter 14, Solution 50.

$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{j\omega L}{R + j\omega L}$$

$H(0) = 0$ and $H(\infty) = 1$ showing that **<u>this circuit is a highpass filter</u>**.

$$\mathbf{H}(\omega_c) = \frac{1}{\sqrt{2}} = \frac{1}{\sqrt{1 + \left(\frac{R}{\omega_c L}\right)^2}} \quad \longrightarrow \quad 1 = \frac{R}{\omega_c L}$$

or $\omega_c = \frac{R}{L} = 2\pi f_c$

$$f_c = \frac{1}{2\pi} \cdot \frac{R}{L} = \frac{1}{2\pi} \cdot \frac{200}{0.1} = \underline{\mathbf{318.3\ Hz}}$$

Chapter 14, Solution 51.

$$\mathbf{H}'(\omega) = \frac{j\omega RC}{1 + j\omega RC} = \frac{j\omega}{j\omega + 1/RC} \qquad \text{(from Eq. 14.52)}$$

This has a unity passband gain, i.e. $H(\infty) = 1$.

$$\frac{1}{RC} = \omega_c = 50$$

$$\mathbf{H}^{\wedge}(\omega) = 10\,\mathbf{H}'(\omega) = \frac{j10\omega}{50 + j\omega}$$

$$\mathbf{H}(\omega) = \underline{\boldsymbol{\frac{j10\omega}{50 + j\omega}}}$$

Chapter 14, Problem 52.

Design an *RL* lowpass filter that uses a 40-mH coil and has a cut-off frequency of 5 kHz.

Chapter 14, Solution 53.

$$\omega_c = \frac{R}{L} = 2\pi f_c$$

$$R = 2\pi f_c L = (2\pi)(10^5)(40 \times 10^{-3}) = \underline{\mathbf{25.13\ k\Omega}}$$

Chapter 14, Solution 54.

$$\omega_1 = 2\pi f_1 = 20\pi \times 10^3$$
$$\omega_2 = 2\pi f_2 = 22\pi \times 10^3$$

$$B = \omega_2 - \omega_1 = 2\pi \times 10^3$$

$$\omega_0 = \frac{\omega_2 + \omega_1}{2} = 21\pi \times 10^3$$

$$Q = \frac{\omega_0}{B} = \frac{21\pi}{2\pi} = \underline{11.5}$$

$$\omega_0 = \frac{1}{\sqrt{LC}} \longrightarrow L = \frac{1}{\omega_0^2 C}$$

$$L = \frac{1}{(21\pi \times 10^3)^2 (80 \times 10^{-12})} = \underline{\mathbf{2.872\ H}}$$

$$B = \frac{R}{L} \longrightarrow R = BL$$

$$R = (2\pi \times 10^3)(2.872) = \underline{\mathbf{18.045\ k\Omega}}$$

Chapter 14, Solution 55.

$$\omega_c = 2\pi f_c = \frac{1}{RC} \longrightarrow R = \frac{1}{2\pi f_c C} = \frac{1}{2\pi x 2x10^3 x 300x10^{-12}} = \underline{265.3k\Omega}$$

Chapter 14, Solution 56.

$$\omega_o = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(25 \times 10^{-3})(0.4 \times 10^{-6})}} = 10\ \text{krad/s}$$

$$B = \frac{R}{L} = \frac{10}{25 \times 10^{-3}} = 0.4\ \text{krad/s}$$

$$Q = \frac{10}{0.4} = \underline{\mathbf{25}}$$

$$\omega_1 = \omega_o - B/2 = 10 - 0.2 = 9.8\ \text{krad/s} \qquad \text{or} \qquad f_1 = \frac{9.8}{2\pi} = 1.56\ \text{kHz}$$

$$\omega_2 = \omega_o + B/2 = 10 + 0.2 = 10.2\ \text{krad/s} \qquad \text{or} \qquad f_2 = \frac{10.2}{2\pi} = 1.62\ \text{kHz}$$

Therefore,

$$\underline{\mathbf{1.56\ kHz < f < 1.62\ kHz}}$$

Chapter 14, Solution 57.

(a) From Eq 14.54,

$$\mathbf{H}(s) = \frac{R}{R + sL + \frac{1}{sC}} = \frac{sRC}{1 + sRC + s^2LC} = \frac{s\frac{R}{L}}{s^2 + s\frac{R}{L} + \frac{1}{LC}}$$

Since $B = \frac{R}{L}$ and $\omega_0 = \frac{1}{\sqrt{LC}}$,

$$\mathbf{H}(s) = \underline{\frac{\mathbf{sB}}{\mathbf{s^2 + sB + \omega_0^2}}}$$

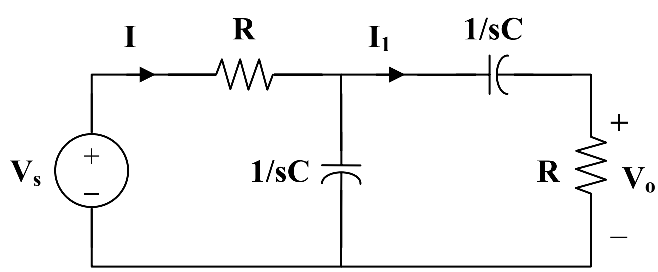
(b) From Eq. 14.56,

$$\mathbf{H}(s) = \frac{sL + \frac{1}{sC}}{R + sL + \frac{1}{sC}} = \frac{s^2 + \frac{1}{LC}}{s^2 + s\frac{R}{L} + \frac{1}{LC}}$$

$$\mathbf{H}(s) = \underline{\frac{\mathbf{s^2 + \omega_0^2}}{\mathbf{s^2 + sB + \omega_0^2}}}$$

Chapter 14, Solution 58.

(a) Consider the circuit below.



$$\mathbf{Z}(s) = R + \frac{1}{sC} \| \left(R + \frac{1}{sC}\right) = R + \frac{\frac{1}{sC}\left(R + \frac{1}{sC}\right)}{R + \frac{2}{sC}}$$

$$\mathbf{Z}(s) = R + \frac{1 + sRC}{sC(2 + sRC)}$$

$$\mathbf{Z}(s) = \frac{1 + 3sRC + s^2R^2C^2}{sC(2 + sRC)}$$

$$\mathbf{I} = \frac{\mathbf{V}_s}{\mathbf{Z}}$$

$$\mathbf{I}_1 = \frac{1/sC}{2/sC + R}\mathbf{I} = \frac{\mathbf{V}_s}{\mathbf{Z}(2 + sRC)}$$

$$\mathbf{V}_o = \mathbf{I}_1 R = \frac{R\,\mathbf{V}_s}{2 + sRC} \cdot \frac{sC(2 + sRC)}{1 + 3sRC + s^2R^2C^2}$$

$$\mathbf{H}(s) = \frac{\mathbf{V}_o}{\mathbf{V}_s} = \frac{sRC}{1 + 3sRC + s^2R^2C^2}$$

$$\mathbf{H}(s) = \frac{1}{3}\left[\frac{\frac{3}{RC}s}{s^2 + \frac{3}{RC}s + \frac{1}{R^2C^2}}\right]$$

Thus, $\omega_0^2 = \frac{1}{R^2C^2}$ or $\omega_0 = \frac{1}{RC} = \underline{\mathbf{1\ rad/s}}$

$$B = \frac{3}{RC} = \underline{\mathbf{3\ rad/s}}$$

(b) Similarly,

$$\mathbf{Z}(s) = sL + R \,||\, (R + sL) = sL + \frac{R(R + sL)}{2R + sL}$$

$$\mathbf{Z}(s) = \frac{R^2 + 3sRL + s^2L^2}{2R + sL}$$

$$\mathbf{I} = \frac{\mathbf{V}_s}{\mathbf{Z}}, \qquad \mathbf{I}_1 = \frac{R}{2R + sL}\mathbf{I} = \frac{R\,\mathbf{V}_s}{\mathbf{Z}(2R + sL)}$$

$$\mathbf{V}_o = \mathbf{I}_1 \cdot sL = \frac{sLR\,\mathbf{V}_s}{2R + sL} \cdot \frac{2R + sL}{R^2 + 3sRL + s^2L^2}$$

$$\mathbf{H}(s) = \frac{\mathbf{V}_o}{\mathbf{V}_s} = \frac{sRL}{R^2 + 3sRL + s^2L^2} = \frac{\frac{1}{3}\left(\frac{3R}{L}s\right)}{s^2 + \frac{3R}{L}s + \frac{R^2}{L^2}}$$

Thus, $\omega_0 = \frac{R}{L} = \underline{\mathbf{1\ rad/s}}$

$$B = \frac{3R}{L} = \underline{\mathbf{3\ rad/s}}$$

Chapter 14, Solution 59.

(a) $\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(0.1)(40\times10^{-12})}} = \underline{\mathbf{0.5\times10^{6}\ rad/s}}$

(b) $B = \frac{R}{L} = \frac{2\times10^3}{0.1} = 2\times10^4$

$$Q = \frac{\omega_0}{B} = \frac{0.5\times10^6}{2\times10^4} = 250$$

As a high Q circuit,

$$\omega_1 = \omega_0 - \frac{B}{2} = 10^4\,(50-1) = \underline{\mathbf{490\ krad/s}}$$

$$\omega_2 = \omega_0 + \frac{B}{2} = 10^4\,(50+1) = \underline{\mathbf{510\ krad/s}}$$

(c) As seen in part (b), $Q = \underline{\mathbf{250}}$