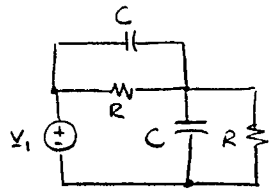
Assignment 4 Solutions from Bobrow, 2nd Ed. Instructor's Manual Copyright Oxford 1996

5.5

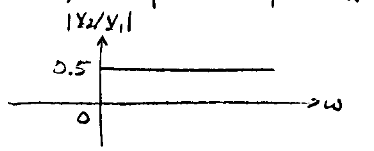


$$\mathbf{V}_2 = \frac{Z}{Z+Z}\mathbf{V}_1 = \frac{Z}{2Z}\mathbf{V}_1 = \frac{1}{2}\mathbf{V}_1$$

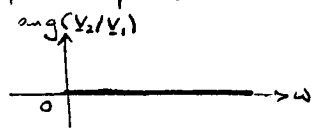
where $Z = \dfrac{R\left(\frac{1}{j\omega C}\right)}{R + \frac{1}{j\omega C}} = \dfrac{R}{j\omega RC + 1} = \dfrac{R}{1 + j\omega RC}$

Thus, $\dfrac{\mathbf{V}_2}{\mathbf{V}_1} = \dfrac{1}{2} = 0.5 \Rightarrow \left|\dfrac{\mathbf{V}_2}{\mathbf{V}_1}\right| = 0.5 \quad \text{ang}\left(\dfrac{\mathbf{V}_2}{\mathbf{V}_1}\right) = 0°$

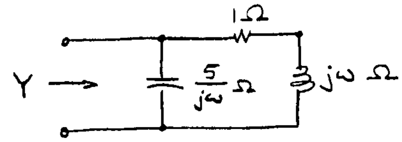
Hence, the amplitude response is:



The phase response is:



5.21



$$Y = \frac{j\omega}{5} + \frac{1}{1+j\omega} = \frac{j\omega(1+j\omega)+5}{5(1+j\omega)} = \frac{j\omega + (j\omega)^2 + 5}{5(1+j\omega)}$$

$$= \frac{(5-\omega^2)+j\omega}{5(1+j\omega)} \cdot \frac{(1-j\omega)}{1-j\omega} = \frac{(5-\omega^2)+j\omega-(5-\omega^2)j\omega-(j\omega)^2}{5(1+\omega^2)}$$

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

$$= \frac{5+j\omega(1-5+\omega^2)}{5(1+\omega^2)} = \frac{5+j\omega(-4+\omega^2)}{5(1+\omega^2)}$$

For resonance, $\omega(-4+\omega^2) = 0$ (See note at bottom)

$\therefore \omega = 0$ rad/s — the trivial case.

$-4+\omega^2 = 0$

$\omega^2 = 4 \Rightarrow \omega = \underline{2 \text{ rad/s} = \omega_r}$

5.39 $R = 1.24\text{ M}\Omega$, $L = 0.62\text{ mH}$, $C = 20\text{ pF}$

(a) $\omega_r = \dfrac{1}{\sqrt{LC}} = \dfrac{1}{\sqrt{(0.62m)(20p)}} = 8.98$ Mrad/s

$f_r = \dfrac{\omega_r}{2\pi} = \dfrac{8.98M}{2\pi} = \underline{1.43\text{ MHz}}$

(b) $Q = R\sqrt{\dfrac{C}{L}} = 1.24M\sqrt{\dfrac{20p}{0.62m}} = \underline{223}$

(c) $BW = \dfrac{1}{RC} = \dfrac{1}{(1.24M)(20p)} = 40.32$ k rad/s

$BW = \dfrac{40.32k}{2\pi} = \underline{6.42\text{ kHz}}$

(d) $Y = \dfrac{1}{R} + \dfrac{1}{j\omega L} + j\omega C = \dfrac{1}{R} + j\left(\omega C - \dfrac{1}{\omega L}\right)$

$|Y| = \sqrt{\left(\frac{1}{R}\right)^2 + \left(\omega C - \frac{1}{\omega L}\right)^2}$ $\quad \omega = 2\pi(1430k) = 8.985$ M rad/s

$|Y| = \sqrt{\left(\frac{1}{1.24M}\right)^2 + \left[(8.985M)(20p) - \frac{1}{(8.985M)(0.62m)}\right]^2} = 0.828\mu\mho$

$|\mathbf{V}| = \dfrac{|\mathbf{I}|}{|Y|} = \dfrac{5\mu}{0.828\mu} = \underline{6.04}$ V rms

(e) $\omega = 2\pi(1450k) = 9.11$ M rad/s

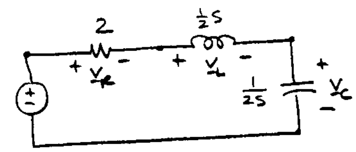
$|Y| = \sqrt{\left(\frac{1}{1.24M}\right)^2 + \left[(9.11M)(20p) - \frac{1}{(9.11M)(0.62m)}\right]^2} = 5.22\mu\mho$

$|\mathbf{V}| = \dfrac{|\mathbf{I}|}{|Y|} = \dfrac{5\mu}{5.22\mu} = \underline{0.958\text{ V}}$ rms

5.41

$\mathbf{V}_1 = 20\angle 0°$

$s = -6+j3$



(a) $\mathbf{V}_R = \dfrac{2}{2+\frac{1}{2}s+\frac{1}{2s}}\mathbf{V}_1 = \dfrac{4s}{4s+s^2+1}\mathbf{V}_1 = \dfrac{4s}{s^2+4s+1}\mathbf{V}_1$

$= \dfrac{4(-6+j3)}{(-6+j3)^2+4(-6+j3)+1}\mathbf{V}_1 = \dfrac{12(-2+j)}{36-j36-9-24+j12+1}\mathbf{V}_1$

$= \dfrac{12(-2+j)}{4-j24}\mathbf{V}_1 = \dfrac{3(-2+j)}{1-j6}\mathbf{V}_1 = \dfrac{3(\sqrt{5}\angle 153.4°)}{\sqrt{37}\angle -80.5°}(20\angle 0°)$

$= 22.1\angle -126° \Rightarrow v_R(t) = \underline{22.1e^{-6t}\cos(3t-126°)\text{ V}}$

(b) $\mathbf{V}_L = \dfrac{\frac{1}{2}s}{2+\frac{1}{2}s+\frac{1}{2s}}\mathbf{V}_1 = \dfrac{(\frac{1}{4}s)(2)}{2+\frac{1}{2}s+\frac{1}{2s}}\mathbf{V}_1 = \dfrac{1}{4}s\,\mathbf{V}_R$

$= \frac{1}{4}(-6+j3)\mathbf{V}_R = \frac{3}{4}(-2+j)\mathbf{V}_R = \frac{3}{4}(\sqrt{5}\angle 153.4°)(22.06\angle -126°)$

$= 37\angle 27.4° \Rightarrow v_L(t) = \underline{37e^{-6t}\cos(3t+27.4°)\text{ V}}$

(c) $\mathbf{V}_C = \dfrac{\frac{1}{2s}}{2+\frac{1}{2}s+\frac{1}{2s}}\mathbf{V}_1 = \dfrac{(\frac{1}{4s})(2)}{2+\frac{1}{2}s+\frac{1}{2s}}\mathbf{V}_1 = \dfrac{1}{4s}\mathbf{V}_R$

$= \dfrac{1}{4(-6+j3)}\mathbf{V}_R = \dfrac{1}{12(-2+j)}\mathbf{V}_R = \dfrac{22.06\angle -126°}{12(\sqrt{5}\angle 153.4°)}$

$= 0.822\angle 80.6° \Rightarrow v_c(t) = \underline{0.822e^{-6t}\cos(3t+80.6°)\text{ V}}$

Note on 5.21- High-Q coil criterion is not met in this case. Text defines resonance frequency as ω where the imaginary part of the admittance or impedance equals zero (for a circuit with at least one capacitor and one inductor). There may be more than one such frequency. See text, p. 276.