Homework Assignment No. 2 - Solutions

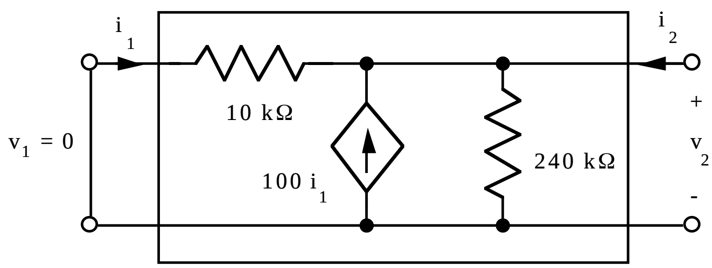
Problem 10.20 (11.16)

$$g_{11} = \left.\frac{\mathbf{i_1}}{\mathbf{v_1}}\right|_{\mathbf{i_2}=0} : \mathbf{v_1} = 10^4\,\mathbf{i_1} + 101\,\mathbf{i_1}(240\text{k}\Omega) \rightarrow g_{11} = 4.124 \text{ x } 10^{-8}\,\text{S} = 4.12 \text{ x } 10^{-8}\,\text{S}$$

$$g_{12} = \left.\frac{\mathbf{i_1}}{\mathbf{i_2}}\right|_{\mathbf{v_1}=0} : \mathbf{i_1} = -\frac{240\text{k}\Omega}{240\text{k}\Omega + 10\text{k}\Omega}(\mathbf{i_2} + 100\mathbf{i_1}) \rightarrow g_{12} = -9.90 \text{ x } 10^{-3}$$

$$g_{21} = \left.\frac{\mathbf{v_2}}{\mathbf{v_1}}\right|_{\mathbf{i_2}=0} : \mathbf{v_2} = 101\mathbf{i_1}(240\text{k}\Omega) \;\; | \;\; \mathbf{i_1} = g_{11}\mathbf{v_1} \rightarrow g_{21} = 1.00$$

$$g_{22} = \left.\frac{\mathbf{v_2}}{\mathbf{i_2}}\right|_{\mathbf{v_1}=0} : \mathbf{i_2} = \frac{\mathbf{v_2}}{240\text{k}\Omega} + \frac{\mathbf{v_2}}{10\text{k}\Omega} + 100\frac{\mathbf{v_2}}{10\text{k}\Omega} \rightarrow g_{22} = 99.0\ \Omega$$



Problem 10.48 (11.34)

$$V_O = V_S \frac{R_{IN}}{R_{IN} + R_S} A \frac{R_{IN}}{R_{IN} + R_{OUT}} A \frac{R_L}{R_L + R_{OUT}}$$

$$A_V = \frac{5000}{5000 + 1000}(-1000)\frac{5000}{5000 + 250}(-1000)\frac{100}{100 + 250} = +2.27 \text{ x } 10^5$$

$$A_I = \frac{I_O}{I_S} = \frac{2.27\text{x}10^5\,V_S}{100}\frac{1}{\frac{V_S}{6000}} = +1.36 \text{ x } 10^7$$

$$A_P = \frac{2.27\text{x}10^5\,V_S(+1.36 \text{ x } 10^7 I_S)}{V_S I_S} = +3.09 \text{ x } 10^{12}$$

Problem 10.57 (11.37)

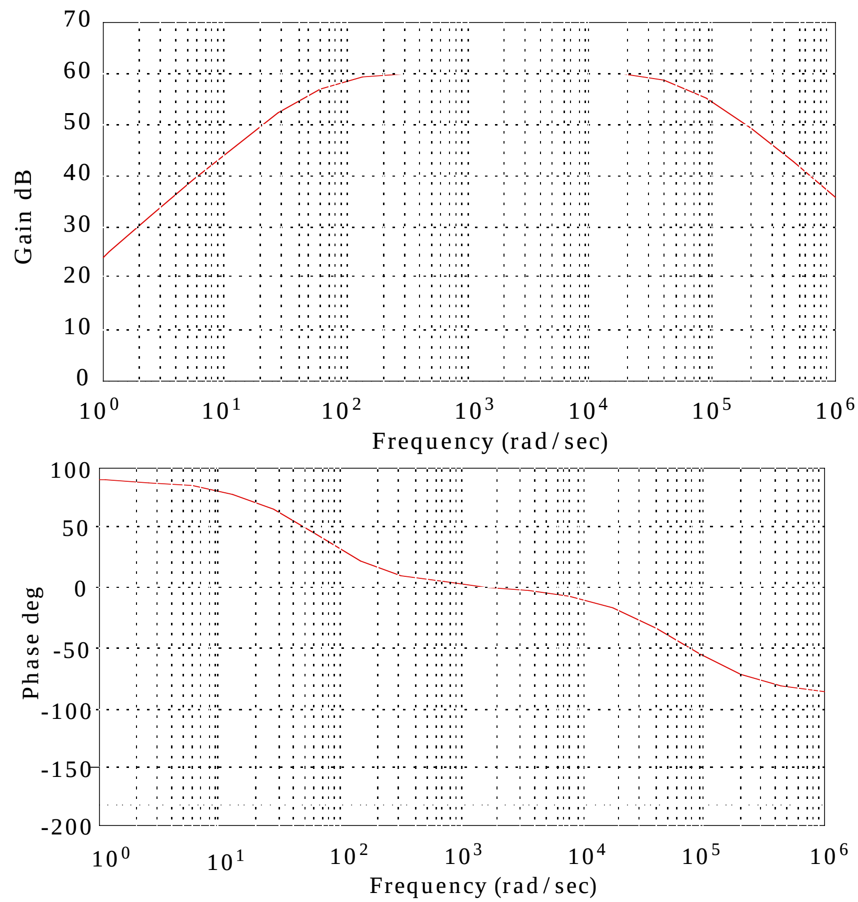
$$A_V = \frac{2\pi \text{ x } 10^7 s}{(s + 20\pi)(s + 2\pi \text{ x } 10^4)} = \frac{1000s}{(s + 20\pi)\left(1 + \frac{s}{2\pi \text{ x } 10^4}\right)} \;\; | \;\; A_{mid} = +1000 = 60 \text{ dB}$$

$$f_L = \frac{20\pi}{2\pi} = 10 \text{ Hz} \;\; | \;\; f_H = \frac{2\pi \text{ x } 10^4}{2\pi} = 10 \text{ kHz} \;\; | \;\; BW = 10\text{kHz} - 10\text{Hz} = 9.99 \text{ kHz}$$

Bandpass Amplifier

Problem 10.63 (11.43)

Using MATLAB: n=[2e7*pi 0]; d=[1 (20*pi+2e4*pi) 40e4*pi^2]; bode(n,d)



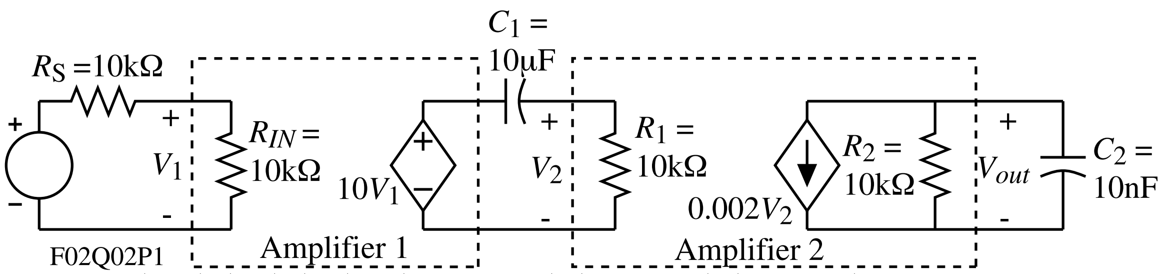
Problem 10.75 (11.55)

(a) $A_{mid} = +10^{\frac{20}{20}} = +10 \quad | \quad A_V = \dfrac{10}{1 + \dfrac{s}{2\pi \text{ x } \left(5 \text{ x } 10^6\right)}} = \dfrac{10}{1 + \dfrac{s}{10^7 \pi}} = \dfrac{10^8 \pi}{s + 10^7 \pi}$

(b) $A_{mid} = -10^{\frac{20}{20}} = -10 \quad | \quad A_V = -\dfrac{10^8 \pi}{s + 10^7 \pi}$

Problem 6

a.) Find the transfer function, $V_{out}(s)/V_S(s)$, of the circuit shown and identify the location of the poles and zeros. What is the gain in the region where the transfer function is independent of frequency?



$$\frac{V_{out}(s)}{V_S(s)} = \left(\frac{V_{out}}{V_2}\right)\left(\frac{V_2}{V_1}\right)\left(\frac{V_1}{V_{in}}\right) = \left(\frac{-G(R_2/sC_2)}{R_2+1/sC_2}\right)\left(\frac{10R_1}{R_1+1/sC_1}\right)\left(\frac{R_{IN}}{R_S+R_{IN}}\right)$$

where G = 0.002 A/V. Rearranging gives,

$$\frac{V_{out}(s)}{V_S(s)} = \left(\frac{R_{IN}}{R_S+R_{IN}}\right)\left(\frac{10sR_1C_1}{sR_1C_1+1}\right)\left(\frac{-GR_2}{sR_2C_2+1}\right) = \left(\frac{10(-20)}{2}\right)\left(\frac{\frac{s}{10}}{\frac{s}{10}+1}\right)\left(\frac{1}{\frac{s}{10^4}+1}\right)$$

Poles are at $\underline{-10 \text{ rads/sec.}}$ and $\underline{-10^4 \text{ rads/sec.}}$ and the zeros are at $\underline{0}$ and $\underline{\underline{\infty}}$.
The gain in the frequency independent range (midband) is $\underline{-100\text{V/V}}$.

b.) Sketch the asymptotic (straight-line) plot for the magnitude and phase of transfer function shown. Use the same plot for phase shift. Label the phase shift on the right side of the plot.

$$A(s) = \frac{-10s}{(s+1)(s+100)} \quad \rightarrow A(j\omega) = \left(\frac{-10}{100}\right)\left(\frac{\frac{j\omega}{1}}{\left(1+\frac{j\omega}{1}\right)\left(1+\frac{j\omega}{100}\right)}\right)$$

The asymptotic plot of the magnitude and phase of the above transfer function is shown: