Homework Assignment No. 2 – Solutions

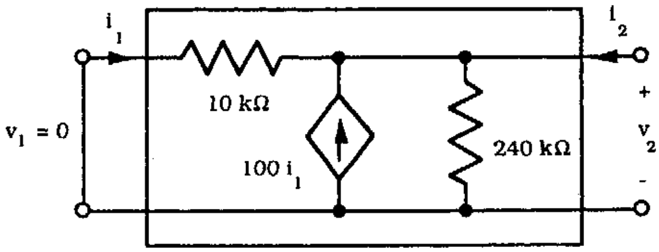
11.16

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

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

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

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



11.34

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

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

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

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

11.37

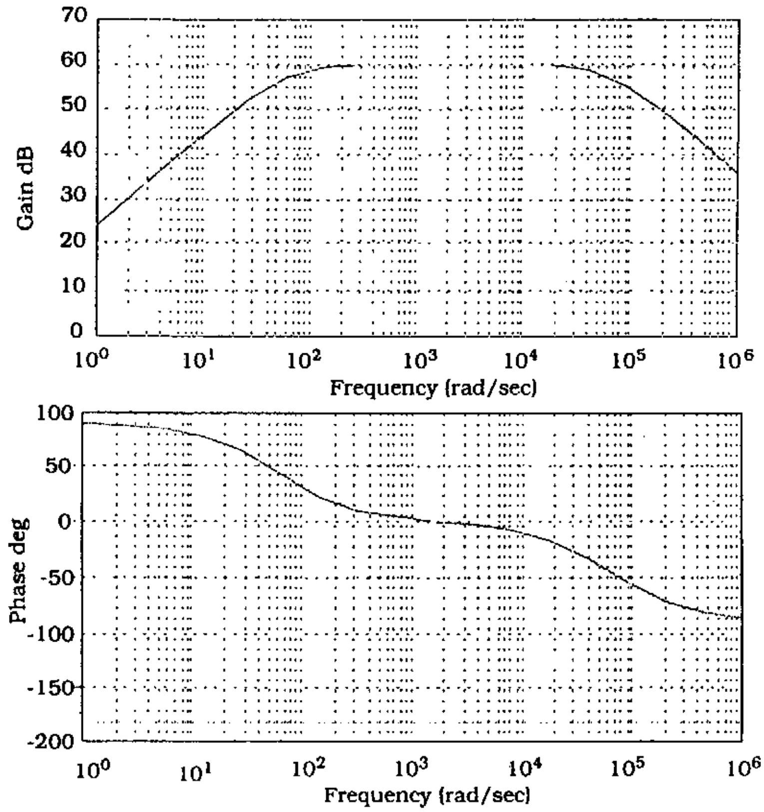
$$A_V = \frac{2\pi \times 10^7 s}{(s + 20\pi)(s + 2\pi \times 10^4)} = \frac{1000s}{(s + 20\pi)\left(1 + \frac{s}{2\pi \times 10^4}\right)} \quad | \quad A_{mid} = +1000 = 60 \text{ dB}$$

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

Bandpass Amplifier

11.43

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



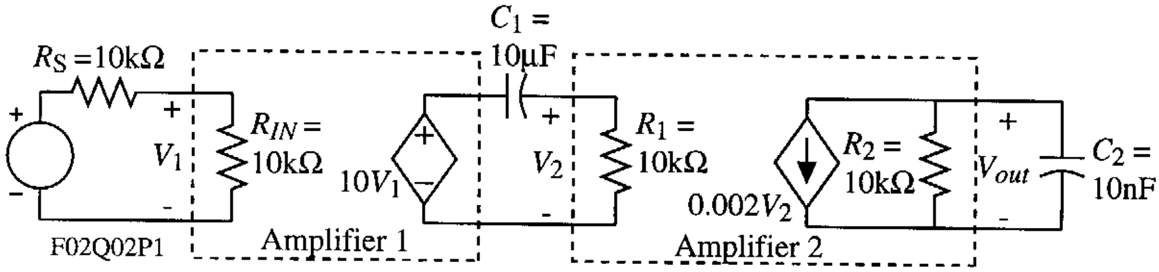
11.55

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

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

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?



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

where G = 0.002 A/V. Rearranging gives,

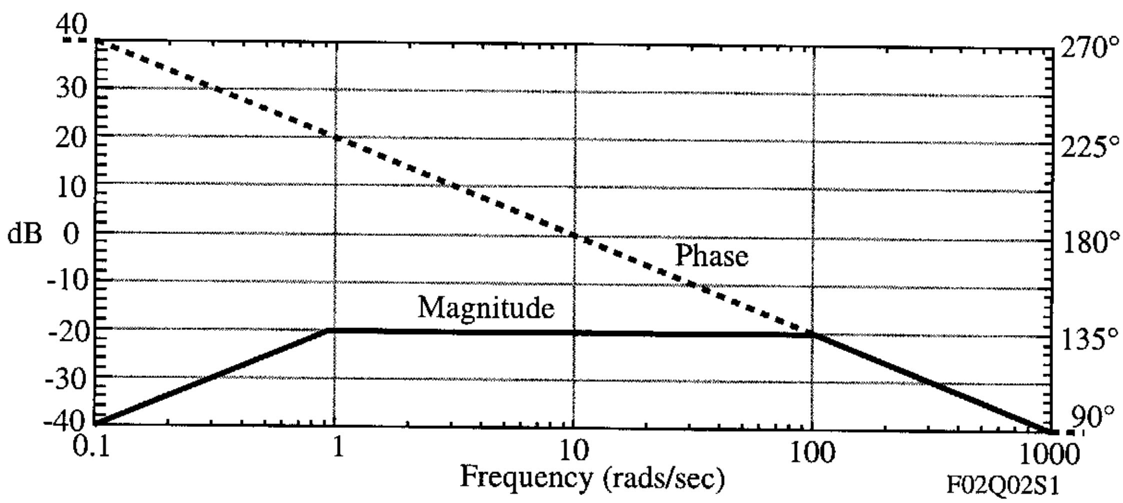
$$\frac{V_{out}(s)}{V_S(s)} = \left(\frac{R_{IN}}{R_S+R_{IN}}\right)\left(\frac{10sR_1C_1}{sR_1C_1+1}\right)\left(\frac{-GR_2}{sR_2C_2+1}\right) = \left(\frac{10(-20)}{2}\right)\left(\frac{\frac{s}{10}}{\frac{s}{10}+1}\right)\left(\frac{1}{\frac{s}{10^4}+1}\right)$$

Poles are at <u>–10 rads/sec.</u> and <u>–10^4 rads/sec.</u> and the zeros are at <u>0</u> and <u>∞</u>.
The gain in the frequency independent range (midband) is <u>–100V/V.</u>

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:



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