Homework Assignment No. 2 – Solutions

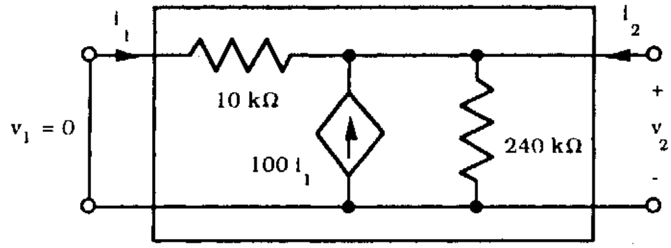
11.16

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

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

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

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



11.34

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

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

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

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

11.37

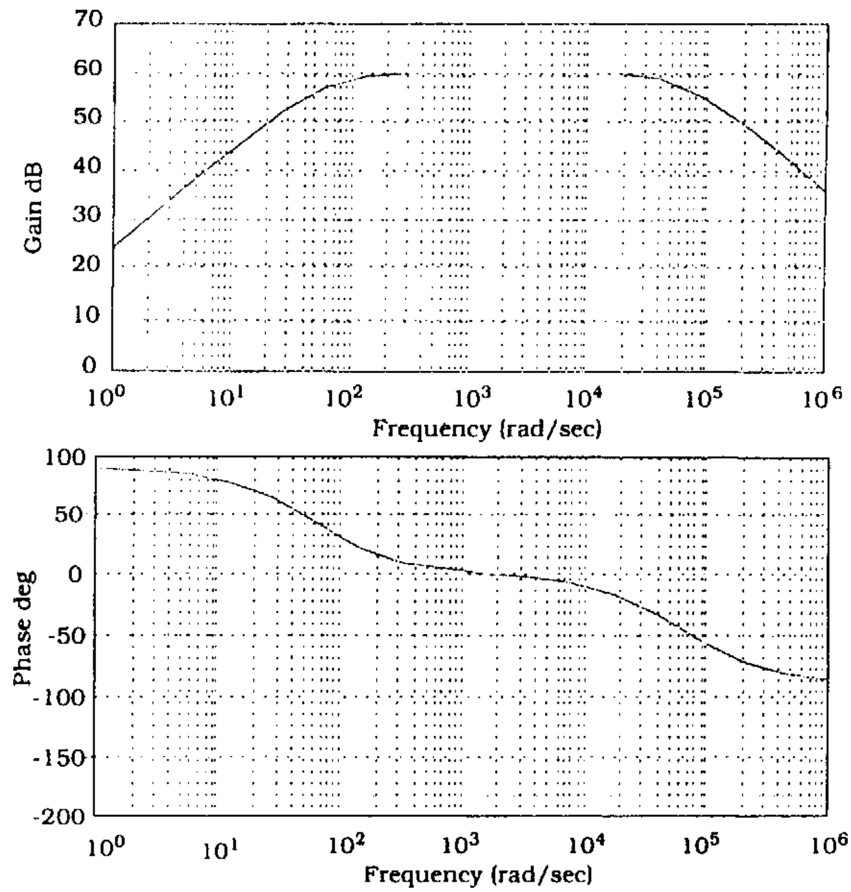
$$A_V = \frac{2\pi \times 10^7 s}{(s+20\pi)\left(s + 2\pi \times 10^4\right)} = \frac{1000s}{(s+20\pi)\left(1 + \frac{s}{2\pi \times 10^4}\right)} \ \ | \ \ A_{mid} = +1000 = 60 \text{ dB}$$

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

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

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

Problem 6

(a.) Find $V_{out}(s)/V_{in}(s)$ and identify the numerical value of the midband gain and all poles and zeros if g_m is 1mA/V.

$$\frac{V_{out}}{V_{in}} = \left(\frac{V_{out}}{V_1}\right)\left(\frac{V_1}{V_{in}}\right) = \left(\frac{g_m R_2 R_3}{R_2+R_3+\frac{1}{sC_1}}\right)\left(\frac{V_1}{V_{in}}\right)$$

$$V_1 = V_{in} - V_{R2} \rightarrow V_1 = V_{in} - \frac{g_m V_1 R_2\left(R_3 + \frac{1}{sC_1}\right)}{R_2+R_3+\frac{1}{sC_1}} \rightarrow \frac{V_1}{V_{in}} = \frac{1}{1 + \frac{g_m R_2\left(R_3+\frac{1}{sC_1}\right)}{R_2+R_3+\frac{1}{sC_1}}}$$

$$\therefore \frac{V_{out}}{V_{in}} = \left(\frac{g_m R_2 R_3}{R_2+R_3+\frac{1}{sC_1}}\right)\left(\frac{R_2+R_3+\frac{1}{sC_1}}{R_2+R_3+\frac{1}{sC_1} + g_m R_2\left(R_3+\frac{1}{sC_1}\right)}\right)$$

$$= \frac{(g_m R_2 R_3)\, s}{s(R_2+R_3+g_m R_2 R_3) + \frac{1+g_m R_2}{C_1}} = \left(\frac{\frac{g_m R_2 R_3}{R_2+R_3}}{1 + \frac{g_m R_2 R_3}{R_2+R_3}}\right)\left(\frac{s}{s + \frac{1+g_m R_2}{C_1(R_2+R_3+g_m R_2 R_3)}}\right)$$

$$\therefore \boxed{\text{MBG} = \frac{\frac{g_m R_2 R_3}{R_2+R_3}}{1 + \frac{g_m R_2 R_3}{R_2+R_3}} = \frac{5}{6}}$$

Zero at s = 0

Pole at $s = \frac{-(1+g_m R_2)}{C_1(R_2+R_3+g_m R_2 R_3)} = -91.67$ rads/sec.

(b.) The asymptotic magnitude plot for $\frac{V_{out}(s)}{V_{in}(s)} = \frac{100\,s}{s+100}$ is shown below.