Homework Assignment No. 9 - Solutions

17.1

$A_V(s) = 25\dfrac{s^2}{(s+1)(s+20)}$ | $A_{mid} = 25$ | $F_L(s) = \dfrac{s^2}{(s+1)(s+20)}$ | Poles: $-1, -20$ | Zeros: 0,0

yes, $s = -20$ | $A_V(s) \approx 25\dfrac{s}{(s+20)}$ | $\omega_L = 20\dfrac{rad}{s}$ | $f_L = \dfrac{\omega_L}{2\pi} \cong \dfrac{20}{2\pi} = 3.18Hz$

$f_L = \dfrac{1}{2\pi}\sqrt{20^2 + 1^2 - 2(0)^2 - 2(0)^2} = 3.19Hz$

$|A_V(j\omega)| = \dfrac{25\omega^2}{\sqrt{\omega^2+1^2}\sqrt{\omega^2+20^2}}$ | MATLAB: -3.19 Hz

17.4

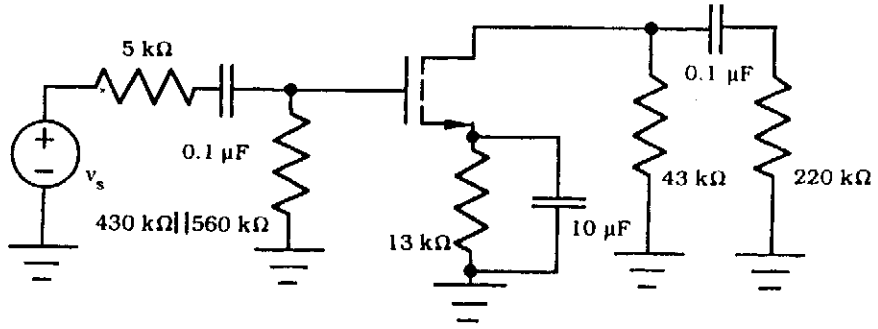
$A_V(s) = \dfrac{(2x10^{11})(10^{-4})(10^{-5})}{\left(\frac{s}{10^4}+1\right)\left(\frac{s}{10^5}+1\right)} = \dfrac{200}{\left(\frac{s}{10^4}+1\right)\left(\frac{s}{10^5}+1\right)}$ | $A_{mid} = 200$ | $F_H(s) = \dfrac{1}{\left(\frac{s}{10^4}+1\right)\left(\frac{s}{10^5}+1\right)}$

Poles: $-10^4, -10^5\ \dfrac{rad}{s}$ | Yes: $A_V(s) \approx \dfrac{200}{\frac{s}{10^4}+1}$ | $\omega_H = 10^4\dfrac{rad}{s}$ | $f_H \approx \dfrac{10^4}{2\pi} = 1.59kHz$

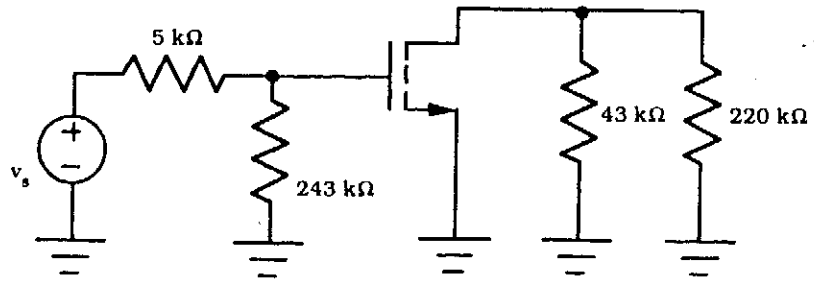
$$f_H \cong \frac{1}{2\pi}\left(\sqrt{\left(\frac{1}{10^4}\right)^2 + \left(\frac{1}{10^5}\right)^2 - 2\left(\frac{1}{\infty}\right)^2 - 2\left(\frac{1}{\infty}\right)^2}\right)^{-1} = 1.58\ kHz$$

$$|A_V(j\omega)| = \frac{2x10^{11}}{\sqrt{\omega^2+(10^4)^2}\sqrt{\omega^2+(10^5)^2}}$$ | MATLAB: 1.58 kHz

17.10



Low frequency:



17.10 Continued

Mid-band:

$$g_m = \frac{2I_{DS}}{V_{GS} - V_{TN}} = \frac{2(0.2\text{mA})}{1\text{V}} = 0.400\text{mS}$$

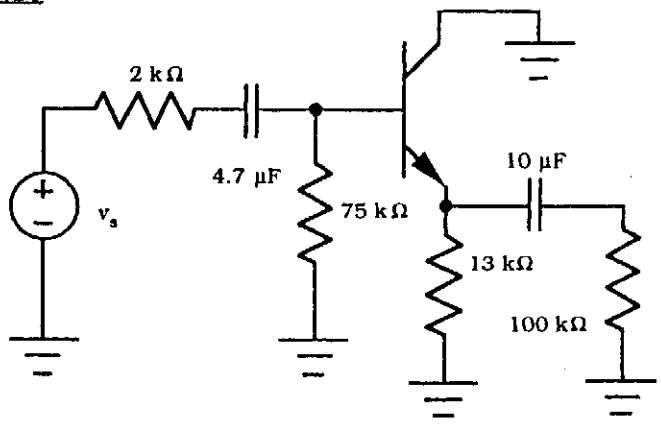
$$A_{mid} = -\frac{243\text{k}\Omega}{243\text{k}\Omega + 5\text{k}\Omega}(0.400\text{mS})(43\text{k}\Omega \| 220\text{k}\Omega) = -14.1$$

$$\omega_1 = \frac{1}{(10^{-7}\text{F})(243\text{k}\Omega + 5\text{k}\Omega)} = 40.3\frac{\text{rad}}{\text{s}} \quad | \quad \omega_2 = \frac{1}{(10^{-7}\text{F})(43\text{k}\Omega + 220\text{k}\Omega)} = 38.0\frac{\text{rad}}{\text{s}}$$

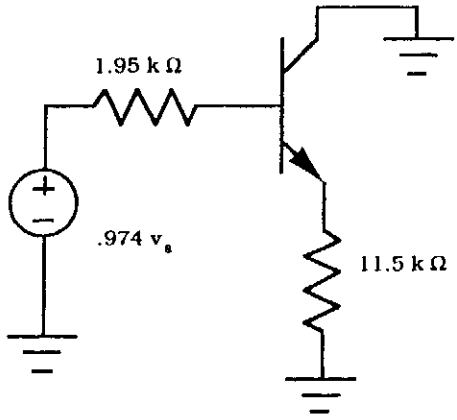
$$\omega_3 = \frac{1}{(10^{-5}\text{F})\left(13\text{k}\Omega \| \frac{1}{g_m}\right)} = \frac{1}{(10^{-5}\text{F})(13\text{k}\Omega \| 2.5\text{k}\Omega)} = 47.7\frac{\text{rad}}{\text{s}} \quad | \quad \omega_Z = \frac{1}{(10^{-5}\text{F})(13\text{k}\Omega)} = 7.69\frac{\text{rad}}{\text{s}}$$

Using Eq. (17.16): $f_L \cong \frac{1}{2\pi}\sqrt{(40.3)^2 + (38.0)^2 + (47.7)^2 - 2(7.69)^2} = 11.5\text{ Hz}$

17.16



Low frequency



Mid-band

(b) $v_{th} = \frac{75\text{k}\Omega}{75\text{k}\Omega + 2\text{k}\Omega} v_s = 0.974 v_s$ | $R_{th} = 75\text{k}\Omega \| 2\text{k}\Omega = 1.95\text{k}\Omega$ | $R_L = 13\text{k}\Omega \| 100\text{k}\Omega = 11.5\text{k}\Omega$

$$r_\pi = \frac{100}{40(0.25\text{mA})} = 10.0\text{k}\Omega \quad | \quad A_{mid} = 0.974\frac{101(11.5\text{k}\Omega)}{[1.95 + 10.0 + 101(11.5)]\text{k}\Omega} = 0.964$$

$$R_{1S} = R_S + R_B \| [r_\pi + (\beta_o + 1)R_L] = 2\text{k}\Omega + 75\text{k}\Omega \| [10.0\text{k}\Omega + (101)11.5\text{k}\Omega] = 72.5\text{k}\Omega$$

$$\omega_1 = \frac{1}{(72.5\text{k}\Omega)4.7\text{x}10^{-6}} = 2.94\frac{\text{rad}}{\text{s}}$$

$$R_{3S} = R_7 + R_4 \| \frac{R_{th} + r_\pi}{(\beta_o + 1)} = 100\text{k}\Omega + 13\text{k}\Omega \| \frac{1.95\text{k}\Omega + 10.0\text{k}\Omega}{101} = 100\text{k}\Omega$$

$$\omega_3 = \frac{1}{10^{-5}(10^5)} = 1\frac{\text{rad}}{\text{s}} \qquad f_L \approx \frac{(2.94 + 1)}{2\pi} = 0.627\text{Hz}$$
