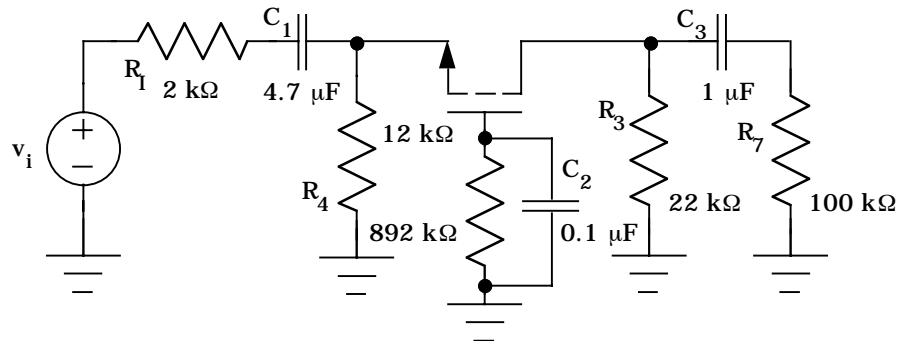


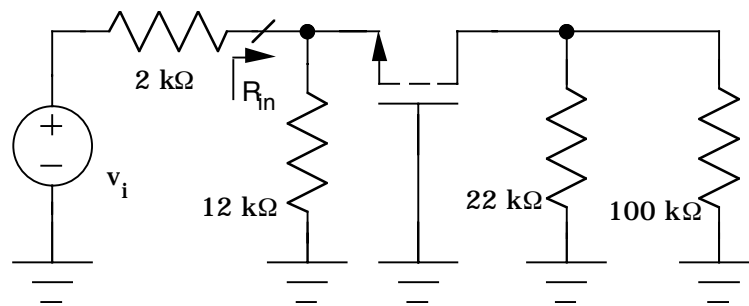
Homework Assignment No. 10 - Solutions

1.) Problem 17.21 (17.14) of the text.

Low Frequency:



Mid-band:



$$g_m = \frac{2(0.1mA)}{1V} = 0.200mS \quad | \quad \frac{1}{g_m} = 5000\Omega$$

$$R_{in} = R_s \parallel \frac{1}{g_m} = 12k\Omega \parallel 5k\Omega = 3.53k\Omega \quad | \quad R_L = 22k\Omega \parallel 100k\Omega = 18.0k\Omega$$

$$A_{mid} = \frac{R_{in}}{R_1 + R_{in}} g_m R_L = \frac{3.53k\Omega}{2k\Omega + 3.53k\Omega} (0.200mS)(18k\Omega) = 2.30 \quad (7.24dB)$$

$$\omega_1 = \frac{1}{C_1(R_1 + R_{in})} = \frac{1}{4.7 \times 10^{-6}(2k\Omega + 3.53k\Omega)} = 38.5 \frac{rad}{s} \quad | \quad \omega_2 = \text{doesn't matter since } i_s = 0!$$

$$\omega_3 = \frac{1}{C_3(R_3 + R_7)} = \frac{1}{10^{-7}(100k\Omega + 22k\Omega)} = 82.0 \frac{rad}{s} \quad | \quad f_L \cong \frac{1}{2\pi}(38.5 + 82.0) = 19.2Hz$$

2.) Problem 17.24 (17.17) of the text.

$$\text{SCTC requires: } \omega_L \cong \sum_{i=1}^3 \frac{1}{R_{is}C_i} = 2\pi(500) = 3140 \frac{\text{rad}}{\text{s}}$$

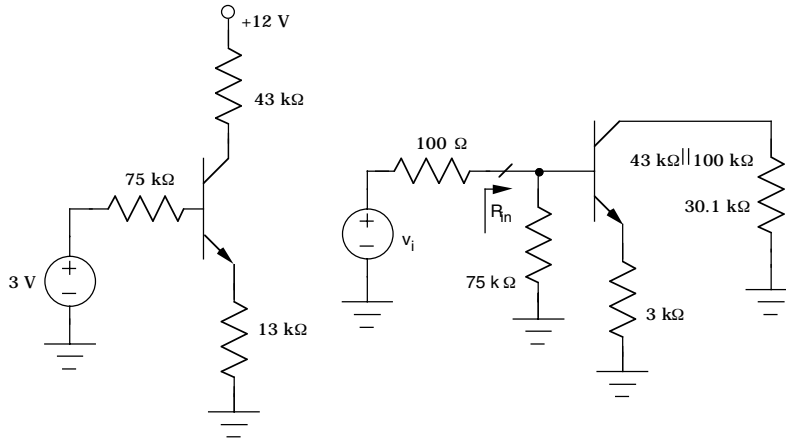
$$\omega_1 = \frac{1}{(10^{-7}F)(2.43M\Omega + 1k\Omega)} = 4.11 \frac{\text{rad}}{\text{s}} \quad | \quad \omega_2 = \frac{1}{(10^{-7}F)(43k\Omega + 1M\Omega)} = 9.59 \frac{\text{rad}}{\text{s}}$$

$$\omega_1 + \omega_2 \ll \omega_L \quad | \quad \omega_3 \text{ will be dominant} \rightarrow \omega_3 \cong \omega_L$$

$$\omega_3 = \frac{1}{C_3 \left(R_s \parallel \frac{1}{g_m} \right)} \quad | \quad g_m = \frac{2I_D}{V_{GS} - V_{TN}} = \frac{2(0.2\text{mA})}{1\text{V}} = 0.400\text{mS} \quad | \quad \frac{1}{g_m} = 2.50\text{k}\Omega$$

$$C_3 = \frac{1}{3140(13\text{k}\Omega \parallel 2.5\text{k}\Omega)} = 0.152 \mu\text{F} \rightarrow 0.15 \mu\text{F} \text{ from Appendix C}$$

3.) Problem 17.58 (17.41) of the text.



Short-Circuit Time Constants

$$R_{1S} = 100\Omega + 75\text{k}\Omega \parallel \left[300\Omega + 15.1\text{k}\Omega + 101(3\text{k}\Omega) \right] = 60.8\text{k}\Omega$$

$$R_{2S} = 43\text{k}\Omega + 100\text{k}\Omega = 143\text{k}\Omega$$

$$R_{3S} = 10\text{k}\Omega \parallel \left(3\text{k}\Omega + \frac{15.1\text{k}\Omega + 99.9\Omega}{101} \right) = 2.40\text{k}\Omega$$

$$f_L \approx \frac{1}{2\pi} \left[\frac{1}{(60.8\text{k}\Omega)(1\mu\text{F})} + \frac{1}{(143\text{k}\Omega)(0.1\mu\text{F})} + \frac{1}{(2.40\text{k}\Omega)(2.2\mu\text{F})} \right] = 43.9\text{Hz}$$

Open-Circuit Time Constants

Using the results from Table 17.2 on page 1334: $R_{th} + r_x = 99.9\Omega + 300\Omega = 400\Omega$

$$C_{TB} = \frac{3.02\text{pF}}{1 + (6.63\text{mS})(3\text{k}\Omega)} \left(1 + \frac{3\text{k}\Omega}{400\Omega} \right) + 0.5\text{pF} \left[1 + \frac{(6.63\text{mS})(30.1\text{k}\Omega)}{1 + (6.63\text{mS})(3\text{k}\Omega)} + \frac{30.1\text{k}\Omega}{400\Omega} \right]$$

$$C_{TB} = 44.1\text{pF} \quad | \quad f_H = \frac{1}{2\pi(400\Omega)(44.1\text{pF})} = 9.02\text{MHz}$$

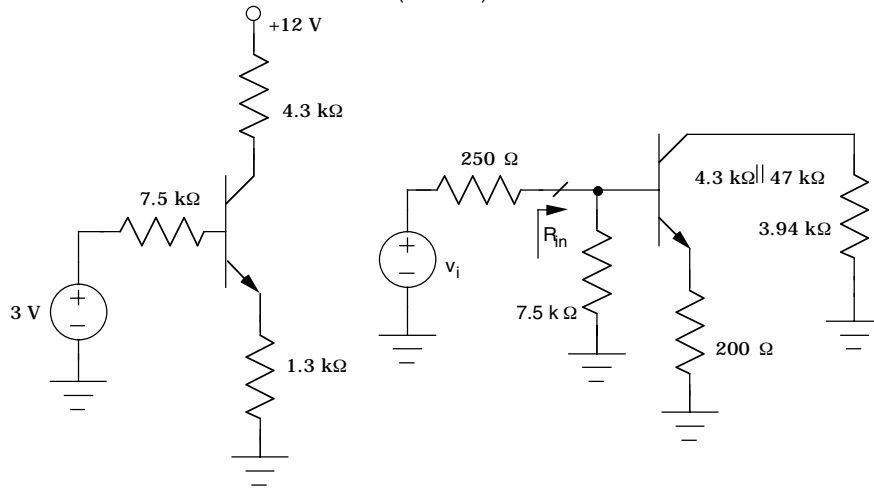
$$(b) \text{GBW} = 9.45(9.02\text{MHz} - 43.9\text{Hz}) = 85.2\text{MHz}$$

4.) Problem 17.60 (17.43) of the text

$$I_C = 100 \left[\frac{3 - 0.7}{7.5k\Omega + 101(1.3k\Omega)} \right] = 1.66mA \quad | \quad V_{CE} = 12 - 4.3k\Omega(I_C) - 1.3k\Omega \left(\frac{I_C}{\alpha_F} \right) = 2.69V$$

$$2.69V \geq 0.7V \quad \text{Active region operation is correct.} \quad | \quad r_\pi = \frac{100(0.025)}{1.66mA} = 1.51k\Omega$$

$$g_m = 40(1.66mA) = 66.4mS \quad | \quad C_\pi = \frac{66.4mS}{2\pi(2 \times 10^8)} - 1 = 51.8pF \quad | \quad r_x = 300\Omega \quad | \quad C_\mu = 1.0pF$$



$$R_{in} = R_1 \parallel R_2 \parallel [r_x + r_\pi + (\beta_o + 1)R_{E1}] = 10k\Omega \parallel 30k\Omega \parallel [0.300k\Omega + 1.51k\Omega + (101)200\Omega] = 5.59k\Omega$$

$$R_{th} = 7.5k\Omega \parallel 250\Omega = 242\Omega \quad | \quad R_L = 4.3k\Omega \parallel 47k\Omega = 3.94k\Omega$$

$$A_{mid} = - \frac{R_{in}}{R_I + R_{in}} \left[\frac{\beta_o R_L}{r_x + r_\pi + (\beta_o + 1)R_{E1}} \right] = - \frac{5.59k\Omega}{250\Omega + 5.59k\Omega} \left[\frac{100(3.94k\Omega)}{22.0k\Omega} \right] = -17.1$$

(b) Using the Short-Circuit Time Constants:

$$R_{1S} = 250\Omega + 7.5k\Omega \parallel [300\Omega + 1.51k\Omega + 101(200\Omega)] = 5.84k\Omega$$

$$R_{2S} = 4.3k\Omega + 43k\Omega = 47.3k\Omega$$

$$R_{3S} = 1.1k\Omega \parallel \left(200\Omega + \frac{1.51k\Omega + 300 + 242\Omega}{101} \right) = 184\Omega$$

$$f_L \cong \frac{1}{2\pi} \left[\frac{1}{(5.84k\Omega)(5\mu F)} + \frac{1}{(47.3k\Omega)(1\mu F)} + \frac{1}{(184\Omega)(4.7\mu F)} \right] = 193Hz$$

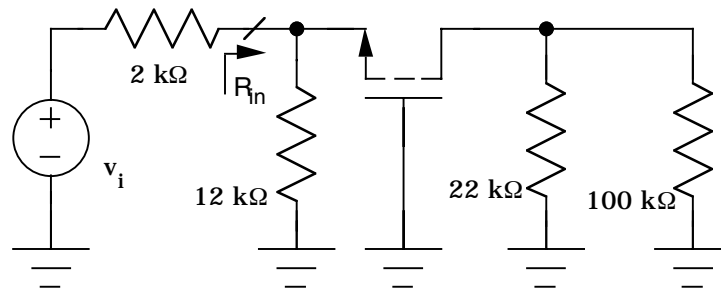
(c) Using the Open-Circuit Time Constants:

Using the results from Table 17.2 on page 1334: $R_{th} + r_x = 242\Omega + 300\Omega = 542\Omega$

$$C_{TB} = \frac{51.8pF}{1 + (66.4mS)(200\Omega)} \left(1 + \frac{200\Omega}{542\Omega} \right) + 1pF \left[1 + \frac{(66.4mS)(3.94k\Omega)}{1 + (66.4mS)(200\Omega)} + \frac{3.94k\Omega}{542\Omega} \right]$$

$$C_{TB} = 31.6pF \quad f_L = \frac{1}{2\pi(542\Omega)(31.6pF)} = 9.29MHz$$

5.) Problem 17.66 (17.48) of the text.



$$R_{th} = 12k\Omega \parallel 2k\Omega = 1.71k\Omega \quad | \quad R_L = 22k\Omega \parallel 100k\Omega = 18.0k\Omega \quad | \quad C_{GS} = 3.0pF \quad | \quad C_{GD} = 0.6pF$$

$$g_m = \frac{2(0.1mA)}{1V} = 0.2mS \quad | \quad R_{in} = 12k\Omega \parallel \frac{1}{g_m} = 12k\Omega \parallel \frac{1}{0.2mS} = 3.53k\Omega$$

$$A_{mid} = \frac{R_{in}}{R_i + R_{in}} g_m R_L = \frac{3.53k\Omega}{2k\Omega + 3.53k\Omega} (0.2mS)(18.0k\Omega) = +2.30$$

$$f_H = \frac{1}{2\pi} \left(\frac{1}{\frac{C_{GS}}{G_{th} + g_m} + C_{GD}R_L} \right) = \frac{1}{2\pi} \left(\frac{1}{\frac{3.0pF}{(0.5848 + 0.2)mS} + 0.6pF(18.0k\Omega)} \right) = 10.9 MHz$$