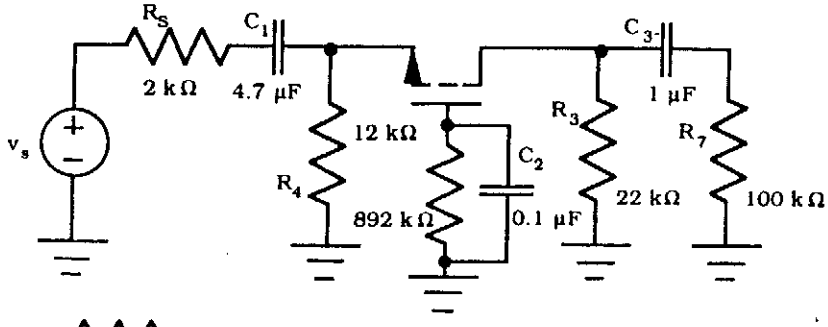
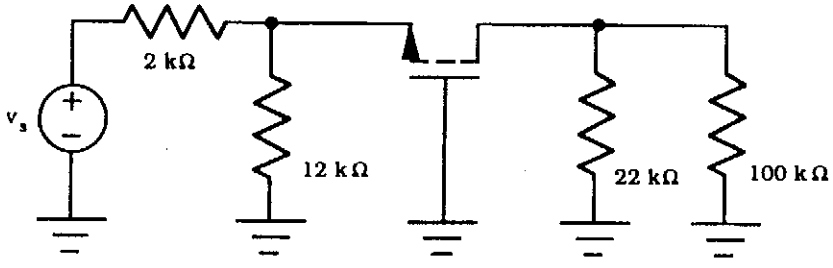
Homework Assignment No. 10 - Solutions

17.14



Low Frequency:



Mid-band:

$$g_m = \frac{2(0.1\text{mA})}{1\text{V}} = 0.200\text{mS} \quad | \quad \frac{1}{g_m} = 5000\Omega \quad | \quad v_{th} = \frac{12\text{k}\Omega}{12\text{k}\Omega + 2\text{k}\Omega} v_s = 0.857 v_s$$

$$R_{th} = 12\text{k}\Omega \| 2\text{k}\Omega = 1.71\text{k}\Omega \quad | \quad R_L = 22\text{k}\Omega \| 100\text{k}\Omega = 18.0\text{k}\Omega$$

$$A_{mid} = 0.857 \frac{R_L}{R_{th} + \frac{1}{g_m}} = 0.857 \frac{18.0\text{k}\Omega}{1.71\text{k}\Omega + 5\text{k}\Omega} = 2.30 \quad (7.24\text{dB})$$

$$\omega_1 = \frac{1}{4.7\text{x}10^{-6}(2\text{k}\Omega + 12\text{k}\Omega \| 5\text{k}\Omega)} = 38.5 \frac{\text{rad}}{\text{s}} \quad | \quad \omega_2 = \text{doesn't matter since } i_g = 0!$$

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

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

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

$\omega_1 + \omega_2 << \omega_L$ | ω_3 will be dominant $\rightarrow \omega_3 \equiv \omega_L$

$$\omega_3 = \frac{1}{C_3\left(R_4 \left\| \frac{1}{g_m}\right.\right)} \quad | \quad g_m = \frac{2I_{DS}}{V_{GS} - V_{TN}} = \frac{2(0.2\text{mA})}{1\text{V}} = 0.400\text{mS} \quad | \quad \frac{1}{g_m} = 2.50\text{k}\Omega$$

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

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$$C_\pi = g_m\tau_F \;\mid\; C_\pi = \frac{g_m}{\omega_T} - C_\mu \;\mid\; V_{CB} = 5 - 0.7 = 4.3V \;\mid\; C_\mu = \frac{C_{\mu o}}{\sqrt{1+\dfrac{V_{CB}}{\phi_{jc}}}} = \frac{2pF}{\sqrt{1+\dfrac{4.3V}{0.9V}}} = 0.832pF$$

$$C_\pi = \frac{40\left(2x10^{-3}\right)}{2\pi\left(5x10^{8}\right)} - 0.832pF = 24.6\ pF \;\mid\; \tau_F = \frac{C_\pi}{g_m} = \frac{24.6x10^{-12}}{40\left(2x10^{-3}\right)} = 0.308ns = 308\ ps$$

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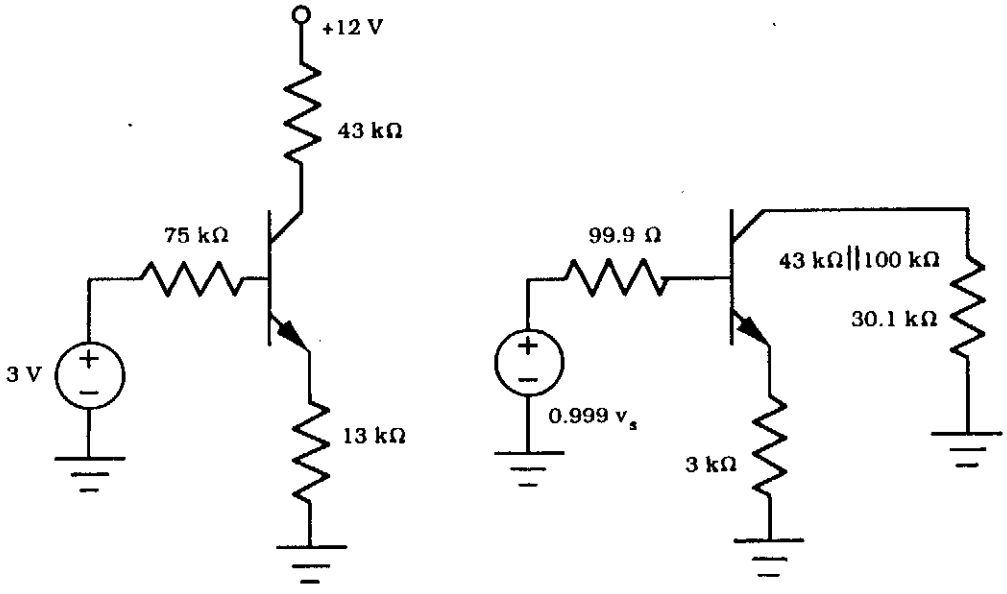


$$I_B = \frac{3-0.7}{75k\Omega + 101(13k\Omega)} = 1.657\mu A \;\mid\; I_C = 166\mu A \;\mid\; V_{CE} = 12 - 43k\Omega(I_C) - 13k\Omega\left(\frac{I_C}{\alpha_F}\right) = 2.70V$$

$2.70V \geq 0.7V$ Forward - active region is correct. $\mid\; r_\pi = \dfrac{100(0.025)}{0.166\ mA} = 15.1\ k\Omega$

$$g_m = 40(0.166\ mA) = 6.63mS \;\mid\; C_\pi = \frac{6.63mS}{2\pi\left(3x10^{8}\right)} - 0.5 = 3.02\ pF \;\mid\; r_x = 300\Omega \;\mid\; C_\mu = 0.5pF$$

$$\mathbf{v_{th}} = \frac{75k\Omega}{75k\Omega + 100\Omega}\mathbf{v_s} = 0.999\mathbf{v_s} \;\mid\; R_{th} = 75k\Omega\|100\Omega = 99.9\Omega \;\mid\; R_L = 43k\Omega\|100k\Omega = 30.1k\Omega$$

$$A_{mid} = 0.999\frac{-100(30.1k\Omega)}{99.9\Omega + 300\Omega + 15.1k\Omega + 101(3k\Omega)} = -9.44$$

Short-Circuit Time Constants

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

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

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

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

Prob. 7.41- Continued

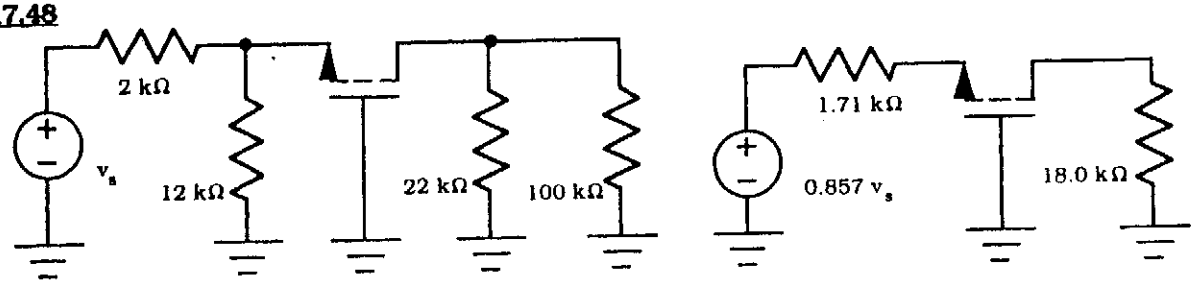
Open-Circuit Time Constants

Using the result in Table 17.2 on page 944: $R_{th} + r_x = 99.9\Omega + 300\Omega = 400\Omega$

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

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

17.48



$$v_{th} = \frac{12\text{k}\Omega}{12\text{k}\Omega+2\text{k}\Omega}v_s = 0.857v_s \;\mid\; R_{th} = 12\text{k}\Omega\|2\text{k}\Omega = 1.71\text{k}\Omega \;\mid\; R_L = 22\text{k}\Omega\|100\text{k}\Omega = 18.0\text{k}\Omega$$

$$g_m = \frac{2(0.1\text{mA})}{1\text{V}} = 0.2\text{mS} \;\mid\; C_{GS} = 3.0\text{pF} \;\mid\; C_{GD} = 0.6\text{pF}$$

$$A_{mid} = 0.857\frac{R_L}{R_{th}+\dfrac{1}{g_m}} = 0.857\frac{18.0\text{k}\Omega}{1.71\text{k}\Omega+\dfrac{1}{0.2\text{mS}}} = +2.30$$

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