Electronics II, Spring 2019 Exam1 Solution 2019/3/29

#1

a.

$$R_{TH} = R_1 \| R_2 = 10 \| 1.5 = 1.304 \text{ k}\Omega$$

$$V_{TH} = \left(\frac{R_2}{R_1 + R_2} \right) V_{CC} = \left(\frac{1.5}{1.5+10} \right)(12) = 1.565 \text{ V}$$

$$I_{BQ} = \frac{1.565 - 0.7}{1.30 + (101)(0.1)} = 0.0759 \text{ mA}$$

$$I_{CQ} = 7.585 \text{ mA}$$

$$r_\pi = \frac{(100)(0.026)}{7.59} = 0.343 \text{ k}\Omega$$

$$g_m = \frac{7.59}{0.026} = 292 \text{ mA/V}$$

$$R_i = R_1 \| R_2 \| [r_\pi + (1+\beta) R_E]$$

$$= 10 \| 1.5 \| [0.343 + (101)(0.1)]$$

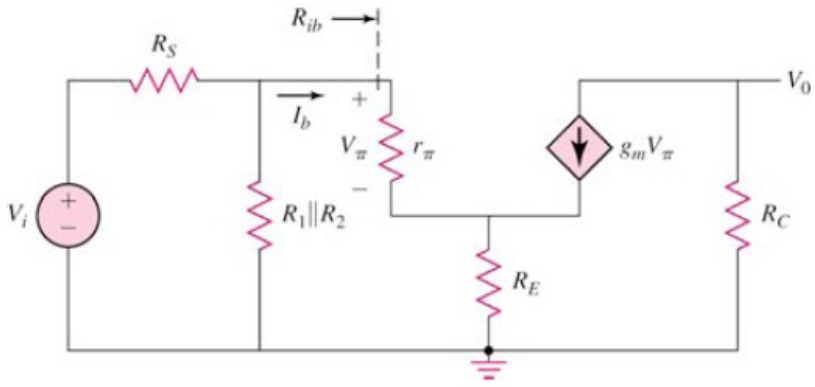
$$= 1.30 \| 10.44 \Rightarrow R_i = 1.159 \text{ k}\Omega$$

$$\tau = (R_S + R_i) C_C = (0.5 + 1.16) \times 10^3 \times (0.1 \times 10^{-6})$$

$$\tau = 1.659 \times 10^{-4} \text{ s}$$

$$f_L = \frac{1}{2\pi\tau} = \frac{1}{2\pi(1.66 \times 10^{-4})} \Rightarrow f_L = 959 \text{ Hz}$$

b.



$$V_0 = -(\beta I_b) R_C$$

$$R_{1b} = r_\pi + (1+\beta) R_E$$

$$= 0.343 + (101)(0.1) = 10.44 \text{ k}\Omega$$

$$I_b = \left(\frac{R_1 \| R_2}{R_1 \| R_2 + R_{ib}} \right) I_i$$

$$= \left(\frac{1.30}{1.30 + 10.4} \right) I_i = (0.111) I_i$$

$$I_i = \frac{V_i}{R_S + R_1 \| R_2 \| R_{ib}}$$

$$= \frac{V_i}{0.5 + (1.3) \| (10.44)}$$

$$I_i = \frac{V_i}{1.659}$$

$$\left| \frac{V_0}{V_i} \right| = \frac{\beta R_C (0.111)}{1.659} \Rightarrow \left| \frac{V_0}{V_i} \right|_{\text{midband}} = \frac{(100)(1)(0.111)}{1.659} \Rightarrow \underline{\left| \frac{V_0}{V_i} \right|_{\text{midband}} = 6.69}$$

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(2)

$$V_G = \left(\frac{R_2}{R_1 + R_2} \right)(20) - 10 = \left(\frac{22}{22+8} \right)(20) - 10$$

$$V_G = 4.67 \text{ V}$$

$$I_D = \frac{10 - V_{SG} - 4.67}{R_S} = K_P (V_{SG} + V_{TP})^2$$

$$5.33 - V_{SG} = (1)(0.5)\left(V_{SG}^2 - 4V_{SG} + 4\right)$$

$$0.5V_{SG}^2 - V_{SG} - 3.33 = 0$$

$$V_{SG} = \frac{1 \pm \sqrt{1 + 4(0.5)(3.33)}}{2(0.5)} \Rightarrow V_{SG} = 3.77 \text{ V}$$

$$g_m = 2K_p\left(V_{SG} + V_{TP}\right) = 2(1)(3.77 - 2)$$

$$g_m = 3.54 \ mA/V$$

b.

$$C_M = C_{gdT}\left(1 + g_m\left(R_D \| R_L\right)\right)$$

$$C_M = (3)\left[1 + (3.54)(2 \| 5)\right] \Rightarrow \underline{C_M = 18.2 \text{ pF}}$$

a.

$$r = R_{eq}\left(C_{gsT} + C_M\right)$$

$$R_{eq} = R_i \| R_1 \| R_2 = 0.5 \| 8 \| 22 = 0.461 \text{ k}\Omega$$

$$r = \left(0.461 \times 10^3\right)(15 + 18.2) \times 10^{-12}$$

$$= 1.53 \times 10^{-8} \text{ s}$$

$$f_H = \frac{1}{2\pi r} \Rightarrow \underline{f_H = 10.4 \text{ MHz}}$$

c.

$$V_0 = -g_m V_{gs}\left(R_D \| R_L\right)$$

$$V_{gs} = \left(\frac{R_1 \| R_2}{R_1 \| R_2 \| R_i}\right) V_i = \left(\frac{5.87}{5.87 + 0.5}\right) V_i \Rightarrow V_{gs} = (0.9215) V_i$$

$$A_v = -(3.54)(0.9215)(2 \| 5) \Rightarrow \underline{A_v = -4.66}$$

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(3)

$$r_H = \left(R_L \| R_C\right) C_L = (10 \| 5) \times 10^3 \times 15 \times 10^{-12}$$

$$r_H = 5 \times 10^{-8} \text{ s}$$

$$f_H = \frac{1}{2\pi r_H} = \frac{1}{2\pi\left(5 \times 10^{-8}\right)} \Rightarrow \underline{f_H = 3.18 \text{ MHz}}$$

$$I_{EQ} = \frac{10 - 0.7}{10} = 0.93 \text{ mA}, \ I_{CQ} = 0.921 \text{ mA}$$

$$g_m = \frac{0.921}{0.026} = 35.4 \text{ mA/V}$$

$$A_v = g_m\left(R_C \| R_L\right) = 35.4(5 \| 10) \Rightarrow \underline{A_v = 118}$$