Electronics II Exam-1 Solution 2022

(1)

$$R_{TH} = R_1 \| R_2 = 1.2 \| 1.2 = 0.6\ k\Omega$$

$$V_{TH} = \left(\frac{R_2}{R_1 + R_2}\right)(V_{CC}) = \left(\frac{1.2}{1.2+1.2}\right)(5) = 2.5\ V$$

$$I_{BQ} = \frac{2.5-0.7}{0.6+(101)(0.05)} = 0.319\ mA$$

$$I_{CQ} = 31.9\ mA$$

$$r_\pi = \frac{(100)(0.026)}{31.9} = 0.0815\ k\Omega$$

$\tau_{C_{C1}} >> \tau_{C_{C2}}$ and $f = \dfrac{1}{2\pi\tau}$ so that $f_{3-dB}(C_{C1}) << f_{3-dB}(C_{C2})$

Then, for $f_{3-dB}(C_{C1}) \Rightarrow C_{C2}$ acts as an open and for $f_{3-dB}(C_{C2}) \Rightarrow C_{C1}$ acts as a short circuit.

$f_{3-dB}(C_{C2}) = 25\ Hz = \dfrac{1}{2\pi\tau_2}$, so that $\tau_2 = \dfrac{1}{2\pi(25)} = 0.006366\ s = R_{eq}C_{C2}$

where

$$R_{eq} = R_L + R_E \left\| \left(\frac{r_\pi + R_1 \| R_2 \| R_S}{1+\beta}\right)\right.$$

$$= 10 + 50 \left\| \left(\frac{81.5 + 600 \| 300}{101}\right)\right. = 10 + 50 \| 2.787 \Rightarrow$$

$$R_{eq} = 12.64\ \Omega \Rightarrow C_{C2} = \frac{0.00637}{12.6} \Rightarrow \underline{C_{C2} = 504\ \mu F}$$

$R_{ib} = r_\pi + (1+\beta)R_E$ Assume C_{C2} an open

$$R_{ib} = 81.5 + (101)(50) = 5132\ \Omega$$

$$\tau_1 = (100)\tau_2 = (100)(0.006366) = 0.6366\ s = R_{eq1}C_{C1}$$

$$R_{eq1} = R_S + R_{TH} \| R_{ib} = 300 + 600 \| 5132 = 837.2\ \Omega$$

So $C_{C1} = \dfrac{0.6366}{837.2} \Rightarrow \underline{C_{C1} = 760\ \mu F}$

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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.

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

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

$$r = \left(0.461\times10^3\right)(15 + 18.2)\times10^{-12}$$

$$= 1.53\times10^{-8} \text{ s}$$

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

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)

dc analysis

$$I_D = \frac{V^+ - V_{SG}}{R_S} = K_P\left(V_{SG} + V_{TP}\right)^2$$

$$5 - V_{SG} = (1)(4)\left(V_{SG} - 0.8\right)^2$$

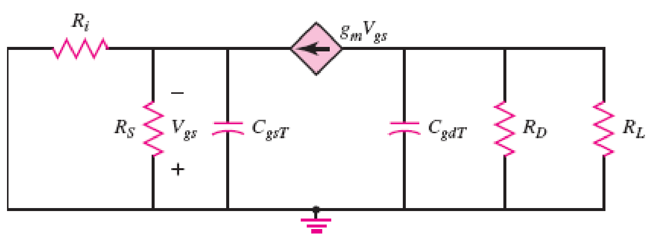
$$= 4\left(V_{SG}^2 - 1.6V_{SG} + 0.64\right)$$

$$4V_{SG}^2 - 5.4V_{SG} - 2.44 = 0$$

$$V_{SG} = \frac{5.4 \pm \sqrt{(5.4)^2 + 4(4)(2.44)}}{2(4)} = 1.707$$

$$g_m = 2K_P\left(V_{SG} + V_{TP}\right) = 2(1)(1.707 - 0.8)$$

$$g_m = 1.81\ mA/V$$



$3\text{-}dB$ frequency due to C_{gsT} : $R_{eq} = \frac{1}{g_m}\|R_S\|R_i$

$$f_A = \frac{1}{2\pi R_{eq} \cdot C_{gsT}}$$

$$R_{eq} = \frac{1}{1.81} \| 4 \| 0.5 = 0.246 \text{ k}\Omega$$

$$f_A = \frac{1}{2\pi(246)(4\times 10^{-12})} = 162 \text{ MHz}$$

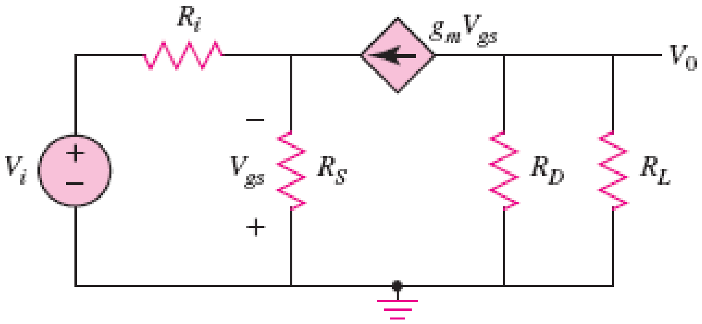
$3-dB$ frequency due to C_{gdT}

$$f_B = \frac{1}{2\pi(R_D \| R_L) C_{gdT}}$$

$$= \frac{1}{2\pi(2\|4)\times 10^{3} \times 10^{-12}}$$

$\underline{f = 119 \text{ MHz}}$

Midband gain



$$V_{gs} = \frac{-\frac{1}{g_m} \| R_S}{\frac{1}{g_m} \| R_S + R_i} \cdot V_i = \frac{-\frac{1}{1.81} \| 4}{\frac{1}{1.81} \| 4 + 0.5} \cdot V_i$$

$$= -0.492 V_i$$

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

$$A_v = (0.492)(1.81)(4\|2) \Rightarrow \underline{A_v = 1.19}$$