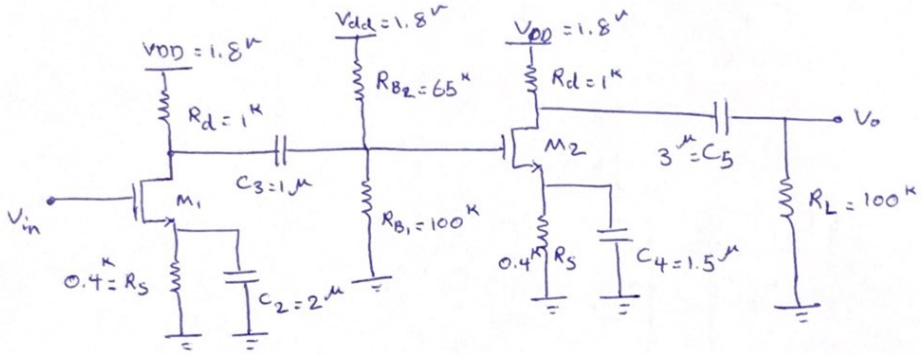
بالطیف

رضا دینی‌نیا
۹۸۱۴۳۰۳
تمرین سری ۲ ، الف ۳

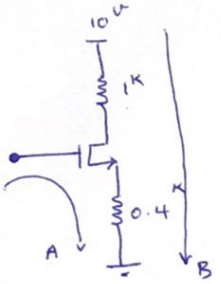


$|V_{th}| = 2^V$ فرض شده

$K' = 2$

$$\begin{cases} W_{1,2} = 28\ \mu m \\ L_{1,2} = 180\ nm \end{cases} \rightarrow \frac{W}{L} = 155$$

dc Analysis:



فرض شده $\rightarrow 5^V$

KVL @ A : $-1 + V_{gs_1} + 0.4^K I_{D_1} = 0$

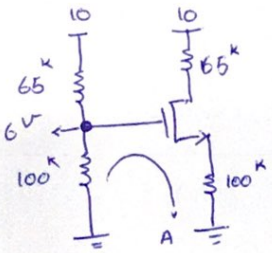
$$\Rightarrow \boxed{V_{gs_1} = 5 - 0.4^K I_{D_1}} \quad (I)$$

$$I_D = \frac{K'}{2}\frac{W}{L}(V_{GS_1} - V_{th})^2 = \frac{2}{2}\cdot\frac{1400}{9}\left(5 - 0.4^K I_D - 2\right)^2$$

$$\Rightarrow \begin{cases} I_D = 8^{mA} \\ \boxed{I_D = 7^{mA}} \checkmark \end{cases} \rightarrow \overset{2.2}{\uparrow}\ V_{GS} - V_{th} \overset{!}{\downarrow} 2$$

KVL @ B : $-10 + 1^K(7^m) + V_{DS} + 0.4^K(7^m) = 0 \Rightarrow V_{DS} = 10 - 7 - 2.8 = 0.2$

$$g_{m_1} = \frac{2I_{D_1}}{V_{gs_1} - V_{th}} = \frac{2\times 7}{2.2 - 2} = \boxed{70^{mmho}} \qquad \boxed{r_{ds} = r_o = \infty}$$



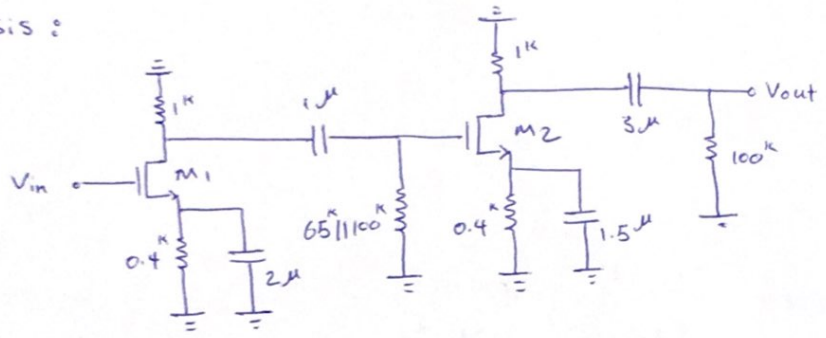
$$V_G = \frac{100}{100+65}\times 10 = 6^V$$

KVL @ A : $-6 + V_{gs_2} + 100^K I_{D_2} = 0 \Rightarrow V_{gs_2} = 6 - 100^K I_{D_2}$

$$\Rightarrow I_{D_2} = \frac{K_2'}{2}\frac{W}{L}\left(V_{gs_2} - V_{th}\right)^2 = \frac{1400}{9}\left[6 - 100^K I_{D_2} - 2\right]^2 \rightarrow \begin{cases} I_D = 0.04^{mA} \\ I_D = 0.03^{mA} \checkmark \end{cases}$$

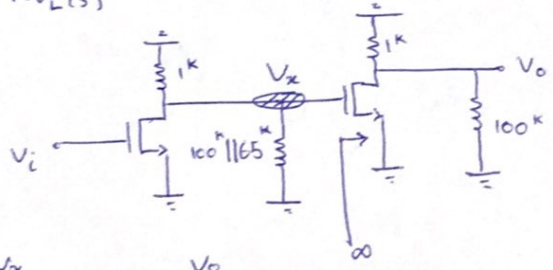
$$I_{D_2} = 0.09^{mA} \longrightarrow g_{m_2} = \frac{2\times 0.09}{3-2} = \boxed{0.06^{mmho}}$$

ac analysis :



$A_{V_{eq}}(s) = A_{V_o} \cdot A_{V_L(s)}$

$A_{V_o} = ?$



$$A_{V_o} = \frac{V_o}{V_x} \times \frac{V_x}{V_i} \quad \Rightarrow \quad \frac{V_o}{V_x} = 2 \rightarrow -g_{m2} R_D = -0.06\left[100^K \| 1^K\right] \approx \boxed{-0.06}$$

$$\frac{V_x}{V_i} = -g_{m_1} R_D = -70\left(100^K \| 65^K \| 1^K\right) \approx -70 \quad \Rightarrow \quad A_{V_o} = -70(0.06) = \boxed{4.2}$$

$$A_{V_L(s)} = \frac{(s+z_1)(s+z_2)(s+z_3)(s+z_4)}{(s+p_1)(s+p_2)(s+p_3)(s+p_4)}$$

$$p_1 = \frac{1}{\tau_1} = \frac{1}{R_{th} C_{th}} = \frac{1}{\left[\frac{1}{g_{m_1}} \| 0.4^K\right] C_{TH}} = \frac{1}{2^\mu \cdot (14^K)} = 35.71^{KHZ}$$

$$p_2 = \frac{1}{\tau_2} = \frac{1}{R_{TH} C_{TH}} = \frac{1}{C_{TH} \cdot \left[1^K + 65^K \| 100^K\right]} = \frac{1}{1^\mu \times 40^K} = 25^{HZ}$$

$$p_3 = \frac{1}{\tau_3} = \frac{1}{R_{TH} C_{TH}} = \frac{1}{C_{TH}\left(0.4^K \| \frac{1}{g_{m2}}\right)} = \frac{1}{1.5^\mu \times 0.4^K} = 1.6^{KHZ}$$

$$p_4 = \frac{1}{\tau_4} = \frac{1}{R_{TH} C_{TH}} = \frac{1}{C_{TH}\left(1^K + 100^K\right)} = \frac{1}{3^\mu \times 101^K} = 303^{HZ}$$

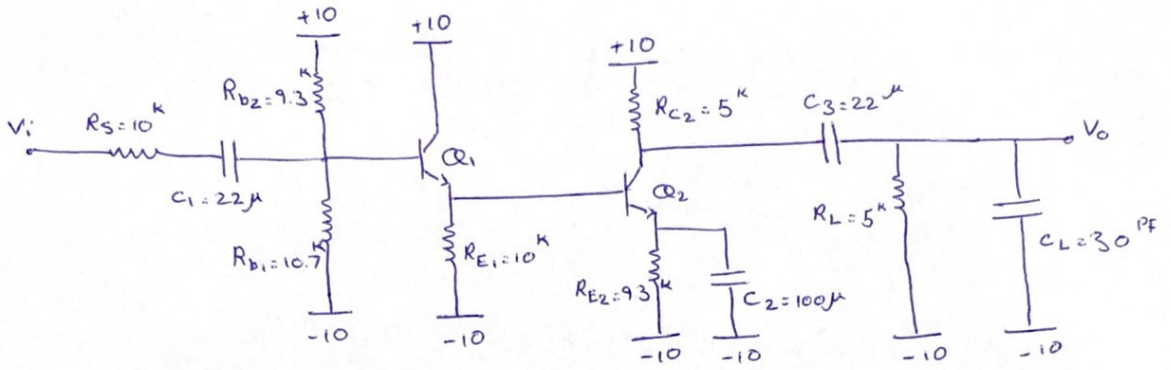
$$z_1 = \frac{1}{0.4} + 2^\mu s = 0 \quad \Rightarrow \quad s = -1.25^{KHZ}$$

$$z_2 = \frac{1}{0.4} + 1.5^\mu s = 0 \quad \Rightarrow \quad s = -1.6^{KHZ}$$

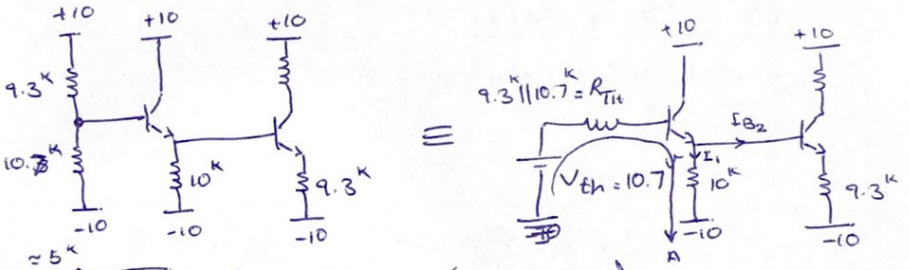
$$\Rightarrow A_{V_L(s)} = \frac{s^2\left((s-1.25^K)(s-1.6^K)\right)}{(s+25)(s+303)(s+1.6^K)(s+35.71^K)}$$

$$\Rightarrow A_{V(s)} = A_{V_o} \cdot A_{V_L(s)} = 4.2 \times \frac{s^2\left[(s+1.25^K)(s-1.6^K)\right]}{(s+25)(s+303)(s+1.6^K)(s+35.71)}$$

$\beta = 100$



dc analysis :



KVL @ A: $-10.7 + \overbrace{(9.3^K \| 10.7^K)}^{\approx 5^K} \cdot \frac{I_{C_1}}{100} + 0.7 + 10\left(I_{C_1} - \frac{I_{C_2}}{100}\right) - 10 = 0$

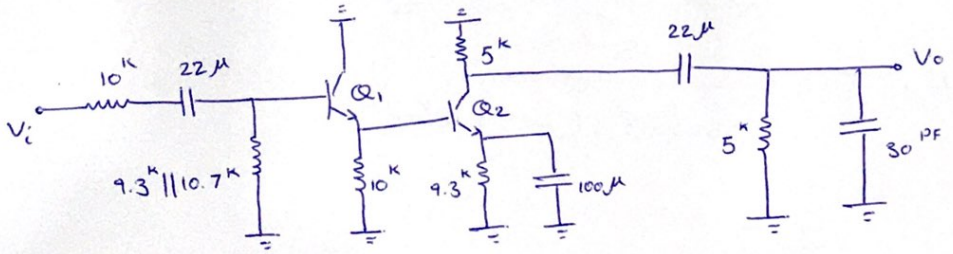
$\Rightarrow -10.7 + \frac{5 I_{C_1}}{100} + 0.7 + 10 I_{C_1} - \frac{I_{C_2}}{10} - 10 = 0 \Rightarrow \boxed{10.05 I_{C_1} - 0.1 I_{C_2} = 20}$ (I)

KVL @ B: $-10.7 + 5^K \cdot \frac{I_{C_1}}{100} + 0.7 + 0.7 + 9.3^K I_{C_2} - 10 = 0$

$\Rightarrow \boxed{0.05 I_{C_1} + 9.3 I_{C_2} = 19.3}$ (II) $\xrightarrow{\text{(I) , (II)}}$ $\begin{cases} I_{C_1} = 2.01^{mA} \\ I_{C_2} = 2.06^{mA} \end{cases}$

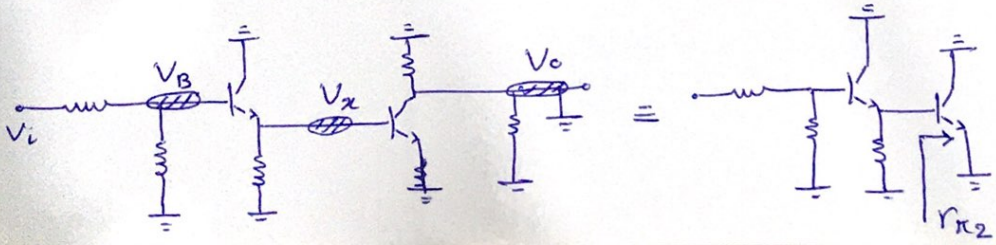
$\begin{cases} r_{\pi_1} = \frac{\beta}{g_{m_1}} = \frac{100}{80.4} = 1.24^K \\ g_{m_1} = 40 I_{C_1} = 80.4^{mmho} \end{cases}$, $\begin{cases} g_{m_2} = 40(2.06) = 82.4^{mmho} \\ r_{\pi_2} = \frac{\beta}{g_{m_2}} = \frac{100}{82.4} = 1.21^{K\Omega} \end{cases}$

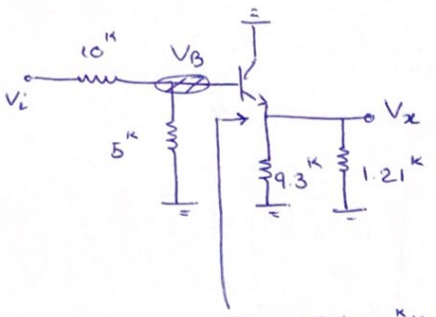
ac Analysis :



$A_{V(S)} = A_{V_o} \times A_{V_L(S)}$

A_{V_o} :





$$A_{V_o} = \frac{V_x}{V_B} \times \frac{V_B}{V_i} = \left[\frac{1.21 \| 9.3}{(1.21 \| 9.3) + \frac{1}{80.4}}\right] \times \left[\frac{5^K \| 108.24}{(5^K \| 108.4) + 10^K}\right]$$

$$= 0.3$$

$$r_{\pi_1} + \beta(9.3^K \| 1.21^K) \simeq 1.24^K + 100(1.07^K) \simeq 108.24^K$$

$$A_{V_L}(s) = \frac{(S+Z_1)(S+Z_2)(S+Z_3)(S+Z_4)}{(S+P_1)(S+P_2)(S+P_3)(S+P_4)}$$

$$P_1 = \frac{1}{\tau_1} = \frac{1}{R_{th} C_{th}} = \frac{1}{C_{th} \cdot [10^K + 9.3^K \| 10.7^K \| 108.24^K]} = \frac{1}{22^\mu \times 14.75^K} = 3.08^{HZ}$$

$$P_2 = \frac{1}{\tau_2} = \frac{1}{R_{th} C_{th}} = \frac{1}{100^\mu \cdot [9.3^K \| \frac{1}{82.4}]} = \frac{1}{100^\mu \times 12} = 1^{KHZ}$$

$$P_3 = \frac{1}{\tau_3} = \frac{1}{R_{th} C_{th}} = \frac{1}{(22^\mu + 30^P) \cdot [5^K + 5^K]} = \frac{1}{20^\mu \times 10^K} = 5^{HZ}$$

$$P_4 = \frac{1}{\tau_4} = \frac{1}{R_{th} C_{th}} = P_3 = 5^{HZ}$$

$$Z_1 = \frac{1}{9.3^K} + 100^\mu S = -1^{HZ} \Rightarrow A_{V_L}(s) = \frac{S^3 \cdot (S+1)}{(S+3.08)(S+5)(S+1^K)(S+5)}$$

$$\Rightarrow A_V = 0.3 \cdot \frac{S^3 \cdot (S+1)}{(S+3.08)(S+5)^2 (S+1^K)}$$