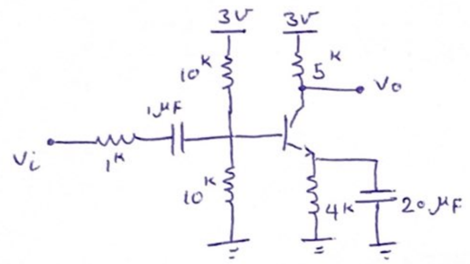
یا لطیف

رضا ادیب پور

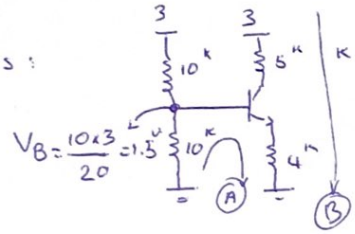
۹۸۱۴۳۰۳

تمرین سری ۳ الک ۳

#1



dc Analysis:

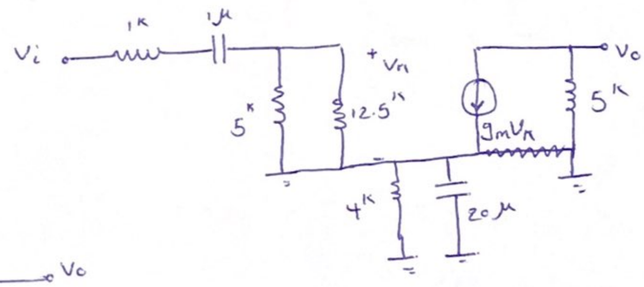


KVL(A): $-1.5+0.7+10^k\|10^k\left(\frac{I_c}{100}\right)+4^k I_c=0$

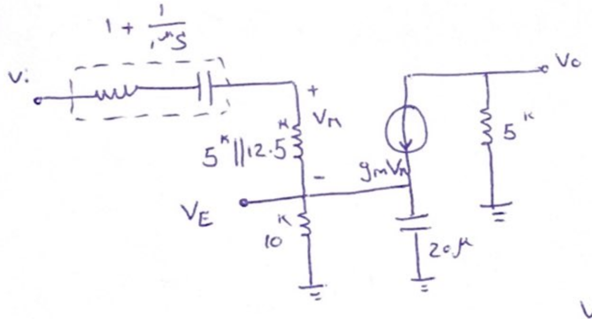
$\Rightarrow I_c\left(\frac{5}{100}+4\right)=0.8 \Rightarrow \boxed{I_c=0.2^{mA}}$

KVL in (B): $-3+5^k(0.2^m)+V_{CE}+4^k(0.2^m)=0 \Rightarrow V_{CE}=3-1-0.8=1.2>V_{CE,sat}$

$\begin{cases} g_m=40I_c=40\times0.2=8\ \text{mmho} \\ r_\pi=\frac{100}{8}=12.5^k \end{cases}$



$\Rightarrow$



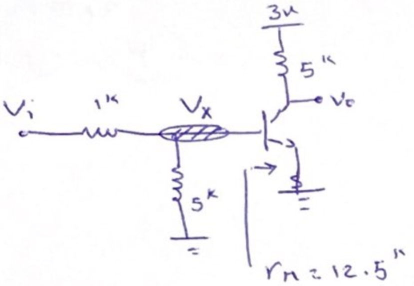
kcl in Vo: $-g_mV_\pi+\frac{V_o}{5^k}=0 \Rightarrow V_\pi=\frac{\frac{V_o}{5^k}}{8^m} \Rightarrow \boxed{V_\pi=\frac{V_o}{40}}$ (II)

kcl in VE: $-g_m\left(\frac{V_o}{40}\right)+20^\mu S(V_E)+\frac{V_E}{10^k}+\frac{V_E}{5^k\|12.5^k}-\frac{V_o}{40(5^k\|12.5^k)}=0$

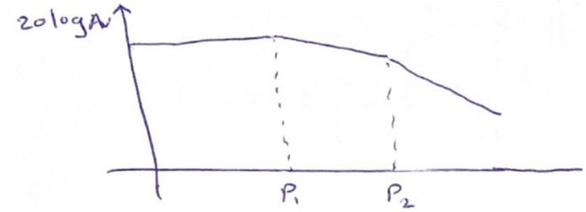
$\Rightarrow V_E\left(20^\mu S+\frac{1}{10^k}+\frac{1}{5^k\|12.5^k}\right)=V_o\left(\frac{-8}{40}+\frac{1}{40(5^k\|12.5)}\right) \Rightarrow \boxed{V_E=\frac{-0.193}{0.38^k+20^\mu S}V_o}$ (I)

kcl in Vπ: $\frac{V_\pi-V_E}{5^k\|12.5^k}+\frac{V_\pi-V_i}{1+\frac{1}{1^\mu S}}=0 \xrightarrow{(I)} 0.007V_o-\frac{1}{5\|12.5}\left(\frac{-0.193V_o}{0.38^k+20^\mu S}\right)$

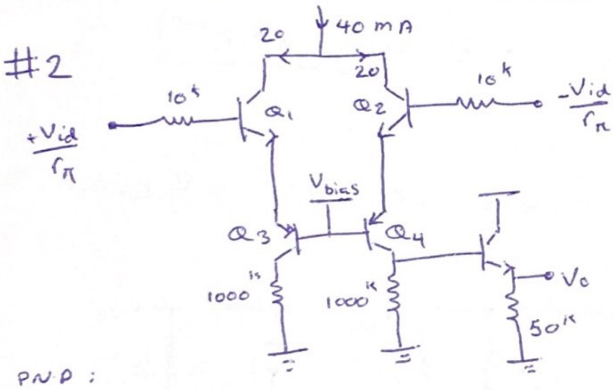
$+\frac{1}{1+\frac{1}{1^\mu S}}\left(\frac{V_o}{40}\right)-\frac{V_i}{1+\frac{1}{1^\mu S}}=0 \Rightarrow \frac{V_o}{V_i}(S)=\frac{(S+10^6)}{\frac{5\times10^{-6}S^3+9.55S^2+5700}{(S+10^6)(20\times10^{-6}S+380)}+0.007}$



$$A_{v_o} = \frac{V_o}{V_x} \times \frac{V_x}{V_i} = -8(5^k) \times \left[\frac{5^k \| 12.5^k}{(5^k \| 12.5^k)+5}\right] \simeq \boxed{-16.6}$$



#2



npn: $\beta = 250$, $C_{jco} = C_{jeo} = 0.3\,PF$, $C_{cs} = 0.5\,PF$

$V_b = 0.8V$, $\tau_F = 1^{ns}$, $V_A = 120V$

PnP: $\beta = 100$, $C_{jco} = C_{jeo} = 0.3\,PF$, $V_b = 0.8V$, $\tau_F = 10^{ns}$

$V_A = 50V$

PNP:

$C_{je} = 2C_{jeo} = 0.6\,PF$

$C_b = g_m \tau_F = 40\left(\frac{40^{mA}}{2}\right) \times 10^{ns} = 800^{PF}$

$C_\pi = C_{je} + C_b \simeq 8^{nF}$

$C_{jc} = C_\mu = \frac{C_{jco}}{\sqrt[2]{1 + \frac{V_{cb}}{V_b}}} = \frac{0.3^{PF}}{\sqrt{1+1}} = 0.21^{PF}$

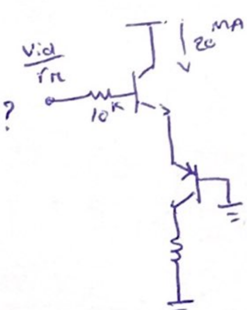
npn:

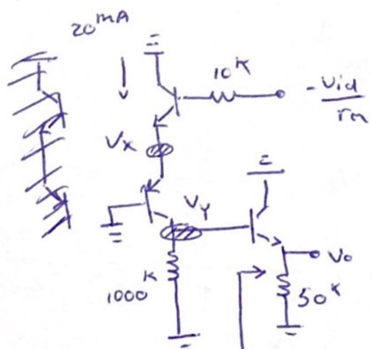
$C_{je} = 2C_{jeo} = 0.6\,PF$

$C_\pi = C_{je} + g_m\tau_F = 0.6 + 40\left(\frac{40}{2}\right) \times 1 = 8.6^{PF}$

$C_\mu = 0.21$, $C_{cs} = 0.5^{PF}$

الف) $A_{vdo} = ?$



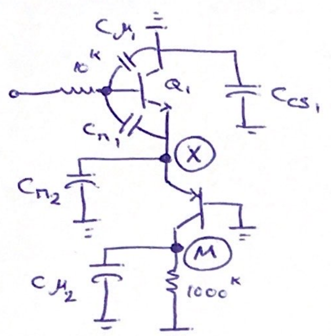


$A_{vdo} = \frac{V_o}{\frac{-V_{id}}{r_\pi}} = -r_\pi \frac{V_o}{V_{id}} = \frac{V_o}{V_Y} \times \frac{V_Y}{V_X} \times \frac{V_X}{\frac{-V_{id}}{r_\pi}}$

$\frac{250}{800} + (250 \times 50^k) = \boxed{12.5^M}$

$A_{vdo} = 0$ چون $\frac{V_o}{V_Y} = \frac{-R_c}{R_E + r_\pi} = 0$

i)

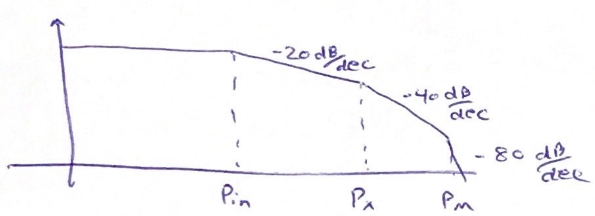


X nude : $P_x = \frac{1}{\tau_x} = \frac{1}{R_{Th} C_{Th}} = \frac{1}{(C_{\pi 2} + C_{\pi 1}) \cdot (\frac{r_m}{2})} = \frac{1}{2\pi (8^{nF} + 8.6^{PF})(0.62)}$

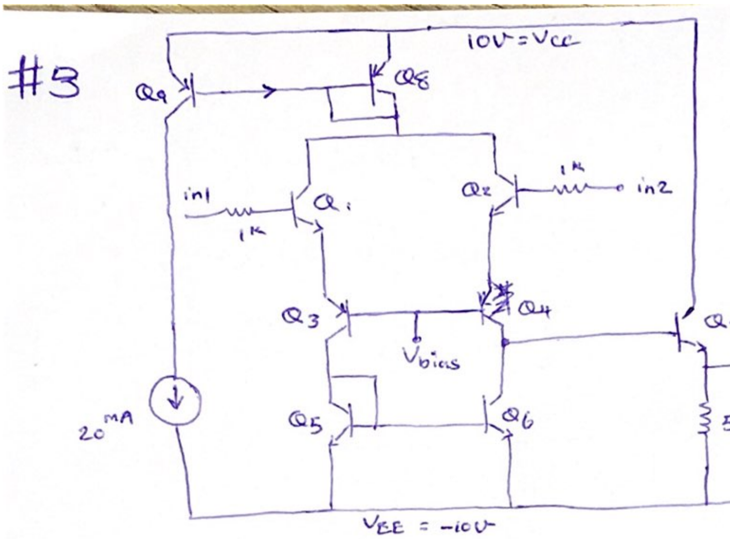
in nude : $P_{in} = \frac{1}{\tau_{in}} = \frac{1}{(10^k \| r_{\pi_1}) \cdot (C_{\pi 1} + C_{\mu 1})} = \frac{1}{2\pi [10^k \| 0.3^k \times (8^{?}F)]}$

M nude : $P_M = \frac{1}{\tau_M} = \frac{1}{2\pi [2.5^k \| 1000^k \times C_{\mu_2}]} = \frac{1}{2\pi [2.5 \| 1000^k \times (0.21^{PF})]}$

$$A_{vd}(s) = A_{vd_0} \times \frac{1}{(\frac{s}{P_{in}} + 1)(\frac{s}{P_x} + 1)(\frac{s}{P_M} + 1)}$$



#3



الف) if $V_i = 0 \rightarrow V_o = -9.2V \rightarrow$ bias Point?

ب) $A_{vdo} = ?$

ج) Pole & Zero $\Rightarrow A_{vd}(s) = ?$

د) bode plt $\Rightarrow f_{-3dB}$, $f_u = ?$

npn: $\beta = 250$, $C_{jo} = 0.3PF$, $C_{cs} = 0.5PF$
$V_0 = 0.8V$, $\tau_F = 1^{ns}$, $V_A = 120V$

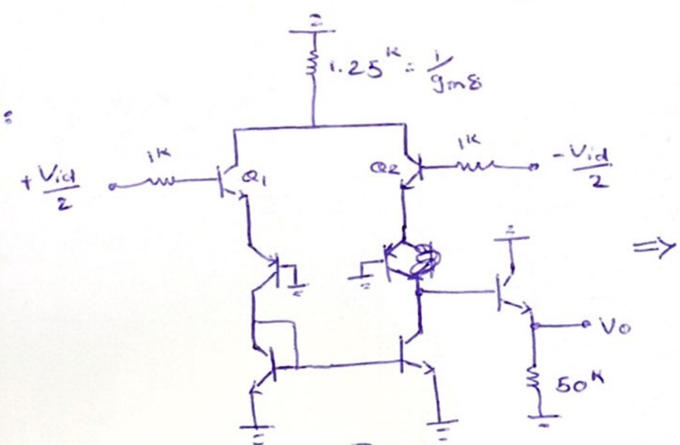
PnP: $\beta = 100$, $C_{jco} = 0.3PF$, $V_0 = 0.8V$
$\tau_F = 10^{ns}$, $V_A = 50V$

الف) for Q_9 : $I_c = 20^{mA} \rightarrow$ Q_8
$$\begin{cases} r_\pi = \dfrac{250}{800} = 312.5\Omega \\ g_m = 40 I_c = 800 \text{mmho} \\ r_o = \dfrac{V_A}{I_c} = 6K\Omega \end{cases}$$

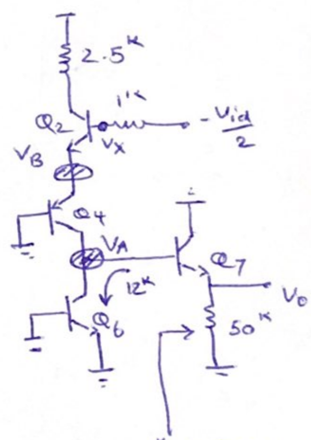
for Q_7 : $I_c = \dfrac{V_o + V_{EE}}{50^K} = \dfrac{-9.2+10}{50^K} = 16\mu A = 0.016^{mA} \rightarrow$
$$\begin{cases} g_m = 0.64 \text{ mmho} \\ r_\pi = \dfrac{250}{0.64} = 390^K \\ r_o = \dfrac{120}{0.016} = 7500^K \end{cases}$$

for othe transistors: $I_c = 10^{mA} \rightarrow$
$$\begin{cases} g_m = 400 \text{ mmho} \\ r_{\pi PNP} = \dfrac{100}{400} = 0.25^K , \quad r_{\pi NPN} = \dfrac{250}{400} = 0.62^K \\ r_{oPNP} = \dfrac{50}{10^m} = 50^K , \quad r_{oNPN} = \dfrac{120}{10} = 12^K \end{cases}$$

ب) ac analysis:



$\Rightarrow$



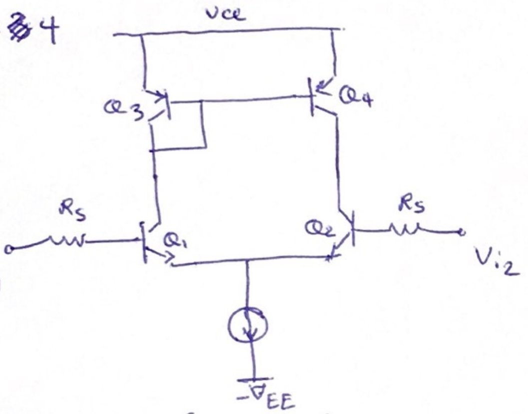
$390^K + 12500 = \boxed{12890^K}$

$$\frac{-V_o}{\frac{V_{id}}{2}} = \frac{V_o}{V_A} \times \frac{V_A}{V_B} \times \frac{V_B}{V_X} \times \frac{-V_X}{\frac{V_{id}}{2}} = \left[\frac{50^K}{50^K + 1.56^K}\right] \times$$

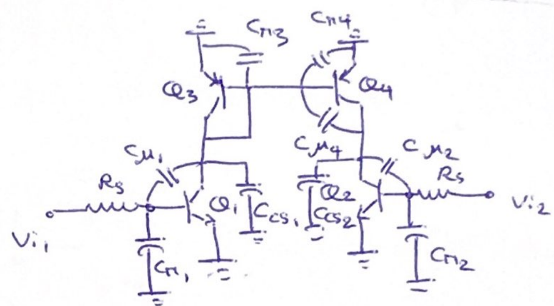
$$\Rightarrow A_{vd} = g_{m7}\left[\beta_{NPN} r_{oNPN} \,\Big\|\, \frac{\beta_{PNP} r_{oPNP}}{2}\right] = 0.64\left[\frac{250 \times \cancel{100} \times \cancel{50}^K}{12} \,\Big\|\, \frac{100 \times 50^K}{2}\right] = 0.64\left(3000^K \| 2500^K\right)$$

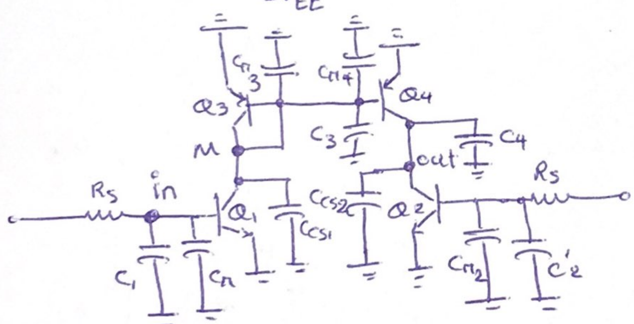
$$\Rightarrow \boxed{A_{vd} = 1363.63 \ ^V/_V}$$

$\cancel{3}$4



ac circuit $\longrightarrow$





$$P_{in} = \frac{1}{\tau_{in}} = \frac{1}{(R_S \| r_{\pi 1})(C_1 + C_\pi)}$$

$$P_M = \frac{1}{\tau_M} = \frac{1}{(r_{o1} \| r_{m3}) \cdot (C_{cs1} + C_{\pi 3} + C_{\pi 4} + C_3)}$$

$$P_{out} = \frac{1}{\tau_{out}} = \frac{1}{(r_{o4} \| r_{o2}) \cdot (C_4 + C_{cs2} + C_L)}$$

$$\frac{V_o}{V_{i1}} = \frac{\overbrace{\tfrac{1}{2} g_m r_o}^{A_{v_o}}}{\left(\frac{S}{P_{in}}+1\right)\left(\frac{S}{P_M}+1\right)\left(\frac{S}{P_o}+1\right)}$$

$$\frac{V_o}{V_{i2}} = \frac{-\tfrac{1}{2} g_m r_o}{\left(\frac{S}{P_{in}}+1\right)\left(\frac{S}{P_M}+1\right)\left(\frac{S}{P_o}+1\right)}$$

$$\Rightarrow \frac{V_o}{V_i} = \frac{V_o}{V_{i1}} + \frac{V_o}{V_{i2}} = \underbrace{g_m r_o}_{= A_{v_o}} \cdot \frac{\left(\frac{S}{2P_M}+1\right)}{\left(\frac{S}{P_{in}}+1\right)\left(\frac{S}{P_M}+1\right)\left(\frac{S}{P_o}+1\right)}$$