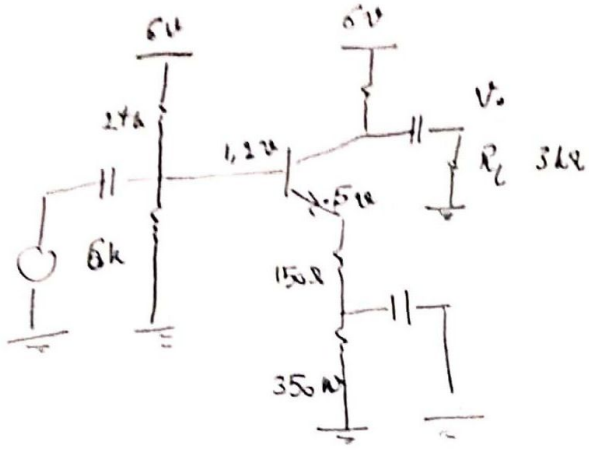
سوال ۱۱



$\rightarrow I_E \simeq I_C = \frac{0,5}{500\Omega} = \underline{1mA}$

$\rightarrow V_b = 1,2V$

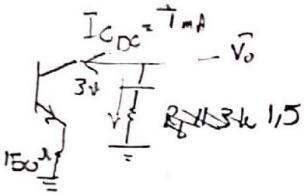
$\rightarrow V_C = 6 - 3\times 1 = \underline{3V}$ $\quad V_{CE} = 3 - 0,5 = 2,5$ ✓

$\begin{cases} g_m = 40\,m\mho \\ r_\pi = 2,5\,k\Omega \end{cases}$

$V_- = 0,3 + 0,7 = \underline{1V}$

$V_+ = \underline{6V}$

→ ولی باید شرط ما برقرار باشد



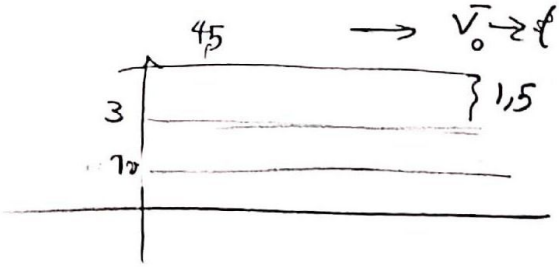
$\frac{V_{o_{AC\,max}}}{1,5} \not< 1mA$

$\rightarrow V_{o_{AC\,max}} = 1,5V \rightarrow V_+ = \underline{4,5V}$

$3 - V_k - 150\left(1mA + \frac{V_{-_{AC\,max}}}{1,5k}\right) = 0,3$

$2,55 = \frac{11}{10} V_{-_{AS}} \rightarrow V_{-_{AC}} = 2,32 \rightarrow min = \underline{0,68V} < 1V$

$\rightarrow V_o \rightarrow (0,1V \;,\; 4,5V)$



$V_{S\,\text{موج}} = 1,5 \times 2 = \underline{3V}$

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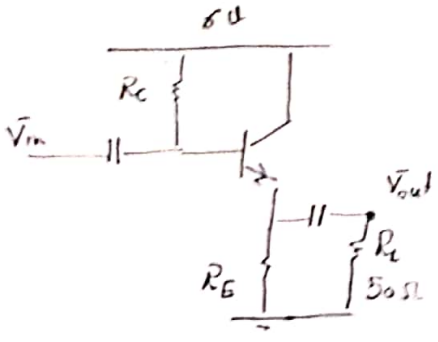
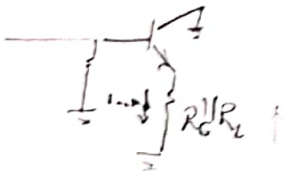


$I_C = 100mA$

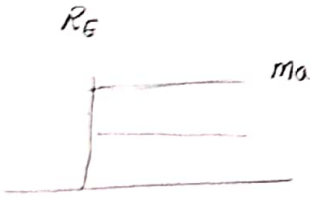
$\rightarrow V_{E_{DC}} = 100 R_E$

$\rightarrow 6 - 100 R_E \geq 0,2$



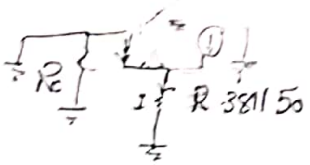
$V_T = 5,8V - 0,1 R_E$

$V_- = \frac{50 R_E}{50 + R_E}$

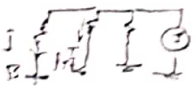


$\max \rightarrow \begin{cases} V_T = 5,8V - 0,1 R_E > 2V \\ V_- = \frac{5 R_E}{50 + R_E} > 1V \end{cases} \rightarrow \begin{cases} R_E < 38\Omega \\ R_E > 33,3\Omega \end{cases}$

$\rightarrow 33,33\Omega < R_E < 38\Omega$



$I_C = 100mA \rightarrow r_\pi = \frac{30 \times 25mA}{100mA} = 7,5\Omega$ $\quad R_E = 38$



$6 - 0,7 - \frac{100}{30} R_C = 0,38 \times 100 = 0$

$1,5 = \frac{100}{30} R_C \rightarrow R_C = 0,45k\Omega$

$r_{in} = \underbrace{R_C}_{0,45} \| \underbrace{r_\pi}_{2,2k} + (50 \| 38)(31) = 450 \| (7,5 + 670) = 270,4\Omega$

$r_{out} = \underbrace{\frac{r_\pi}{\beta}}_{0,25} \| 50 \| 38 = 0,25\Omega$

$A_V = \frac{\overbrace{R_E \| R_0}^{21,6\Omega}}{\underbrace{R_E \| R_0}_{21,6} + \frac{r_\pi}{\beta}} = 0,989$

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$R_E = 33{,}8$

$$\begin{cases} r_{in} = (r_\pi + (50 \parallel 33{,}8)\ 31) \parallel R_C = \underline{305{,}3\ \Omega} \\ r_o = 50 \parallel 33{,}8 \parallel 0{,}25 \simeq \underline{0{,}25\ \Omega} \\ A_v = \dfrac{R_E \parallel R_o}{R_E \parallel R_o + \frac{r_\pi}{\beta}} \simeq \underline{0{,}989} \end{cases}$$

$$R_C = \frac{6 - 0{,}7 - 3{,}38}{} = \underline{590\ \Omega}$$

ج)

$$\begin{cases} V_+ = 5{,}8v - I_C R_E > 2v \\ V_- = \dfrac{50 R_E I_C}{50 + R_E} > 2v \end{cases}$$

کیوپیک

$$5{,}8 - 2 > I_C R_E$$

$$\frac{3{,}8}{R_E} > I_C > \frac{(50 + R_E)\,2}{50 R_E}$$

در ماکسیمم I_C ۱ مقدار دارد

$$\frac{3{,}8}{R_E} > I_C > \left(\frac{1}{R_E} + \frac{1}{50}\right) 2$$

$$\rightarrow \overbrace{\frac{3{,}8}{R_E} - \frac{2}{R_E}}^{1{,}8} = \frac{2}{50} \rightarrow \underline{R_{E_{max}} = 45\ \Omega}$$

د)

$$V_+ = V_- \rightarrow 5{,}8 - R_E I_C = \frac{50 R_E I_C}{50 + R_E}$$

$$\rightarrow 5{,}8 = I_C \left(R_E + \frac{50 R_E}{50 + R_E} \right)$$

$$5{,}8 = I_C \frac{(100 + R_E) R_E}{50 + R_E} \rightarrow \underline{I_C = \frac{(50 + R_E) \times 5{,}8}{(100 + R_E) R_E}}$$

$$R_C = \frac{\overbrace{6 - 0{,}7}^{5{,}3} - \frac{(50 + R_E)\,5{,}8}{(100 + R_E)}}{\frac{(50 + R_E) \times 5{,}8}{(100 + R_E) R_E}}$$

برابر است

$$\rightarrow 2 \times \left(5{,}8 - \cancel{R_E} * \frac{(50 + R_E) \times 5{,}8}{(100 + R_E) \cancel{R_E}}\right)$$

$$= 2(5{,}8)\left(1 - \frac{50 + R_E}{100 + R_E}\right)$$

کیوپیک

$$= \frac{100 \times 5{,}8}{100 + R_E} \rightarrow$$

با افزایش R_E کمتر می‌شود

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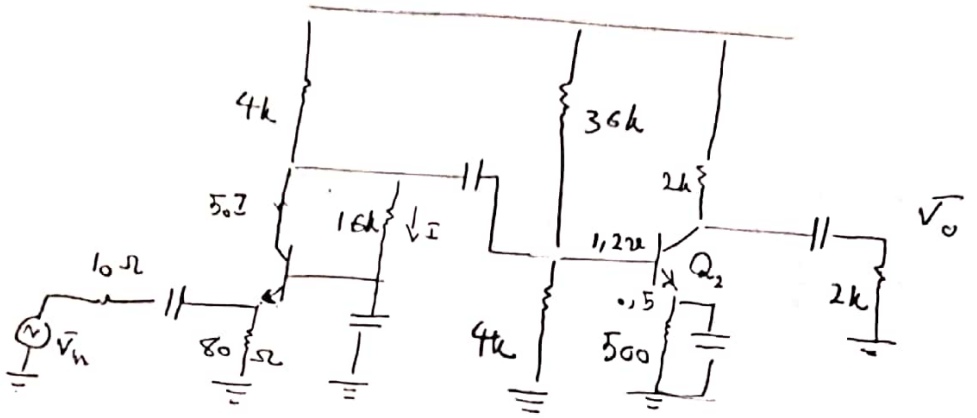
سوال 3



$V_{B_2} = 1,2v$ $\quad I_{C_2} = 1mA$ $\quad V_{CE_2} = 12 - 2\times1 - 0,5 = 9,5v$

$\frac{50\times 1m}{25} =$

$12v - 4\times51 I_{B_1} - 16 I_{B_1} - 0,7 - 80\times51 I_B = 0$

$11,3 =$

$\rightarrow I_{B_1} = 50\times10^{-3}\ mA$

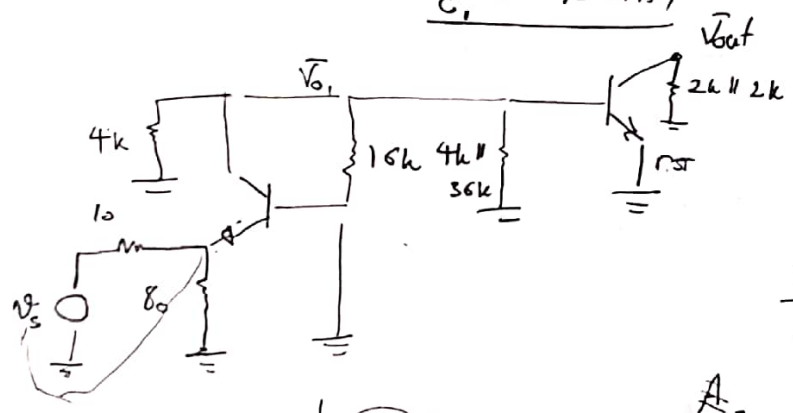
$I_{C_1} = 2,5\ mA$

$g_{m_2} = \frac{1mA}{25mA} = 40m\Omega$

$r_{\pi_2} = \frac{\beta}{g_m} = 1,25k\Omega$

$g_{m_1} = 100m\Omega$

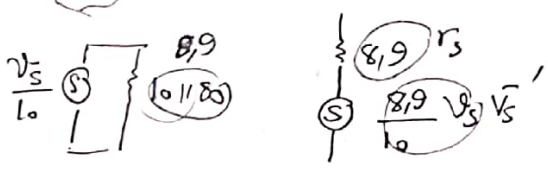
$r_{\pi_1} = 500\Omega$



$\frac{V_{o_1}}{v_s'} = \frac{4k \parallel 16k \parallel (4k \parallel 36k) \parallel 1,25k\Omega}{8,9\Omega + \frac{r_\pi 500}{50}}$

$\frac{50}{10}$

A_v



$= \frac{719}{} = -38,04$

$19,8\Omega$ با منبع

$r_{in} = \frac{r_\pi}{50+1} = 9,8\Omega$ بدون

10Ω منبع

$\frac{v_{out}}{V_{o_1}} = -\frac{2k \parallel 2k}{\frac{4k \parallel 16 \parallel 4 \parallel 36 \parallel 1,25}{50}} = -69,5$

719

$r_{out} = 1k \parallel r_o \infty = 1k$

$0,7 < v_o < 12$ $\quad \frac{v^+}{1} - 1 < 0 \rightarrow v^+ < 1$ کوچک

$V_{pp} = 2v$

$\frac{v_{out}}{v_s'} = -1719$

$A_v = \frac{v_o}{v_s} \simeq -1530$

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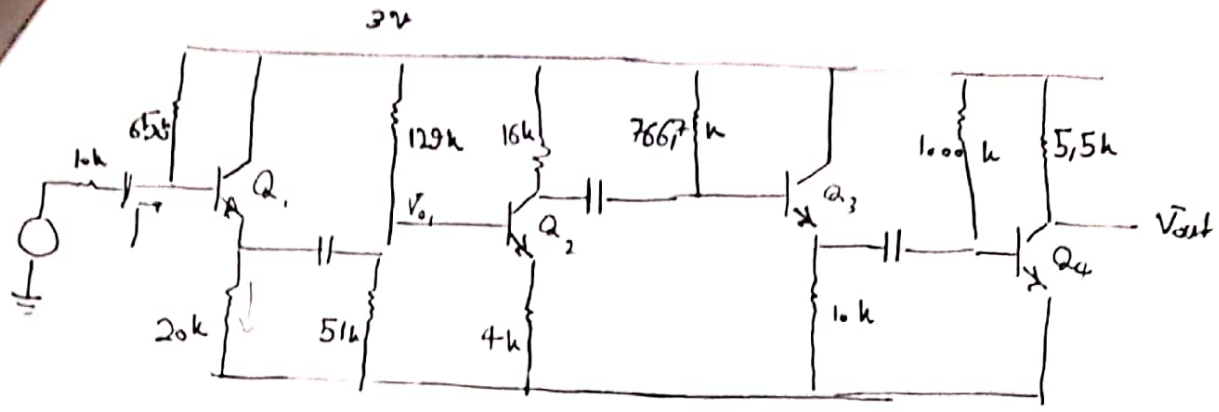
سؤال 14



Q_1 $\quad 3 - I_{B_1}\,650k - .7 - 20\times 101\, I_B = -3$

$\longrightarrow I_{B_1} = 1,98\times 10^{-3}\,mA \rightarrow I_{C_1} = .120\ mA$

$V_{CE} = 3 - (-3 + 20\times .12) = 2.7v$

(i)

Q_2 $\quad V_{B_2} = -1,3v \quad V_{E_2} = -2v \longrightarrow I_E \cong I_C = .125mA$

$V_{CE} = (3 - 16\times .125) - (-3 + 4\times .125) = 6 - \frac{20\times .25}{5} = 1v > .2v$ ✓

Q_3 $\quad 3 - (766.7)I_{B_3} - .7 - 10\times(101)\,I_{B_3} = -3$

$\longrightarrow I_{B_3} = 2,98\times 10^{-3}\,mA \quad I_{C_3} = .3\ mA$

V_{CE_3} $\quad 3 - (-3 + \frac{10\times .3}{3}) = 3v$

Q_4 $\quad 3v - 1000k\, I_{B_4} - .7 = -3 \longrightarrow I_{B_4} = 5,3\times 10^{-3}\,mA \quad I_{C_4} = .53mA$

$V_{CE} = 3 - 5,5\times .53 + 3 = 3,085 \cong 3,1v$

$V_C = 1,085\ v$

Q_1	Q_2	Q_3	Q_4
$I_{C_1} = .12mA$	$I_{C_2} = .125mA$	$I_{C_3} = .3\ mA$	$I_{C_4} = .53mA$
$g_{m_1} = 8mV$	$g_{m_2} = 1.mV$	$g_{m_3} = 12mV$	$g_{m_4} = 21,2\ mV$
$r_{\pi_1} = 12,5k\Omega$	$r_{\pi_2} = 1.k\Omega$	$r_{\pi_3} = 8,3k\Omega$	$r_{\pi_4} = 4,7k\Omega$

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$$R_{in} = 650k \parallel \overset{12,5}{r_{\pi_1}} + (\beta+1)(R_E) = 650k \parallel 582k = \underline{307\,k\Omega}$$

$$R_E = 20k \parallel 51k \parallel 129k \parallel r_{\pi_2} \cong 5,6k$$

$$R_1 = 129 \parallel 51k \parallel \underbrace{r_{\pi_2}}_{1.k} = \underline{7,85\,k\Omega}$$

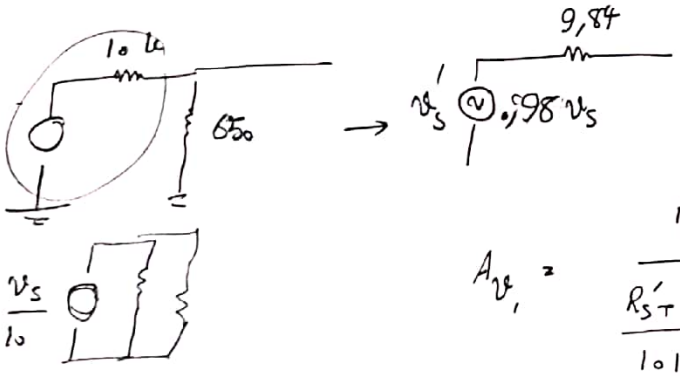
$$R_2 = 766,7k \parallel (\underbrace{r_{\pi_3}}_{8,3} + (\beta+1) R_E) = 7667 \parallel 330,2 = \underline{230,8\,k\Omega}$$

$$R_E = 10k \parallel 1000k \parallel \overset{4,7k}{r_{\pi_4}} = 3,2\,k\Omega$$

$$R_3 = 1000k \parallel r_{\pi_4} = \underline{4,7k}$$

$$r_{o_4} = \frac{100V}{.153} \cong 189\,k\Omega$$

$$R_{out} = 5,5k \parallel 189(1 + \underbrace{g_m(\overbrace{r_{\pi_4} \parallel R_E}^{0})}_{0}) = 5,5k \parallel 189k = \underline{5,3\,k}$$



$$r_{o_1} = 500\,k\Omega$$

$$R_E = 20k \parallel R_1 = 582k$$

$$A_{v_1} = \frac{\overbrace{r_{o_1} \parallel R_E}^{269}}{\frac{R_s' + r_{\pi_1}}{101} + \underbrace{r_{o_1} \parallel R_E}_{269}} = \underline{.999} = \frac{v_{o_1}}{v_s'}$$

$$A_{v_2} = -\frac{16k \parallel \overset{230,8}{R_2}}{0 + \frac{r_{\pi_2} \parallel}{100}} = \underline{-149,6}$$

$$A_{v_3} = \frac{r_{o_3} \parallel (\overbrace{10k \parallel R_3}^{3,20})}{\underbrace{\frac{\overset{8,2}{r_{\pi_3}}}{1.1} + (10k \parallel R_3)}_{3}} = \underline{.976}$$

$$A_{v_4} = -\frac{5,5k}{\frac{\overset{4,7}{r_{\pi_4}}}{100}} = \underline{-117.}$$

$$A_{v_{tot}} \cong \underline{1643.}$$

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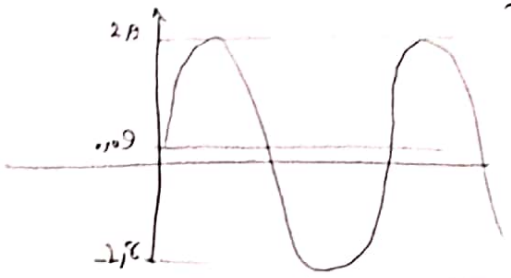
$I_{C_4} = 0.53\,mA \longrightarrow \frac{V_+}{5.5k} = 0.53\,mA \rightarrow V_+ = 2.91$

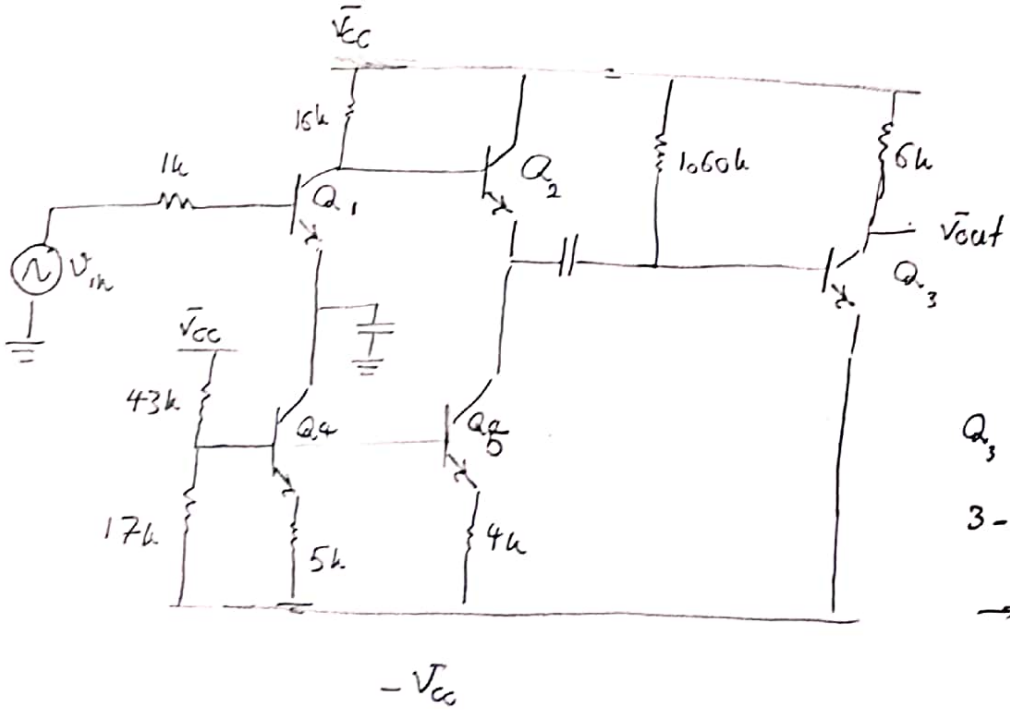
$V_{out} = 0.085 \rightarrow 0.09 - V' > -3 + 0.2$

$\rightarrow V' < 2.89$



$V_{p-p} = 5.8\,V$

د) این بافرها باعث می‌شوند که اثر کم کردن اثر کودینگ منبع از CC یا بافر استفاده می‌کنیم



سوال 15

Q_3

$3 - I_{B_3}(1060) - 0.7 = -0.3$

$\rightarrow I_{B3} = 5\times10^{-3}\,mA$

$I_{C_3} = 0.5\,mA \quad V_{CE} = 3 - 6\times0.5 + 3 = 3\,V$

Q_4 & Q_5 $\quad V_{B_4} = -1.3\,V \rightarrow V_E = -2\,V \rightarrow I_{E_4} = I_{C_4} = \frac{1}{5k} = 0.2\,mA$

$I_{C_5} = 0.2\,mA$

$I_{C_1} = I_{C_4} = 0.2\,mA \rightarrow V_{CE_1} = 3 - 16\times0.2 - \left(-\frac{I_C}{100} - 0.7\right) = 0.5\,V > 0.2$ ✓

$V_{CE_2} = 3 - (3 - 16\times0.2 - 0.7) = 3.9\,V$ ✓

$V_{CE_4} = -\frac{0.2}{100}\times1 - (-3 + 5\times0.2) = 2\,V$

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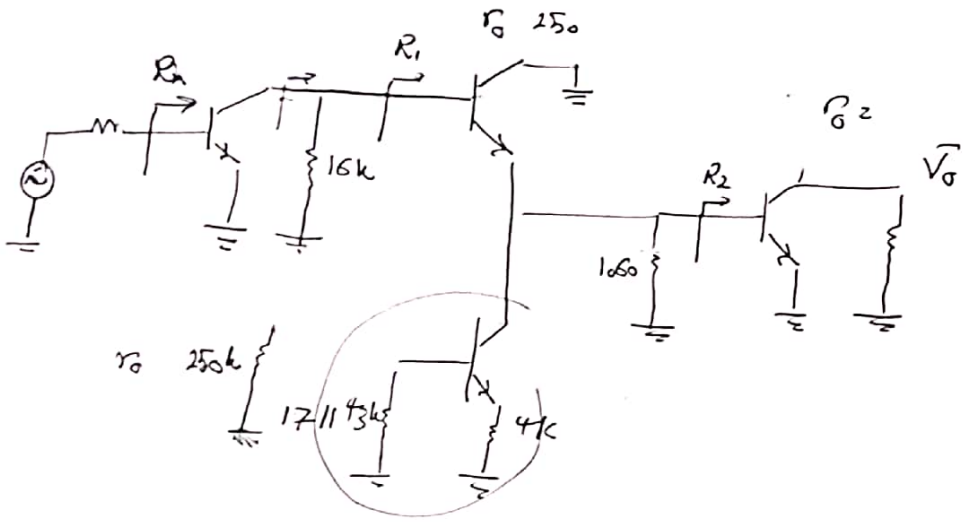
$Q_1 \begin{cases} I_{C_1} = 0{,}2\,mA \\ V_{CE_1} = 0{,}5\,V \\ r_{\pi_1} = 12{,}5\,k\Omega \\ g_{m_1} = 8\,m\mho \end{cases}$ $Q_2 \begin{cases} I_{C_2} = 0{,}2\,mA \\ V_{CE_2} = 3{,}9\,V \\ r_{\pi_2} = 12{,}5\,k\Omega \\ g_{m_2} = 8\,m\mho \end{cases}$ $Q_3 \begin{cases} I_{C_3} = 0{,}5\,mA \\ V_{CE_3} = 3\,V \\ r_{\pi_3} = 5\,k\Omega \\ g_{m_3} = 20\,m\mho \end{cases}$ $Q_4 \begin{cases} I_{C_2} = 0{,}2\,mA \\ V_{CE_2} = 2\,V \\ r_{\pi_4} = 12{,}5\,k\Omega \\ g_{m_4} = 8\,m\mho \end{cases}$ $Q_5 \begin{cases} I_{C_5} = 0{,}2\,mA \\ V_{CE_5} = 1{,}3\,V \\ r_{\pi_5} = 12{,}5\,k\Omega \\ g_{m_5} = 8\,m\mho \end{cases}$



$r_{in} = r_{\pi_1} = 12{,}5\,k\Omega \rightarrow$ بدون R_S

$r_{out} = 6k \,||\, 100k(1+0) = 5{,}7\,k\Omega$

$R_2 = r_{\pi_3} = 5\,k\Omega$

$A_{v_1} = -$

$R_1 = \overbrace{r_{\pi_2}}^{12{,}5} + (101)(\underbrace{1060k \,||\, 5k}_{5} \,||\, 250)$

$= 5{,}8\,k\Omega$

سرپیک

$\frac{V_+}{6k} = 0{,}5$

$A_{v_1} = -\frac{\overbrace{16k \,||\, R_1}^{15{,}8}}{0 + \frac{1k + 12{,}5}{101 \cdot 9{,}5}} = -117{,}8$

$\rightarrow V_+ = +3\,V$

$-V_- > -2{,}8$

$A_{v_2} = +\frac{\overbrace{250 \,||\, 250 \,||\, 1060 \,||\, 10\,k\Omega}^{125}}{\frac{12{,}5}{101} + 9{,}5} = +0{,}987$

$-2{,}8 < V < 3\,V$

$\rightarrow V \rightarrow$ سرپیک $= 2 \times 2{,}8$

$= 5{,}6\,V$

$A_{v_3} = -\frac{6k}{\frac{5k}{100}} = -120$

$\rightarrow A_v = -120 \times 987 \times -117{,}8$

$= 13952$

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