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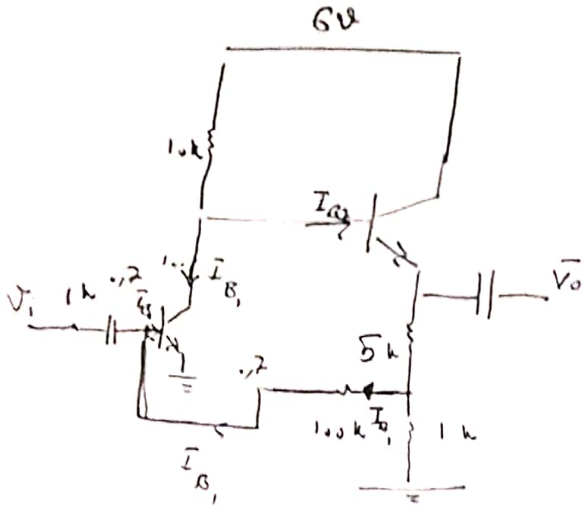
سوال ۱۰



$$6V - (100 I_{B_1} + I_{B_2}) 10k - 0.7 - 101 I_{B_2}(5+1) = 0$$

(ناچیز: I_{B_2})

(I) $5.3 = 1000 I_{B_1} + 606 I_{B_2}$

$0.7 - 100 I_{B_1} - 101 I_{B_2} = 0$

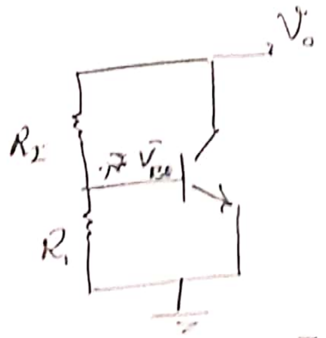
$$\rightarrow \begin{cases} 1000 I_{B_1} + 606 I_{B_2} = 5.3 \\ 101 I_{B_1} + 101 I_{B_2} = 0.7 \end{cases}$$

$I_{B_1} = 2.79 \times 10^{-3}\, mA \quad I_{B_2} = 4.14 \times 10^{-3}\, mA$

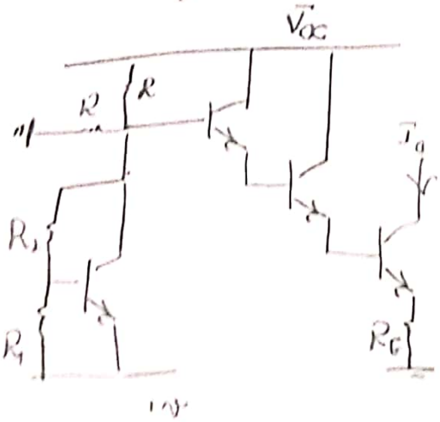
$$\begin{cases} V_{CE_2} = 6 - 2.5 = 3.5V \\ I_{C_2} = 0.414 \end{cases} \qquad \begin{cases} V_{CE_1} = 3.2V \\ I_{C_1} = 0.28\, mA \end{cases}$$

سوال ۱۲

فرض I_B کوچک است



$$\frac{V_o}{R_1 + R_2} = \frac{V_{BE}}{R_1} \rightarrow V_o = \left(1 + \frac{R_2}{R_1}\right) V_{BE}$$

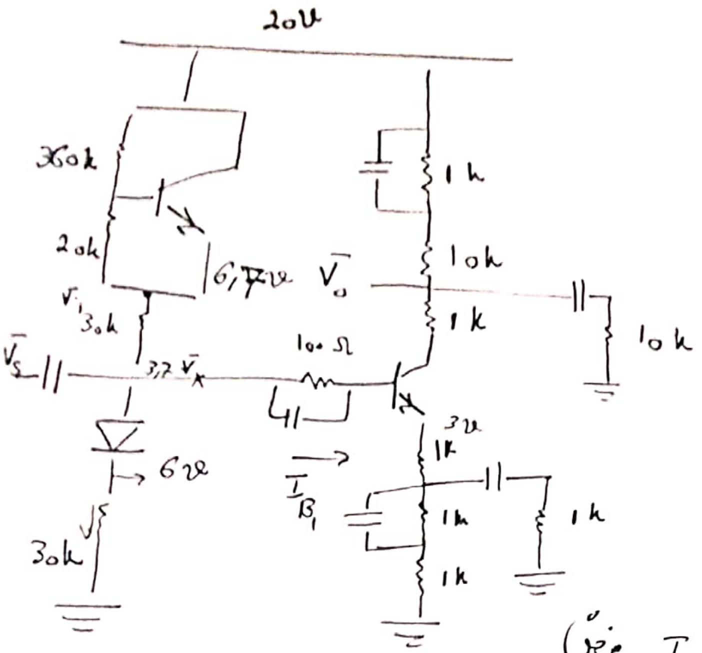


$$V_{B_2} = \left(1 + \frac{R_2}{R_1}\right)(V_{BE} + 1)$$

$$V_{E_4} = \left(1 + \frac{R_2}{R_1}\right)(V_{BE} + 1) - 3V_{BE}$$

$$\rightarrow \left(1 + \frac{R_2}{R_1} - 3\right) V_{BE} + \left(1 + \frac{R_2}{R_1}\right)$$

$\frac{R_2}{R_1} - 2 \rightarrow \frac{R_2}{R_1} = 2 \;\Big|\;$ مستقل از V_{BE}



از سوال قبل $\rightarrow V_1 - 0.7 \left(1+\frac{360}{20}\right) = 20$

19

$\rightarrow \underline{V_1 = 6.7v}$

فرض $I_{B_1} \ll$ [illegible]

$6.7 - I \times 30k - 0.7 - I \times 30k = 0$

$\rightarrow \underline{I = 0.1\,mA} \rightarrow V_x = 30 \times 0.1 + 0.7 = 3.7$

$\rightarrow I_{C_1} = I_{E_1} = \underline{1mA} \rightarrow I_{B_1} = 5 \times 10^{-3}\,mA$

فرض درست بود

$\rightarrow 5 \times 10^{-3}\,mA \ll 0.1\,mA$

$\rightarrow V_C = 20 - 12 \times 1mA = 8v \rightarrow \underline{V_{CE} = 5v} \geq V_{sat}$

$\begin{cases} I_{C_1} = 1mA \\ V_{CE} = 5v \end{cases}$ $\quad g_m = \frac{1mA}{25mV} = 40\,m℧ \qquad g\,v = I$

$r_\pi = \frac{\beta}{g_m} = \frac{200}{40m℧} = \underline{5k\Omega}$

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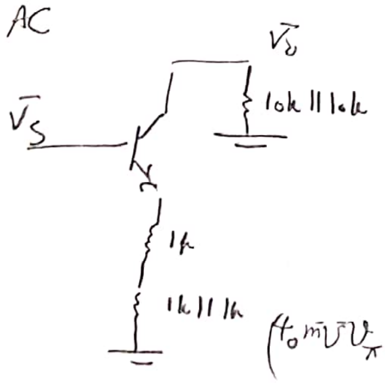
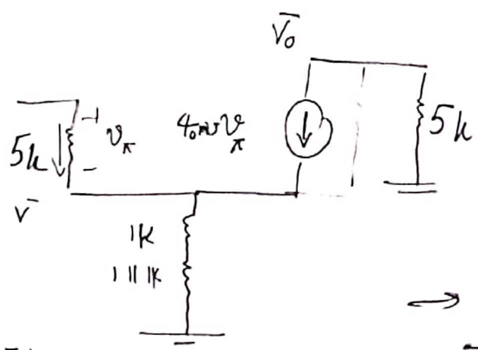




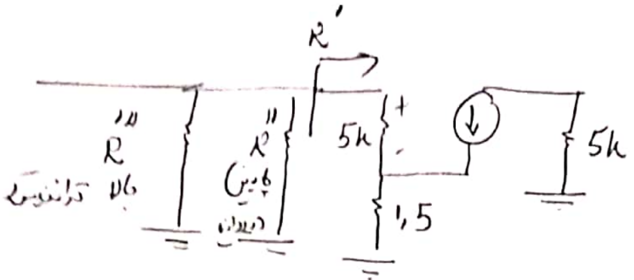
$\left(40m℧\, v_\pi + \frac{v_\pi}{5k}\right)(1+0.5) + v_\pi = v_s$

$v_\pi (61.3) = v_s$

$v_o = -5k \times \frac{v_s}{61.3} \times 40m℧ = -3.26\,v_s$

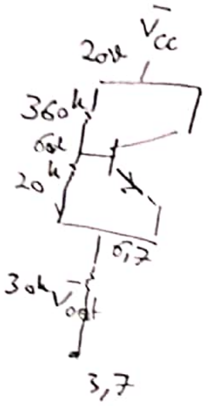
$\rightarrow \underline{A_v = -3.26}$

$R_{in} \rightarrow$



$$R' = 5k + (1+\beta)\, 1,5\,k = 306,5\,k\Omega$$

$$R'' = 30\,k\Omega$$ دیود چینر نیست

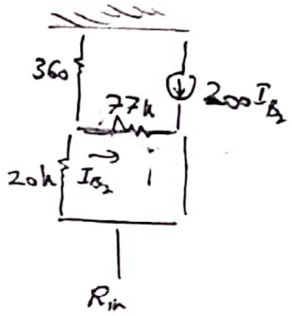


$$V_{CG} = 20v - 6,7 = 13,3\,v$$

$$\frac{6,7 - 3,7}{30k\Omega} = 0,1\,mA$$

$$r_{\pi_2} = 77\,k\Omega$$
$$g_{m_2} = 2,6\,m\mho$$

$$I_{C_2} = 0,1 - 0,035 = 0,065\,mA$$



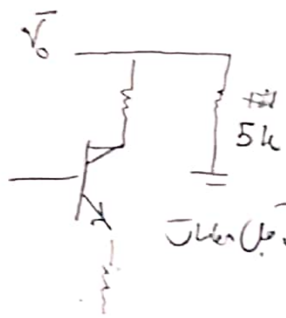
$$1 + \frac{360}{\frac{20\times77}{20+77}} = 24,6 \times r_{in}$$

23,7

$$\rightarrow R''' = 30k + 23,7 \times 0,4 \simeq 39\,k\Omega$$

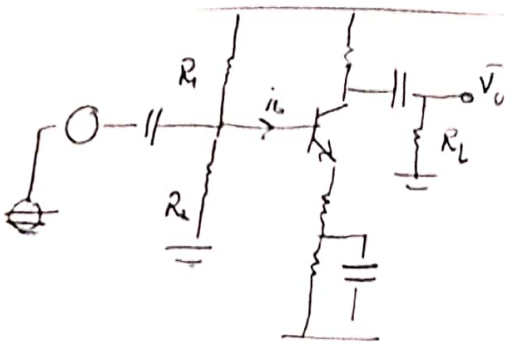
$$\rightarrow R_{in} = 307 \parallel 30k \parallel 39k \simeq 16\,k\Omega$$

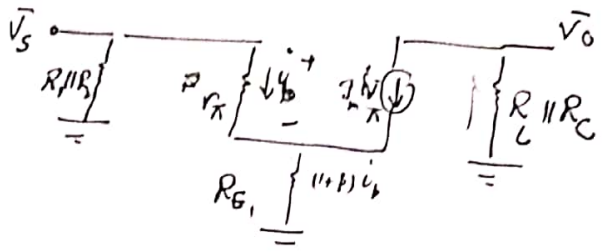
R_{out}



$$R_{out} = 5k$$

$A_V = -3,26$ مثل قبل





$$R_{in} = (R_1 \| R_2) \;\|\; \left(r_\pi + (1+\beta) R_{E_1}\right)$$

$$R_{out} = R_L \| R_C$$

$$\bar{V}_o = -g_m \bar{V}_\pi (R_L \| R_C)$$

$$\bar{V}_s = R_E (1+\beta) i_b + r_\pi i_b \rightarrow \quad i_b = \frac{\bar{V}_s}{(1+\beta) R_E + r_\pi}$$

$$\longrightarrow \bar{V}_o = -\underbrace{g_m \times r_\pi}_{\beta} i_b (R_L \| R_C)$$

$$\frac{\bar{V}_o}{\bar{V}_s} = \frac{-\beta (R_L \| R_C)}{(1+\beta) R_{E_1} + r_\pi} = -\frac{\beta (R_L \| R_C)}{(1+\beta) R_{E_1} + r_\pi}$$

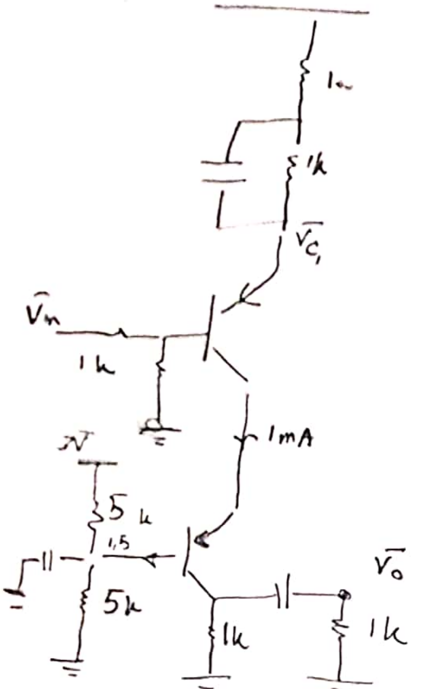
$$\bar{V}_B = \frac{R_1}{R_1 + R_2} \bar{V}_{CC}$$

حل بایاس

$$\longrightarrow I_E = I_C = \frac{\frac{R_1 \bar{V}_{CC}}{R_1 + R_2} - \bar{V}_{BE}}{R_{E_1} + R_{E_2}}$$

$$r_\pi = \frac{\beta V_t}{\frac{\frac{R_1 \bar{V}_{CC}}{R_1 + R_2} - \bar{V}_{BE}}{R_{E_1} + R_{E_2}}}$$

سوال 15



$$\frac{I_{C_1}}{\beta} \times 120k + 0{,}7 + 1{,}01\, I_{C_1} = 3v$$

$$\rightarrow I_{C_1} = 1mA \qquad V_{C_1} = 3 - 1{,}1 I_C = 1{,}9v$$

$$\rightarrow V_{CE} = 0{,}3v$$

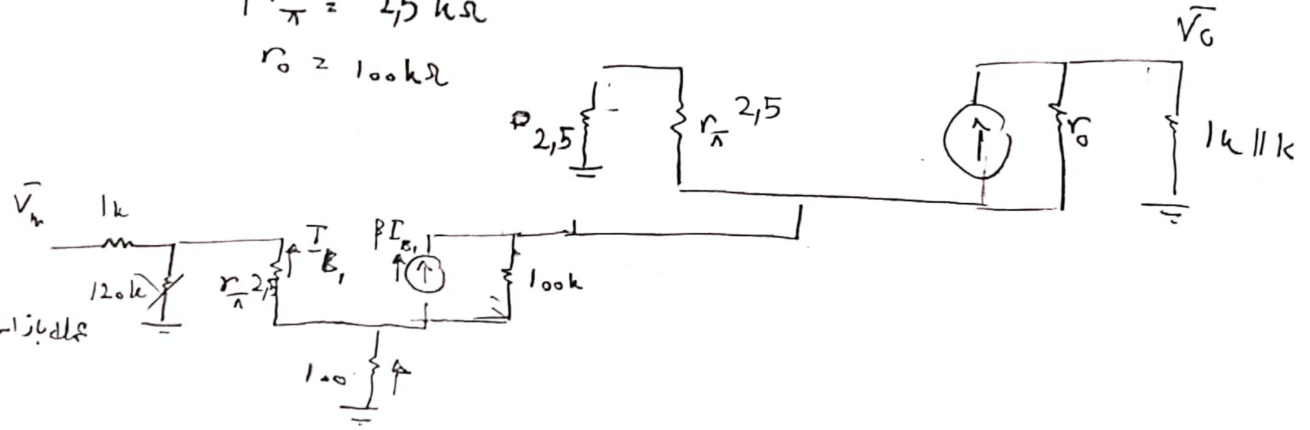
$$\frac{1mA}{\beta} \ll \frac{3}{10k} \rightarrow V_{B_2} = 1{,}5v$$

$$\rightarrow V_{C_2} = V_{E_1} = 2{,}2$$

$$V_{E_2} = 1mA \times 1 = 1v \rightarrow V_{CE_2} = 2{,}2$$

g_m , r_π برابرند

$$g_m = 40m\mho$$
$$r_\pi = 2{,}5\,k\Omega$$
$$r_o = 100k\Omega$$



عملا باز است مقاومت ورودی نیز دارد

$$V_{in} + 2{,}5 I_{B_1} + 0{,}1 \times 101\, I_{B_1} = 0 \qquad I_{B_1} = \frac{-V_{in}}{13{,}6} = -\frac{V_{in}}{13{,}6}$$

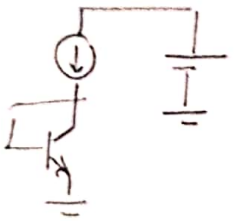
$$101\, I_{B_2} = 100 I_{B_1} \rightarrow V_o = +(1 \parallel 1)\beta I_{B_2} = -0{,}5 \times 100 \times \frac{100}{101} \times \frac{1}{13{,}6} V_{in}$$

$$\rightarrow A_v = -3{,}64$$

$$R_{in} = 1k + 2{,}5k + 0{,}1 \times 100k = 13{,}6k$$

$$R_{out} \rightarrow i_{B_1} = i_{B_2} = 0 \rightarrow R_{out} = 100k \parallel 0{,}5k \cong 0{,}5k$$

سوال ۱۶

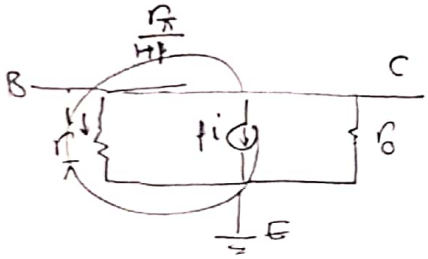


$V_{BE} = V_{CB} > V_{sat}$

$\rightarrow I_C = I_S\left(e^{\frac{V_{BE}}{V_t}} - 1\right)$

$\rightarrow I_C = I_1 = I_S\left(e^{\frac{V_{BE}}{V_t}} - 1\right)$

(ب



$\rightarrow R_C = r_o \parallel \frac{r_\pi}{1+\beta}$

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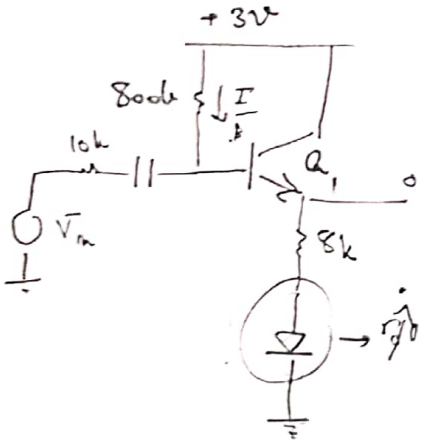


$3V - 800\frac{I_C}{100} - 8I_C - 0.7 = 0$

$\rightarrow I_C = 0.1\,mA$

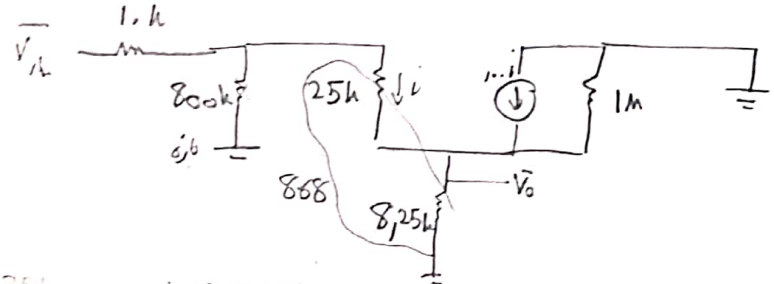
$I_{C_2} = I_{C_1}$

$r_\pi = 25k$

$g_m = 4mV$

$r_o = 1M\Omega$

$\rightarrow R_C = 1M\Omega \parallel \frac{25}{61} \approx 0.25k\Omega$



$R_{in} = 10k + 800k \parallel 868$

$= 426k$

$V_x = 35x - 25 + 101 \times 8,25 = 868$

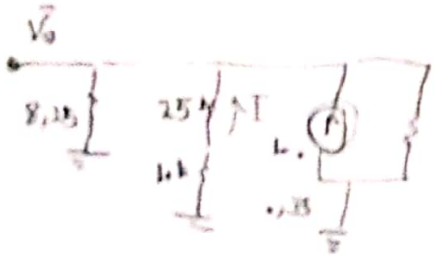
R_{out}

$V_{in} - i \times \frac{868}{800} \times 800 - 100(i)\left(1 + \frac{868}{800}\right)$

$V_{out} = 8,25 \times 101\, i$

$\rightarrow \frac{V_{out}}{V_{in}} = 0,946$

R_{out}



→ $R_{out} = 8{,}25 \parallel 35\,k \parallel 0{,}35 \parallel \int_m$ ≙ 350 Ω.