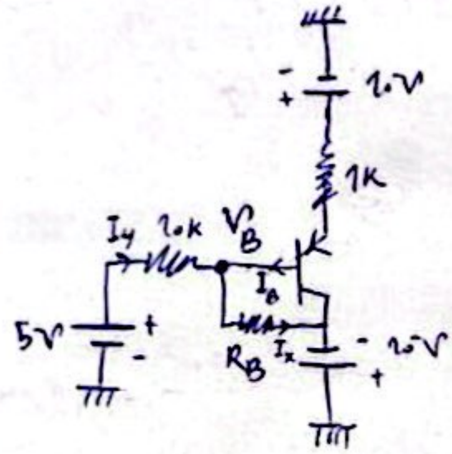
1- الف)



$V_B = 10 - I_E - 0.7 = 9.3 - I_E$

به میلی آمپر

$\beta = 100 \Rightarrow I_B = \frac{I_E}{101}$, $I_y = \frac{5 - V_B}{10} = \frac{-4.3 + I_E}{10}$

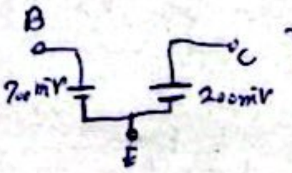
$I_B + I_y = I_x \rightarrow V_B - R_B I_x = -10$

$\Rightarrow 9.3 - I_E - 5\left(\frac{I_E}{101} + \frac{I_E - 4.3}{10}\right) = -10$

از معادله بالا $\rightarrow I_E = 13.843 \text{ mA}$ $\Rightarrow V_E = 10 - 1K \times 13.843_{mA} = -3$

$\underbrace{I_E = 13.843 \text{mA}}$ $\underbrace{V_E = -3.843 \text{ V}}$

ب) برای اشباع $V_{EC} = 0.2$



$V_{EC} = 0.2 \Rightarrow V_E = -9.8$

$\Rightarrow I_E = \frac{10 - (-9.8)}{1K} = \underbrace{19.8 \text{ mA}}$ $\Rightarrow I_B = \frac{19.8 \text{ mA}}{101}$

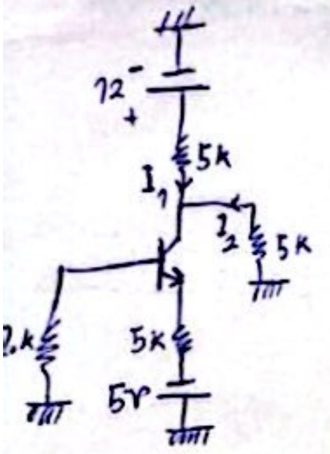
$V_B = V_E - 0.7 = -105$ $\Rightarrow I_y = \frac{5 - (-10.5)}{10} = \frac{15.5}{10} = 1.55 \text{ mA}$

$V_B + R_B I_x = -10 \rightarrow -10.5 + R_B\left(1.55^{mA} + \frac{19.8 \text{mA}}{101}\right) = -10$

چون جهت I_x عوض می‌شود

$\Rightarrow \boxed{R_B \simeq 286.362 \Omega}$

-2



$V_C = 12 - 5I_{\cancel{B}} = 5I_2$ بجای ۲ $\Rightarrow 12 = 5(\underbrace{I_1 + I_2}_{I_c})$

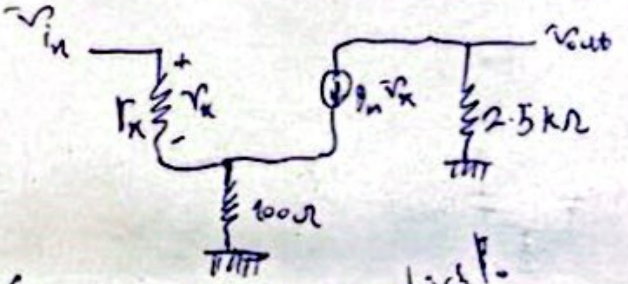
$\Rightarrow I_c = 2.4\ mA$

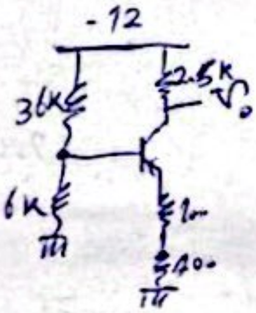
$\Rightarrow I_B = \frac{2.4}{100}\ mA \Rightarrow V_B = 10k \times \frac{2.4mA}{100} = 0.24V$

$V_B - V_{BE} - 5 \times \frac{101}{100} \times 2.4 = -5$

$V_{BE} = -6.88 \rightarrow$ تناقض. ترانزیستور روشن نیست

-3





r_o بی نهایت یعنی جریانی نمی‌کشد و می‌توان صرف نظر کرد از

با فرض $V_{EB} = 0.7$ و ناچیز بودن I_B

$\Leftarrow V_B = \frac{-1}{7} \times 12$

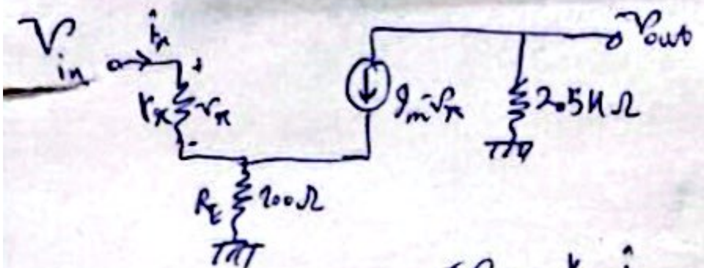
$V_E = 0.7 - \frac{12}{7} \simeq -1.014 \Rightarrow I_E \simeq I_c = \frac{0-(-1.014}{0.5K}$

$I_c = 2.028\ mA$

$g_m = \frac{I_c}{V_T} = \frac{2.028}{25}$

$r_\pi = \frac{\beta}{g_m} = \frac{100 \times 25}{2.028} = 1232.741\ \Omega$

ادامه‌ی 3.



$$v_\pi = r_\pi i_{in}$$

$$\frac{v_{in}}{I_{in}} = R_{in}$$

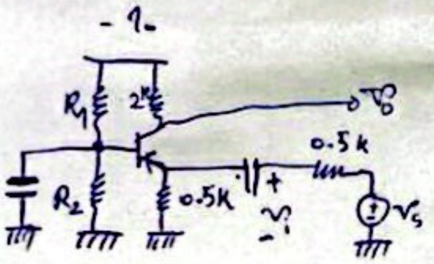
$$i_{in} r_\pi + (i_{in} + g_m(r_\pi i_{in})) R_E = v_{in}$$

$$i_{in}\left(r_\pi + R_E + \underbrace{g_m r_\pi}_{\beta} R_E\right) = v_{in}$$

$$\Rightarrow R_{in} = \frac{v_{in}}{I_{in}} = \underbrace{r_\pi + R_E(1+\beta)} = 1232.741 + 10100$$

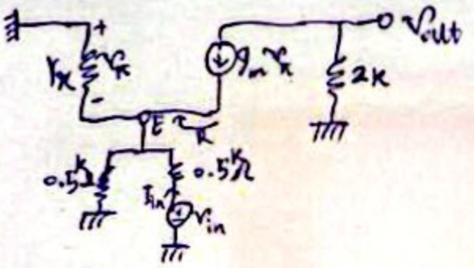
$$= 11332.741 \simeq \underline{11.332K}$$

$$A_v = \frac{v_{out}}{v_{in}} = \frac{-g_m v_\pi \times 2.5K}{v_\pi + \left(\frac{v_\pi}{r_\pi} + g_m v_\pi\right) R_E} = \frac{-g_m \times 2.5K}{1 + \left(\frac{1}{r_\pi} + g_m\right) R_E} \simeq \underbrace{-22.059}$$



4- نسبت R_1 و R_2 را سؤال به ما نداده برای همین نمی‌توان جریان بایاس را به دست آورد. پارامتری جلو می‌رویم:

r_o بی‌نهایت می‌توان صرف نظر کرد



$$R_{in} = 0.5K + \left(\underset{\text{دیده‌شده از امیتر}}{R} \parallel 0.5K\right)$$

$$\underset{\text{از سمت امیتر}}{R} = \frac{1}{g_m + \frac{1}{r_\pi}} \Rightarrow R_{in} = 0.5K + \left(\frac{1}{g_m + \frac{1}{r_\pi}} \parallel 0.5K\right)$$

$$A_v = \frac{v_{out}}{v_{in}} = \frac{g_m v_\pi\, 2K}{-v_{in}}$$

(ادامه‌ی سوال 4)

$$v_{in} = v_E + I_{in} \times 0.5k = -v_\pi + 0.5 I_{in} k$$

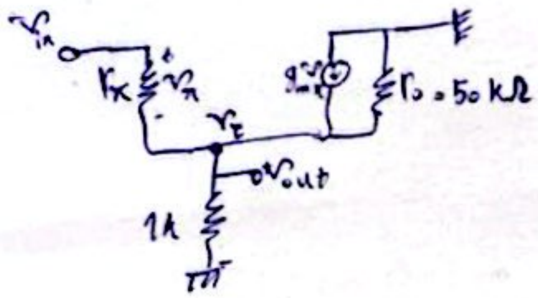
$$-I_{in} = \frac{v_\pi}{r_\pi} + g_m v_\pi - \frac{\frac{1}{g_m + \frac{1}{r_\pi}}}{\frac{1}{g_m + \frac{1}{r_\pi}} + 0.5k} I_{in}$$

$$\Rightarrow I_{in} \left(\frac{\frac{1}{g_m + \frac{1}{r_\pi}}}{\frac{1}{g_m + \frac{1}{r_\pi}} + 0.5k} - 1 \right) = v_\pi \left(\frac{1}{r_\pi} + g_m \right)$$

$$I_{in} = \frac{v_\pi \left(\frac{1}{r_\pi} + g_m \right)}{\frac{1}{1 + 0.5k\left(\frac{1}{r_\pi} + g_m\right)} - 1} \Rightarrow v_{in} = v_\pi \left(\frac{0.5k\left(\frac{1}{r_\pi} + g_m\right)}{\frac{1}{1 + 0.5k\left(\frac{1}{r_\pi} + g_m\right)} - 1} - 1 \right)$$

$$\frac{1}{r_\pi} = \frac{g_m}{\beta} \Rightarrow v_{in} = v_\pi \left(\frac{0.5k \times \frac{76}{75} g_m}{\frac{1}{1 + 0.5k \times \frac{76}{75} g_m} - 1} - 1 \right)$$

$$A_v = \frac{g_m v_\pi \, 2k}{v_\pi \left(\frac{0.5k \times \frac{76}{75} g_m}{\frac{1}{1 + 0.5k \frac{76}{75} g_m} - 1} - 1 \right)}$$



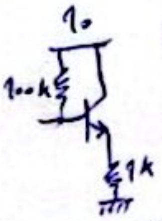
$$\frac{v_{out}}{v_{in}} = \frac{\left(g_m v_\pi + \frac{v_\pi}{r_\pi} + \frac{(0-v_E)}{r_o}\right)1k}{v_{in}}$$

$$v_E = v_{out} \Rightarrow v_{out} = \left(g_m v_\pi + \frac{v_\pi}{r_\pi} - \frac{v_{out}}{r_o}\right) R_E$$

$$\Rightarrow v_{out} = \frac{\left(g_m v_\pi + \frac{v_\pi}{r_\pi}\right) R_E}{\left(1 + \frac{R_E}{r_o}\right)}$$

$$v_{in} = v_{out} + v_\pi = \frac{v_\pi\left(g_m R_E + \frac{R_E}{r_\pi}\right)}{1 + \frac{R_E}{r_o}} + v_\pi$$

تحلیل بزرگ سیگنال



$V_T = 25\,mV$ ، با فرض $V_{BE} = 0.7$

$$I_C + 0.7 = 10 - 100\frac{I_C}{100}$$

$$2I_C = 9.3 \Rightarrow I_C = 4.65\,mA$$

$\beta = 100$

$V_T = 25\,mV$

$$g_m = \frac{I_C}{V_T} = \frac{4.65}{25}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100 \times 25}{4.65}$$

$$\Rightarrow A_v = \frac{v_{out}}{v_{in}} = \frac{\dfrac{\left(g_m v_\pi + \frac{v_\pi}{r_\pi}\right) R_E}{1 + \frac{R_E}{r_o}}}{v_\pi\left(\dfrac{g_m R_E + \frac{R_E}{r_\pi}}{1 + \frac{R_E}{r_o}} + 1\right)} = \frac{g_m R_E + \frac{R_E}{r_\pi}}{g_m R_E + \frac{R_E}{r_\pi} + 1 + \frac{R_E}{r_o}} \simeq 0.99A$$

$\downarrow$

تقریباً 1 است