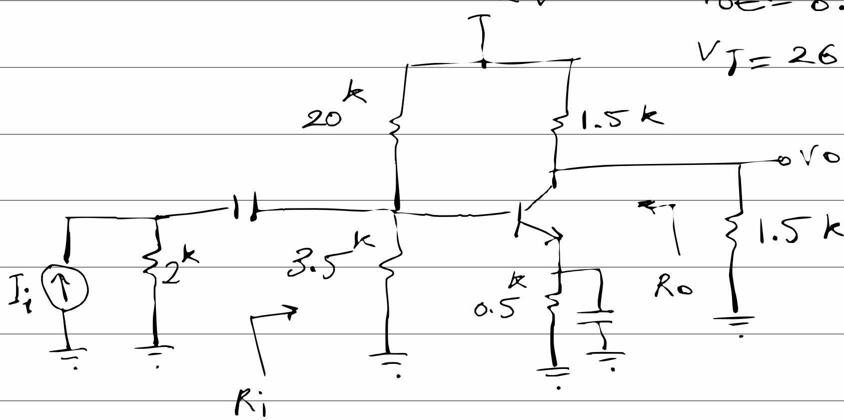
1. Calculate R_i & R_o :

$\beta = 100$

$V_{BE} = 0.7^v$

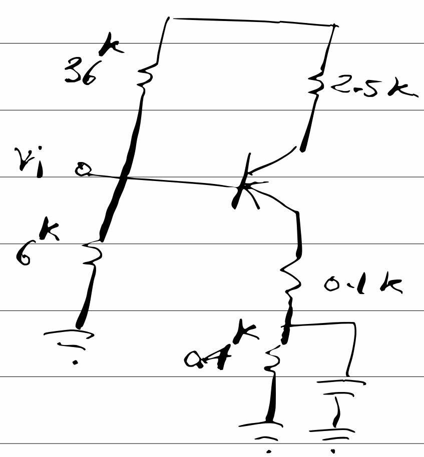
$V_T = 26\,mV$



2. Calculate R_i ?

$\beta = 100$ $V_{EB} = 0.7^v$

$V_T = 26\,mV$

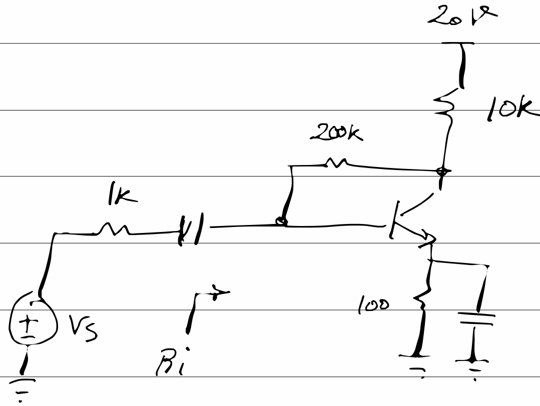


3. Calculate A_v ?

$V_T = 26\ mV$

$V_{BE} = 0.7\ V$

$\beta = 100$



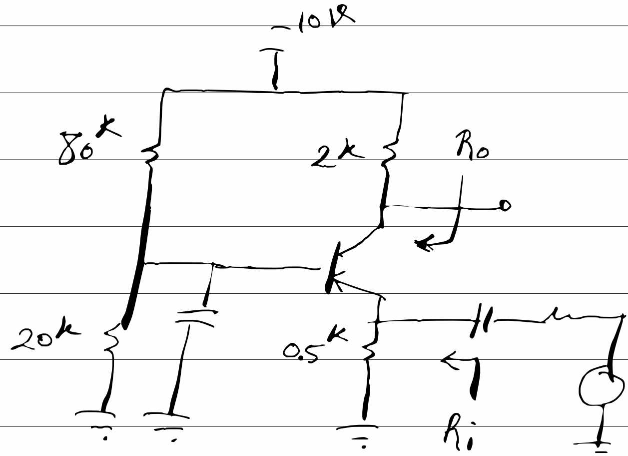
4. Calculate R_i in Q_3 ?

5. Calculate R_i :

$V_{EB} = 0.7$

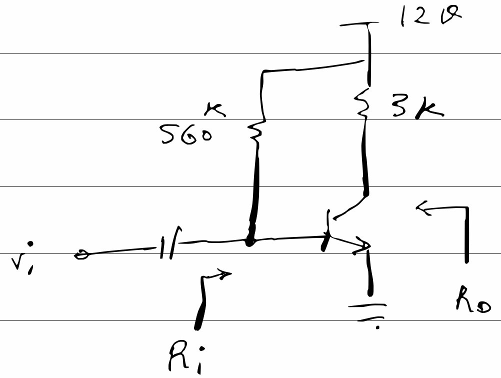
$\beta = 100$

$V_T = 26\ mV$



6. Calculate R_i & R_o ?

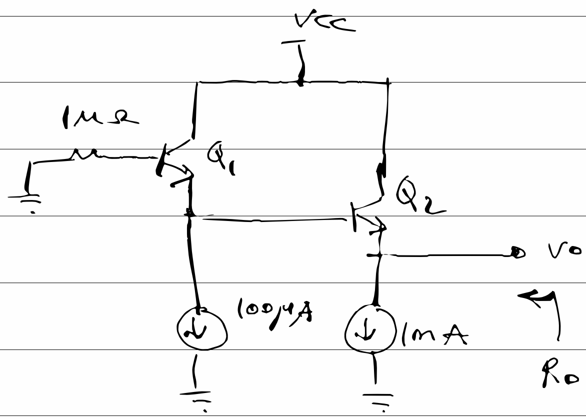
$\beta = 100$ $\quad I_C = 2mA$ $\quad r_\pi = 1.3k\Omega$



7. Calculate R_o

$V_T = 25mV$

$\beta = 100$



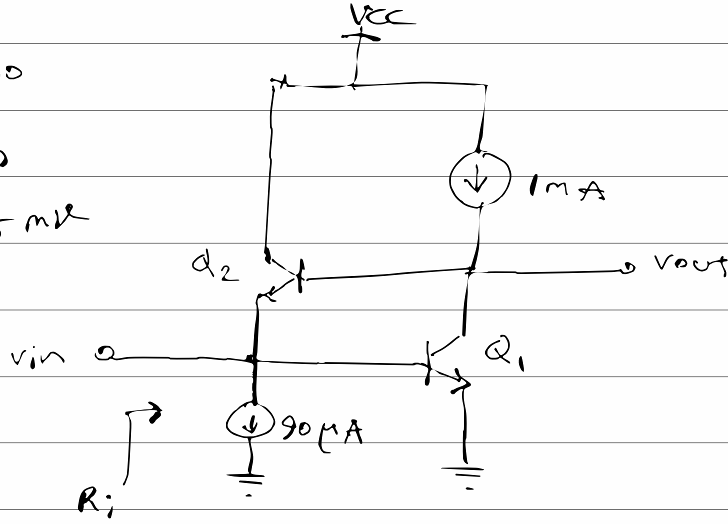
8. The circuit is in Active Region.

Calculate R_{in}

$\beta = 100$

$V_A = \infty$

$V_T = 25\ mV$



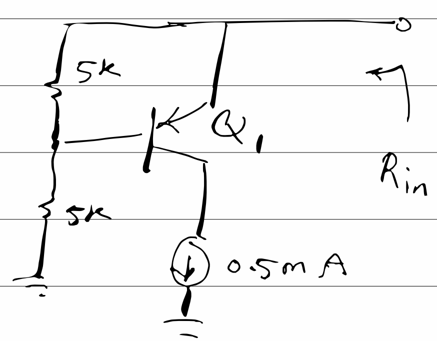
9. The circuit is in Active Region.

Calculate R_{in}

$\beta = 100$

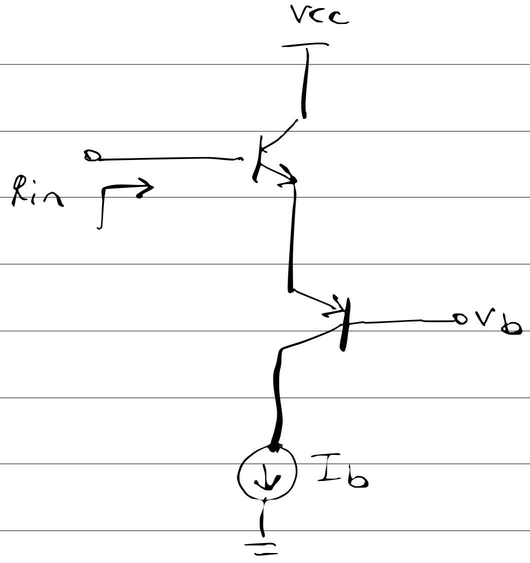
$V_A = \infty$

$V_T = 25\ mV$

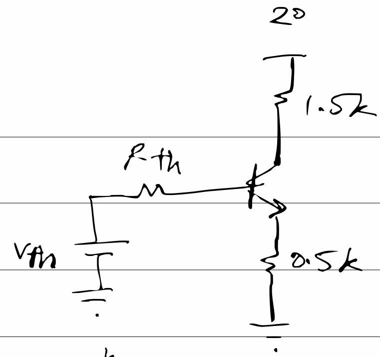


10. The circuit is in Active Region.

Calculate R_{in} :



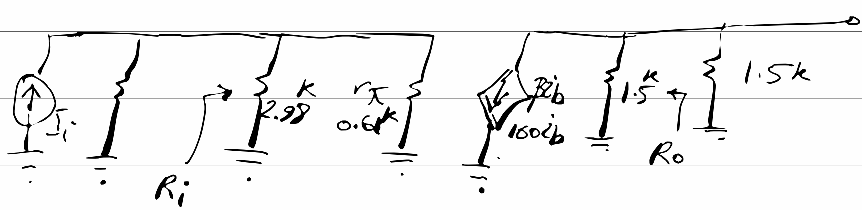
1.



$V_{th} = 20 \times \frac{3.5^k}{3.5^k + 1.5^k} = 2.98$ $R_{th} = 20^k \| 3.5^k = 2.98^k$

$I_E = \frac{V_{th} - V_{BE}}{R_E + R_{th}/(1+\beta)} = 4.31^{mA}$ $r_\pi = \beta \frac{V_T}{I_C} \simeq 0.61 k\Omega$

ac model



$R_i = 2.98^k \| 0.61k = 0.505\ k\Omega$

R_o : if $I_i = 0 \rightarrow i_b = 0 \Rightarrow R_o = 1.5^k$

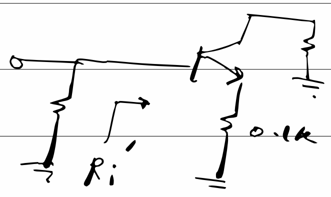
2. $R_{th} = 36^k \parallel 6^k = 5.14^k$

$V_{th} = \frac{-12}{36+6} \times 6 = -1.71\,V$

$I_E = \frac{-V_{th} - V_{EB}}{R_{E1} + R_{E2} + R_{th}/(1+\beta)} = 1.83\,mA$

$I_C = \alpha I_E = 1.81\,mA$ $\quad r_\pi = \beta \frac{V_T}{I_C} = 1.44\,k\Omega$

$R_i' = r_\pi + (\beta+1)\,0.1k = 11.54^k$



$R_i = 5.14^k \parallel R_i' = 3.56k$

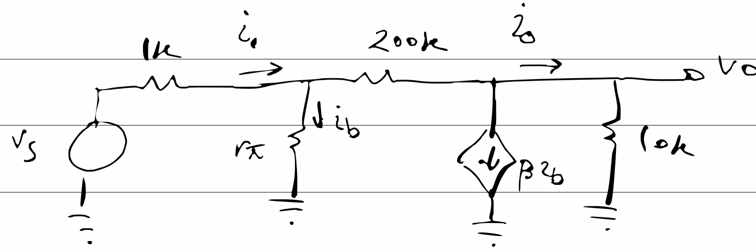
3. KVL: $20 = R_C(I_B + I_C) + R_B I_B + V_{BE} + R_E I_E$

$I_E = (\beta+1) I_B$

$I_E = 1.6\,mA$ $\quad I_C = 1.58\,mA$

$r_\pi = \beta \frac{V_T}{I_C} = 1.645\,k\Omega$

3.



$$v_i = 200^k (i_o + \beta i_b) + V_o, \quad i_b = \frac{v_i}{r_\pi} \quad i_o = \frac{V_o}{10^k}$$

$$v_i = 20 V_o + \frac{200^k \beta \, v_i}{r_\pi} + V_o$$

$$21 V_o = \left(1 - \frac{200\beta}{r_\pi}\right) v_i \Rightarrow A_V = \frac{V_o}{V_i} = -579$$

4.

$$V_i = 200(i_i - i_b) + V_o, \quad i_b = \frac{V_i}{r_\pi}, \quad V_o = A_V V_i$$

$$v_i = 200\left(i_i - \frac{v_i}{r_\pi}\right) + A_V v_i \rightarrow$$

$$v_i\left(1 + \frac{200^k}{r_\pi} - A_V\right) = 200\, i_i \rightarrow R_i = \frac{v_i}{i_i} \cong 285\,\Omega$$

5. $R_{Th} = 20^k \parallel 80^k = 16^k$

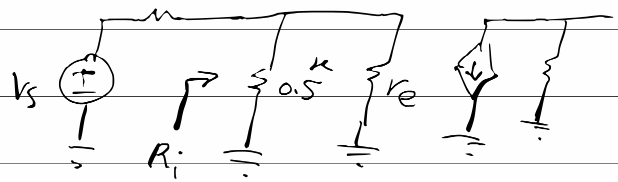
$V_{th} = \frac{-10}{20+80} \times 20 = -2\,V$

$I_E = \frac{-V_{Th} - V_{EB}}{R_E + R_{th}/(1+\beta)} = 1.97\ mA$

$I_C = \alpha I_E = 1.95\ mA$, $r_\pi = \beta \frac{V_T}{I_C} = 1.33k\,\Omega$

Common Base model:

$r_e = \frac{r_\pi}{\beta+1} = 13.2\,\Omega$



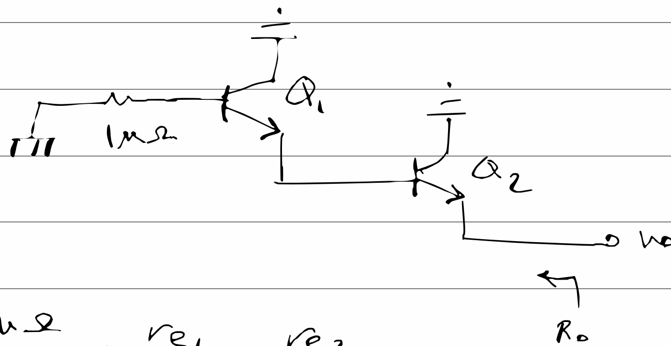
$R_i = 500^\Omega \parallel 13.2 \simeq 12.86\,\Omega$

6.

$R_i \simeq r_\pi = 1.3k\Omega$

$R_o = 3k\,\Omega$

7. ac model



$$R_o \simeq \frac{1M\Omega}{\beta^2} + \frac{r_{e1}}{\beta} + r_{e2}$$

$$r_{e1} = \frac{V_T}{I_{C1}} = \frac{25mV}{0.1mA} = 250\Omega$$

$$r_{e2} = \frac{V_T}{I_{C2}} = \frac{25mV}{1mA} = 25\Omega$$

$$R_o = \frac{10^6\Omega}{10000} + \frac{250\Omega}{100} + 25\Omega = 127.5\Omega$$

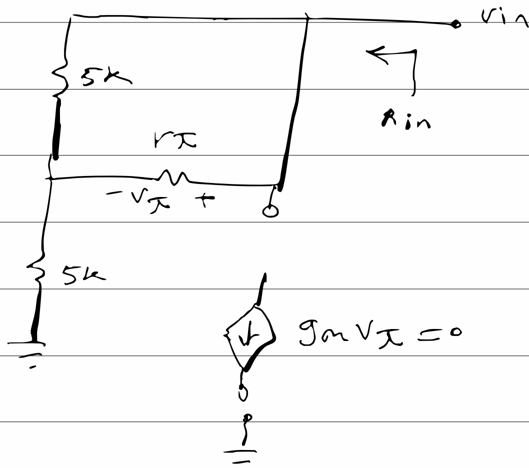
8. $I_{C1} \simeq 1mA \quad I_{B1} = \frac{I_{C1}}{\beta} = 10\mu A$

$$I_{C2} \simeq I_{E2} = 90\mu A + I_{B1} = 100\mu A$$

$$r_{e1} = \frac{25mV}{1mA} = 25\Omega$$

$$R_{in} = r_{\pi 1} = \beta r_{e1} = 2.5k\Omega$$

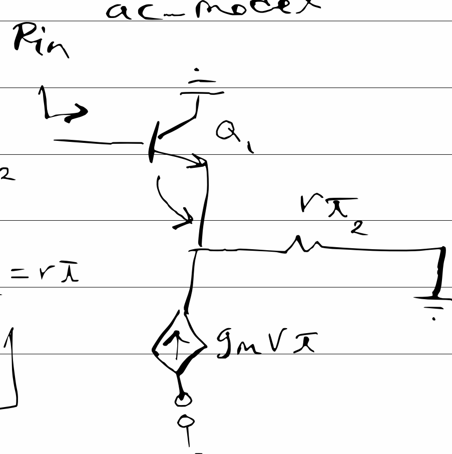
9. ac-model



$$r_e = \frac{25\,mV}{0.5\,mA} = 50\,\Omega \qquad r_\pi = \beta r_e = 5\,k\Omega$$

$$R_{in} = (5^k \parallel r_\pi) + 5^k = 7.5\,k\Omega$$

10. ac-model



$$R_{in} = r_{\pi_1} + (\beta+1) r_{\pi_2}$$

$$I_{C_1} = I_{C_2} \rightarrow r_{\pi_1} = r_{\pi_2} = r_\pi$$

$$R_{in} = (\beta+2) r_\pi$$