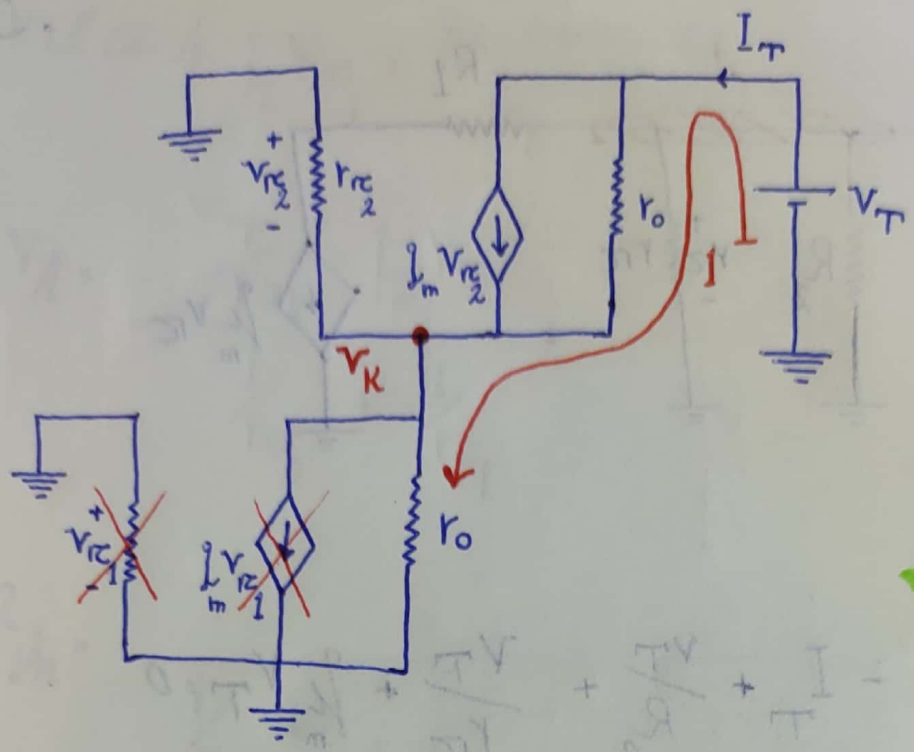


$$V_K = I_T (r_o \parallel r_{\pi_2}) \qquad V_{\pi_2} = -V_K \quad \text{I}$$

(a

$$\text{KVL @ 1}: \; -V_T + r_o (I_T - g_m V_{\pi_2}) + I_T (r_o \parallel r_{\pi_2}) = 0$$

$$V_T = r_o (I_T - g_m V_{\pi_2}) + I_T (r_o \parallel r_{\pi_2}) \quad \text{II}$$

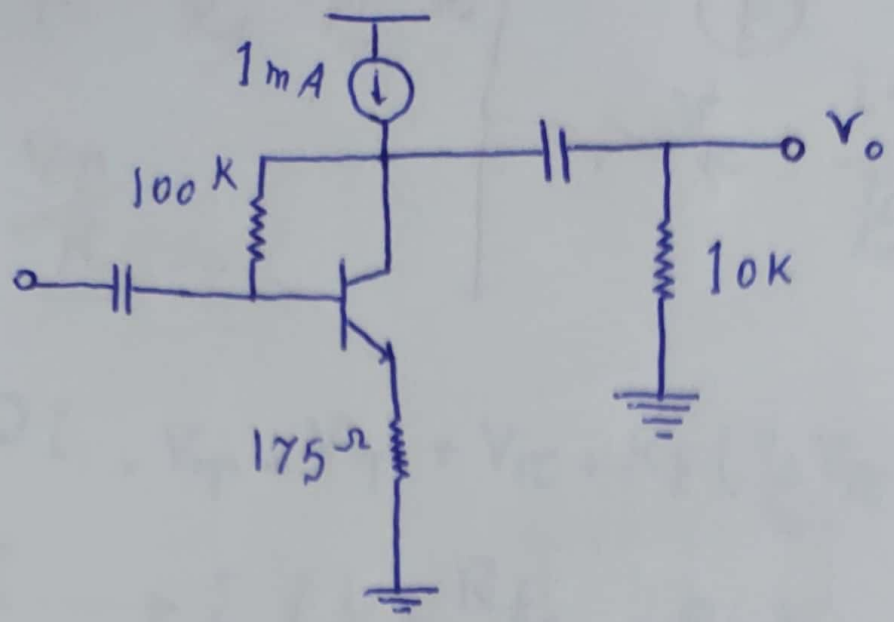
I in II $\quad R_A = r_{o_2} + (r_{o_1} \parallel r_{\pi_2}) + g_m r_{o_2} (r_{o_1} \parallel r_{\pi_2})$

(b

$$I_{C_1} = I_{C_2} = 1\,mA \qquad r_{o_1} = r_{o_2} = \frac{V_A}{I_C} = 50\,K\Omega$$

$$g_{m_1} = g_{m_2} = 40\ mA/V \qquad r_{\pi_1} = r_{\pi_2} = 5\,K$$

$$R_A \simeq 9\,M\Omega$$



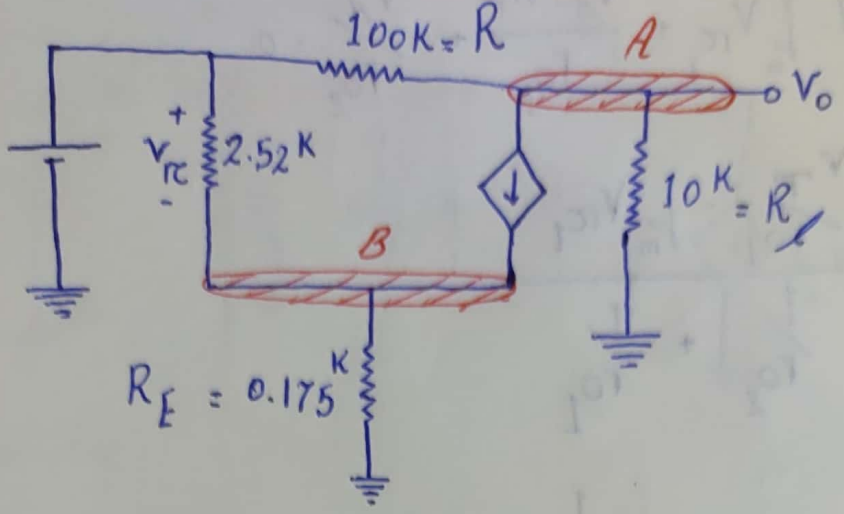
$$I_C + I_B = 1mA$$

$I_C = 0.99$

$I_B = 0.01$

$g_m = 39.6$

$r_{\pi} = 2.52$



KCL @ A. $\frac{V_o}{R_\ell} + g_m V_{rc} + \frac{V_A - V_i}{R} = 0$ I

KCL @ B: $\frac{V_B}{R_E} - g_m V_{rc} + \frac{V_B - V_i}{r_{rc}} = 0$ II

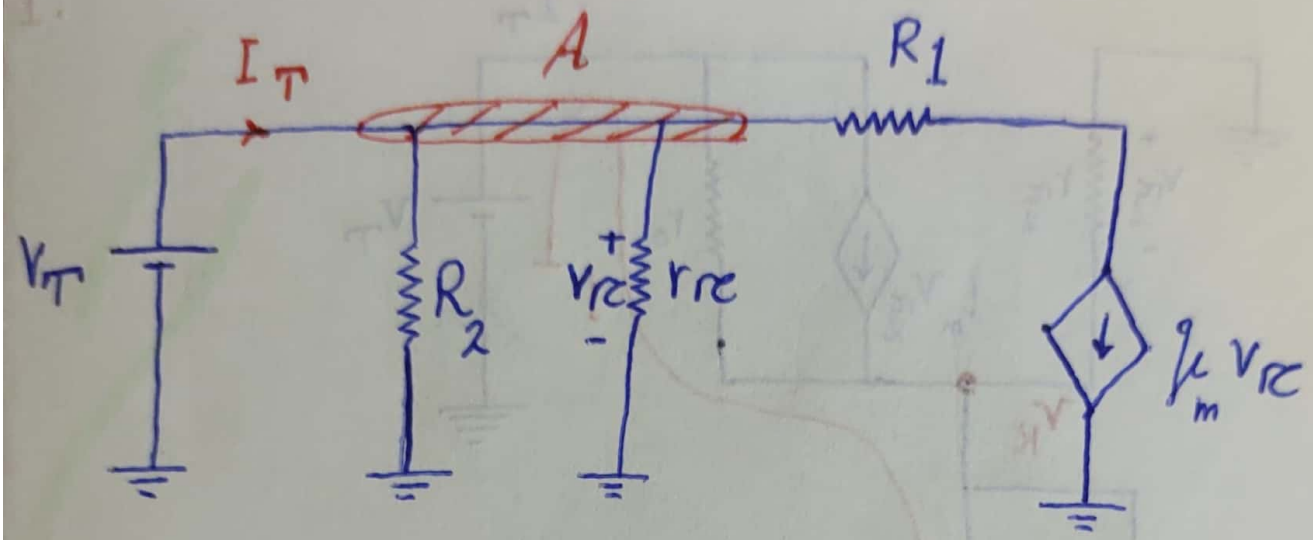
$V_o = V_A$ III

$V_B = V_i - V_{rc}$ IV

IV in II $\rightarrow$ $V_{rc} = \frac{V_i}{1 - R_E g_m + \frac{R_E}{r_{rc}}}$ V

V & III in I

$$\frac{V_o}{V_i} = \frac{R_\ell R}{R_\ell + R}\left[\frac{-g_m}{1 - R_E g_m + \frac{R_E}{r_{rc}}} + \frac{1}{R}\right]$$

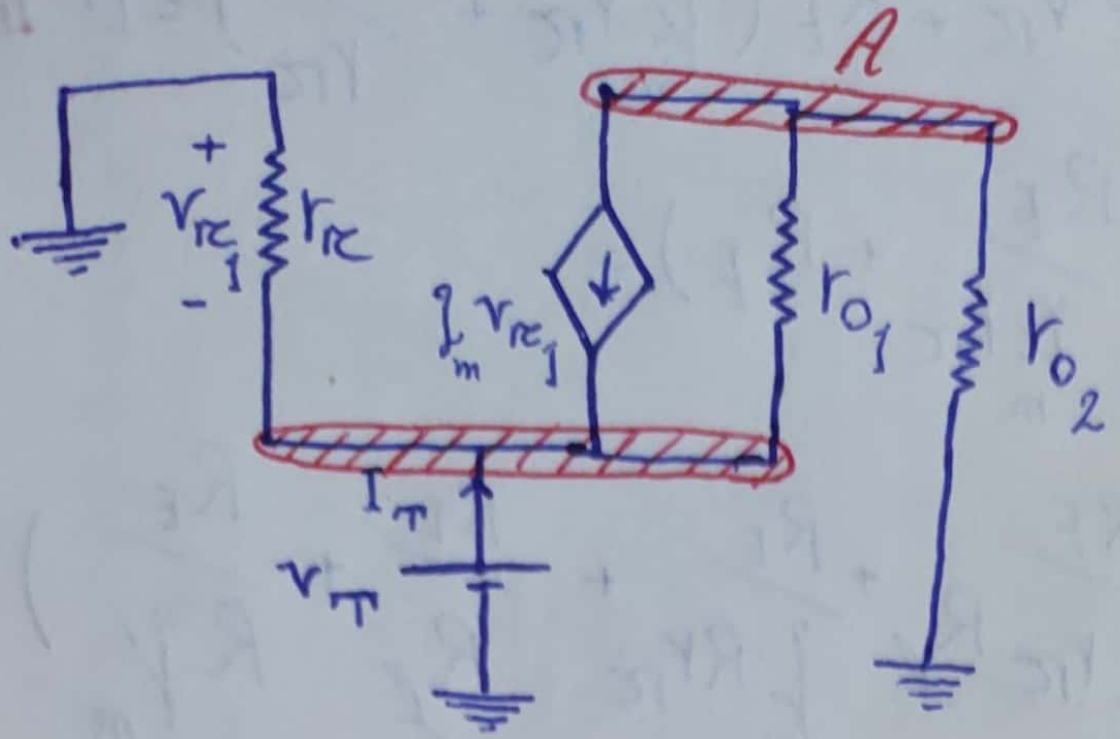


$$V_T = V_{rc}$$

$$\text{KCL @ A: } -I_T + \frac{V_T}{R_2} + \frac{V_T}{r_{rc}} + g_m V_T = 0$$

$$I_T = V_T\left(\frac{1}{R_2} + \frac{1}{r_{rc}} + g_m\right)$$

$$R_{th} = \frac{1}{(R_2 \parallel r_{rc}) + g_m}$$



$$V_\pi = -V_T$$

$$\text{Kcl @ } V_T: \quad -I_T + \frac{V_T}{r_\pi} - g_m V_{\pi 1} + \frac{V_T - V_A}{r_{o1}} = 0$$

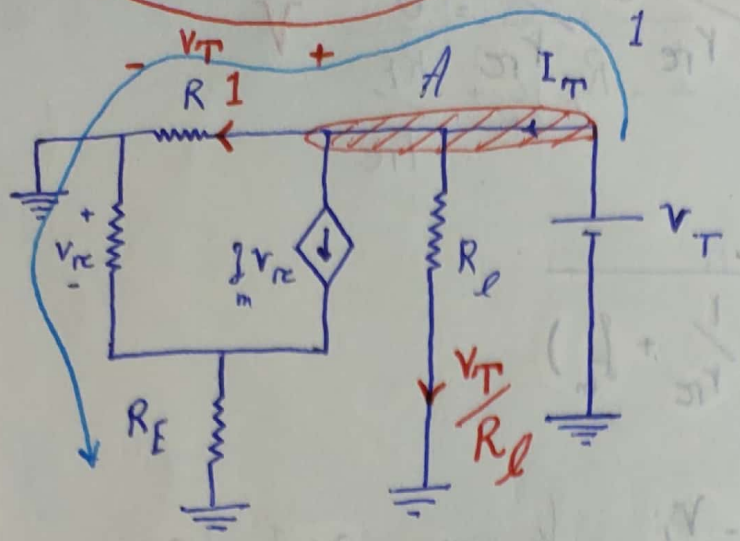
KCL @ A: $g_m V_{\pi_1} + \frac{V_A - V_T}{r_{o_1}} + \frac{V_A}{r_{o_2}} = 0$

$$V_A = \frac{\frac{V_T}{r_{o_1}} - g_m V_{\pi_1}}{\frac{1}{r_{o_2}} + \frac{1}{r_{o_1}}}$$

$$R_{th} = \frac{1}{\frac{1}{r_\pi} + g_m + \frac{1}{r_{o_1}} - \frac{\frac{1}{r_{o_1}} + g_m}{\frac{r_{o_1}}{r_{o_2}} + 1}}$$

$\beta \to \infty \qquad r_\pi \to \infty \qquad r_{o_1} = r_{o_2}$

$$R_{th} = \frac{1}{\frac{3}{2} g_m + \frac{1}{2 r_o}}$$



KCL @ A: $-I_T + \frac{V_T}{R_\ell} + \frac{V_T}{R} + g_m V_{\pi} = 0$

$$I_1 = I_T - \frac{V_T}{R_\ell} - g_m V_{\pi}$$

$$I_1 = \frac{V_T}{R}$$

$$\Longrightarrow V_{\pi} = \frac{I_T}{g_m} - \frac{V_T}{g_m R_\ell} - \frac{V_T}{R g_m} \quad (I)$$

KVL @ 1: $-V_T + V_T + V_{\pi} + R_E\left(g_m V_{\pi} + \frac{V_{\pi}}{r_{\pi}}\right) = 0$ (II)

I in II $\longrightarrow$ $I_T\left(\frac{1}{g_m} + \frac{R_E}{g_m r_{\pi}} + R_E\right) =$

$$V_T\left(\frac{1}{g_m R_\ell} + \frac{1}{g_m R} + \frac{R_E}{g_m r_{\pi} R_\ell} + \frac{R_E}{g_m R r_{\pi}} + \frac{R_E}{R_\ell} + \frac{R_E}{R g_m}\right)$$

$$R_{out} = \frac{V_T}{I_T}$$