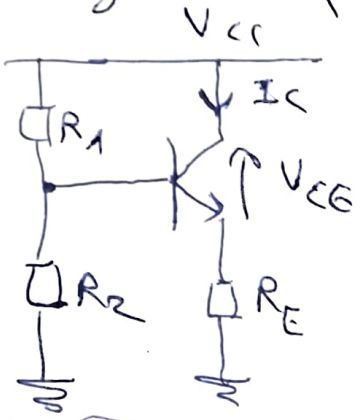
Exo 1 :

1) Droite de charge statique :



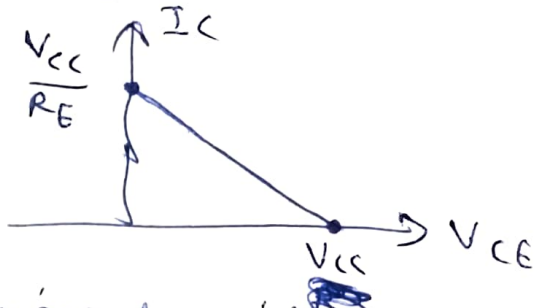
$V_{CC} - R_E I_E - V_{CE} = 0$

$I_E = \frac{\beta+1}{\beta} I_C$

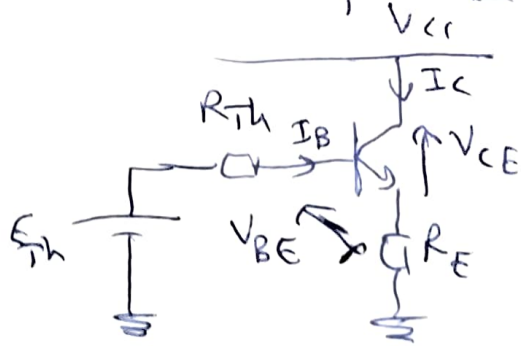
$\beta = 100$

$\Rightarrow I_E \approx I_C$

$$\Rightarrow \boxed{I_C = -\frac{1}{R_E} V_{CE} + \frac{V_{CC}}{R_E}}$$



2) Coordonnées du point de repos :



$R_{Th} = R_1 // R_2$

$E_{Th} = \frac{R_2}{R_1+R_2} . V_{CC}$

$E_{Th} - R_{Th} I_B - V_{BE} - R_E I_E = 0$, $V_{BE} \approx V_{BE0}$, $I_E \approx I_C$

$\Rightarrow I_B = \frac{E_{Th} - V_{BE0}}{R_{Th} + \beta R_E} \Rightarrow I_C = \beta I_B$

$$\Rightarrow \boxed{I_C = I_{CQ} = \beta \frac{E_{Th} - V_{BE0}}{R_{Th} + \beta R_E}}$$

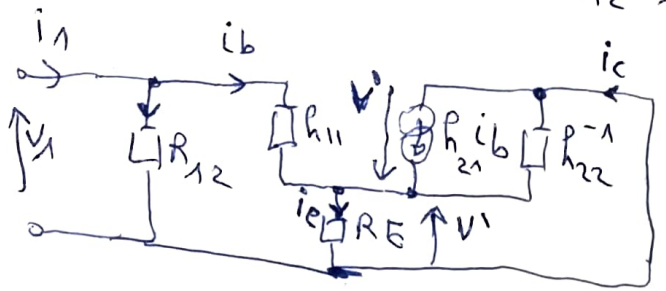
A.N. : $I_{CQ} = 5{,}3$ mA

$V_{CE} = V_{CEQ} = V_{CC} - R_E I_{EQ} \approx V_{CC} - R_C I_{CQ}$

A.N. : $V_{CEQ} = 2{,}5$ V

3) Résistance d'entrée :

$R_{12} = R_1 // R_2$



$V_1 = R_{12}(i_1 - i_b)$ ——— (1)

$V_1 = h_{11} i_b + R_E i_e$ ——— (2)

$V' = R_E i_e$ ——— (3)

$V' = h_{22}^{-1}(i_c - h_{21} i_b)$ ——— (4)

$i_e = i_c + i_b$ ——— (5)

(3) = (4) $\Rightarrow$ $R_E i_e = -h_{22}^{-1}\left(i_c - h_{21} i_b\right)$

(5) $\longrightarrow$ (6) :

$$R_E(i_c + i_b) = -h_{22}^{-1}\left(i_c - h_{21} i_b\right) \quad (6)$$

$$\Rightarrow \left(R_E + h_{22}^{-1}\right) i_c = \left(h_{22}^{-1} h_{21} - R_E\right) i_b$$

$$\Rightarrow i_c = \frac{h_{21} h_{22}^{-1} - R_E}{R_E + h_{22}^{-1}} i_b \quad (7)$$

(7) $\longrightarrow$ (5) :

$$i_e = \left(\frac{h_{21} h_{22}^{-1} - R_E}{R_E + h_{22}^{-1}} + 1\right) i_b$$

$$\Rightarrow i_e = \frac{h_{21} h_{22}^{-1} + h_{22}^{-1}}{R_E + h_{22}^{-1}} \cdot i_b \quad (8)$$

(8) $\longrightarrow$ (2) :

$$V_1 = h_{11} i_b + R_E \cdot \frac{(h_{21}+1)\, h_{22}^{-1}}{R_E + h_{22}^{-1}} i_b$$

$$\Rightarrow i_b = \frac{V_1}{h_{11} + R_E \cdot \frac{(h_{21}+1) h_{22}^{-1}}{R_E + h_{22}^{-1}}} \quad (9)$$

(9) $\longrightarrow$ (1) :

$$V_1 = R_{12} i_1 - R_{12} \cdot \frac{V_1}{h_{11} + R_E \frac{(h_{21}+1) h_{22}^{-1}}{R_E + h_{22}^{-1}}}$$

$$\Rightarrow V_1 \left[1 + R_{12} \cdot \frac{1}{h_{11} + R_E \frac{(h_{21}+1) h_{22}^{-1}}{R_E + h_{22}^{-1}}}\right] = R_{12} i_1$$

$$\Rightarrow R_e = \frac{V_1}{i_1} = \frac{R_{12}}{1 + R_{12} \frac{1}{h_{11} + R_E \frac{(h_{21}+1) h_{22}^{-1}}{R_E + h_{22}^{-1}}}}$$

h_{22} $h_{22}^{-1} = \frac{V_A}{I_{CQ}} = \frac{90}{5{,}3 \times 10^{-3}} \Rightarrow h_{22}^{-1} \approx 17\ k\Omega$

$h_{22}^{-1} \approx 17\ k\Omega$

$h_{11} = \beta \frac{V_T}{I_{CQ}} = 156 \cdot \frac{26 \cdot 10^{-3}}{5{,}3\ 10^{-3}} = 762{,}72\ \Omega$

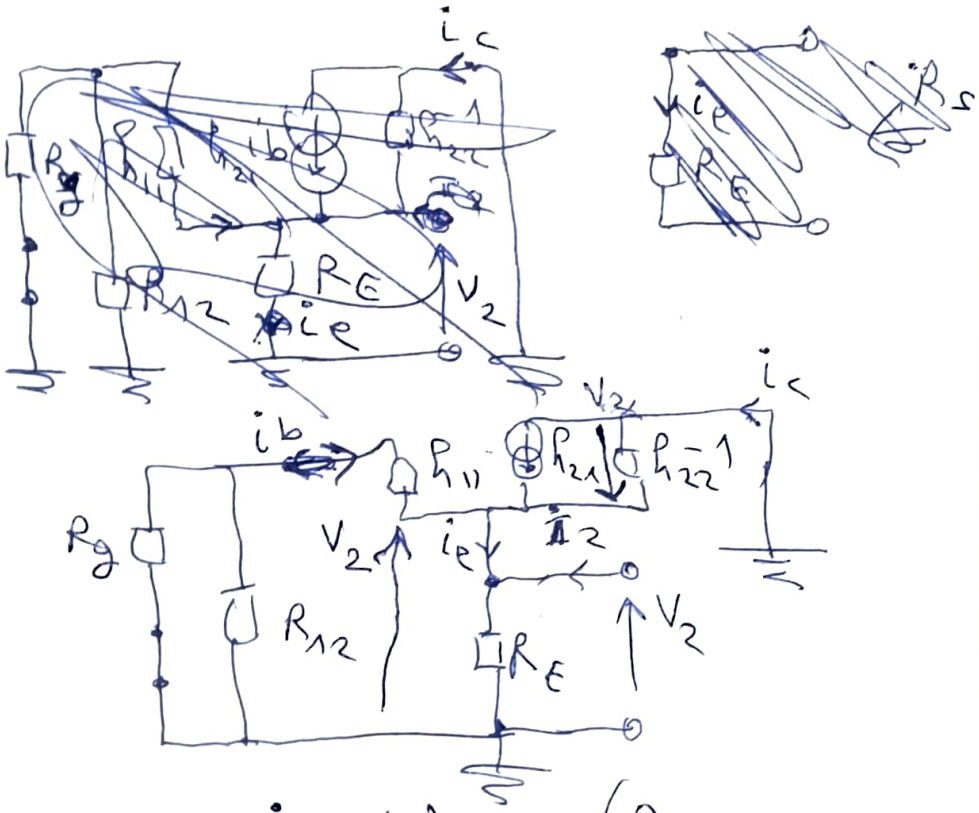
$\Rightarrow R_e \approx 13{,}148\ k\Omega$ à vide

③ $R_e(\text{en charge}) = R_e(\text{à vide})$

$RE \Rightarrow RE \,//\, R_L$

$R_e(\text{en charge}) = 11{,}45\ k\Omega$

④ Résistance de sortie :



$V_2 = R_E(i_2 + i_e)$ — (1)

$V_2 = -h_{22}^{-1}(i_c - h_{21} i_b)$ — (2)

$V_2 = ((R_g // R_{12}) + h_{11}) \cdot i_b$ — (3)

$i_e = i_c + i_b$ — (4)

(3) $\Rightarrow$ $i_b = \dfrac{-V_2}{(R_g // R_{12}) + h_{11}}$ — (5)

(5) $\rightarrow$ (2) :

$$V_2 = -h_{22}^{-1} i_c - h_{21} h_{22}^{-1} \cdot \frac{V_2}{(R_g // R_{12}) + h_{11}}$$

$$\Rightarrow i_c = -\frac{\dfrac{h_{21} h_{22}^{-1}}{(R_g // R_{12}) + h_{11}} + 1}{h_{22}^{-1}} \cdot V_2$$ — (6)

(5) & (6) $\rightarrow$ (4) :

$$i_e = \left[\frac{1}{(R_g // R_{12}) + h_{11}} + \frac{\dfrac{h_{21} h_{22}^{-1}}{(R_g // R_{12}) + h_{11}} + 1}{h_{22}^{-1}} \right] V_2$$ — (7)

(7) ⟶ (1) :

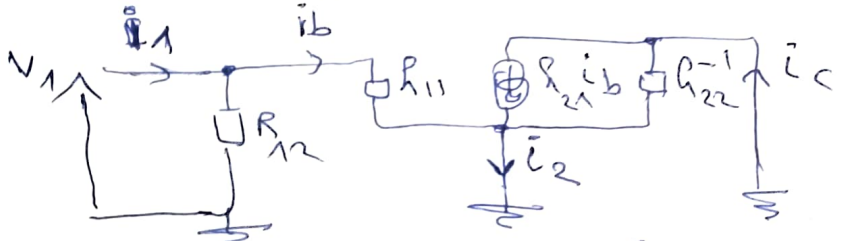
$$V_2 = R_E i_2 = R_E \left[\frac{1}{(R_g // R_{12}) + h_{11}} + \frac{\frac{h_{21} h_{22}^{-1}}{(R_g // R_{12}) + h_{11}} - 1}{h_{22}^{-1}} \right] V_2$$

$$R_s = \frac{V_2}{i_2} = \frac{R_E}{1 + R_E \left[\frac{1}{(R_g // R_{12}) + h_{11}} + \frac{\frac{h_{21} h_{22}^{-1}}{(R_g // R_{12}) + h_{11}} + 1}{h_{22}^{-1}} \right]}$$

A.N. :

$R_s = 7{,}68\ \Omega$

(5) Gain en courant de court-circuit ($R_L = 0$)



$V_1 = R_{12}(I_1 - i_b)$ — (1)

$V_1 = h_{11} i_b$ — (2)

$i_2 = i_b + i_c$, $i_c = h_{21} i_b$

Car : $V_{h_{22}^{-1}} = 0$

$\Rightarrow i_2 = i_b + h_{21} i_b$ — (3)

$\Rightarrow i_2 = (h_{21} + 1) i_b$ — (3)

(1) = (2) : $R_{12}(i_1 - i_b) = h_{11} i_b$

$\Rightarrow R_{12} i_1 = (R_{12} + h_{11}) i_b$ — (4)

$\frac{(3)}{(4)}$: $G_{is} = \frac{i_2}{i_1} = \frac{(h_{21} + 1) R_{12}}{R_{12} + h_{11}}$

A.N. : $G_{is} = 150$

(6) Schéma équivalent :

$G_i = \frac{i_L}{i_1}$, $i_L = \frac{R_s}{R_s + R_L} \cdot G_{is}\, i_1$

A.N. : $G_i = 2{,}4$ $\Rightarrow G_i = G_{is} \cdot \frac{R_s}{R_s + R_L}$