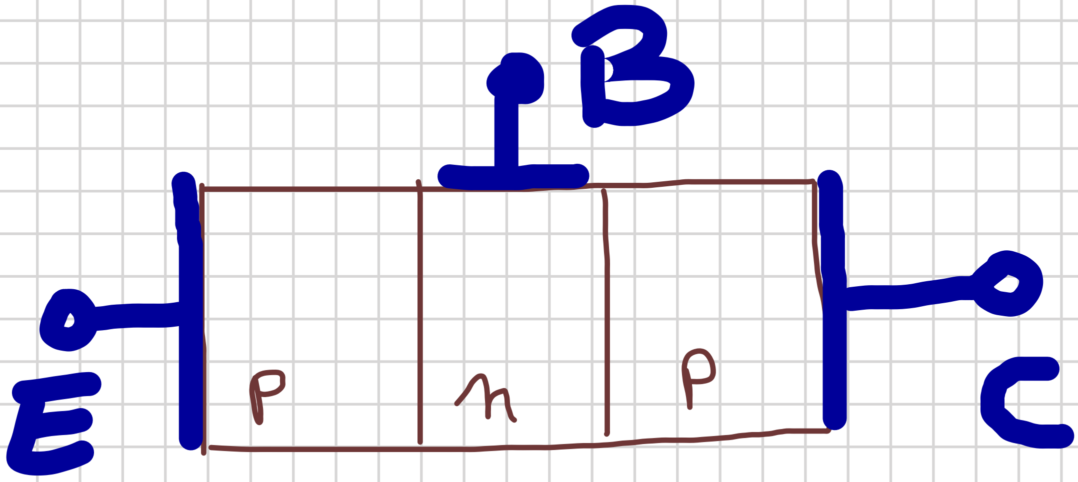
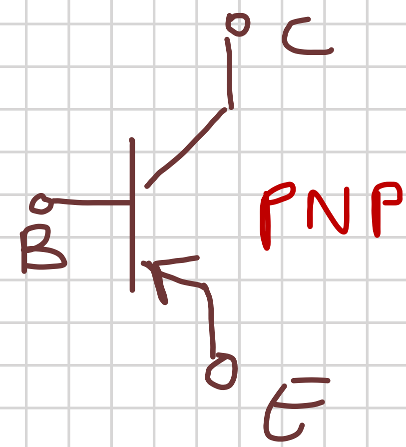
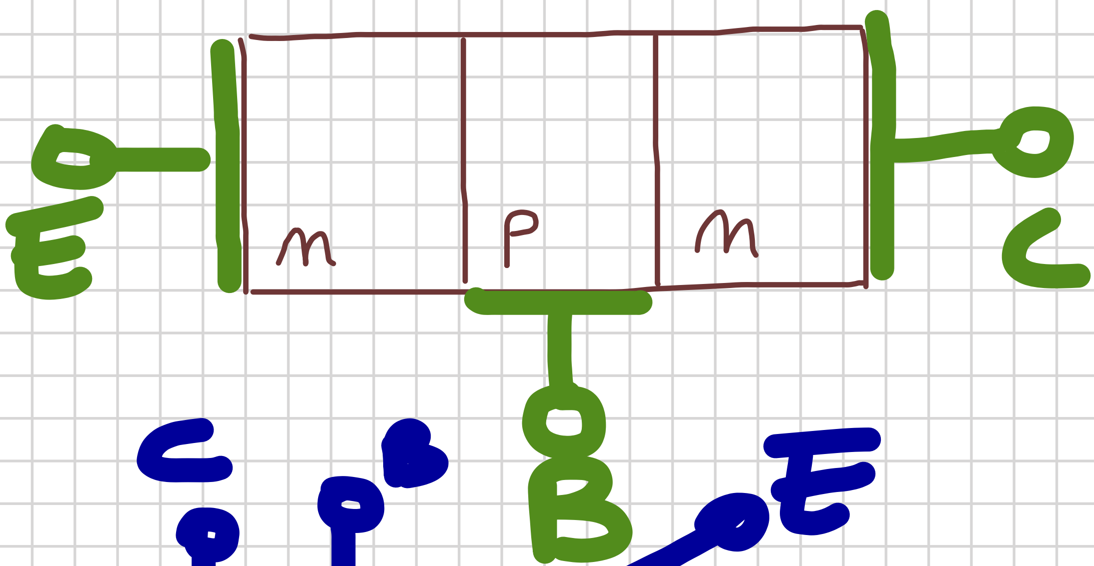
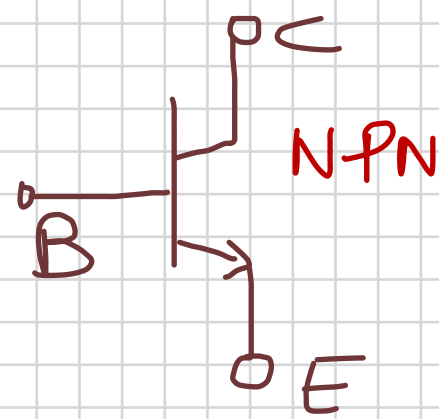
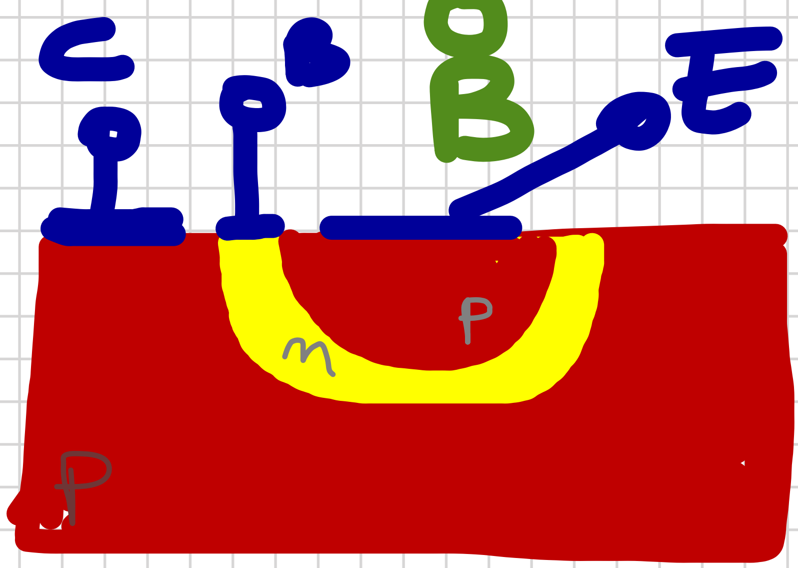
BJT

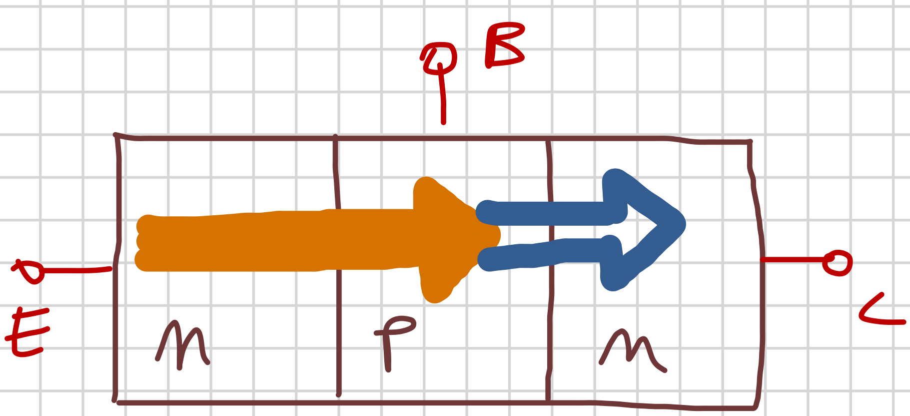


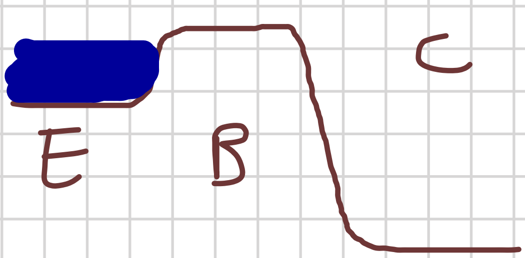


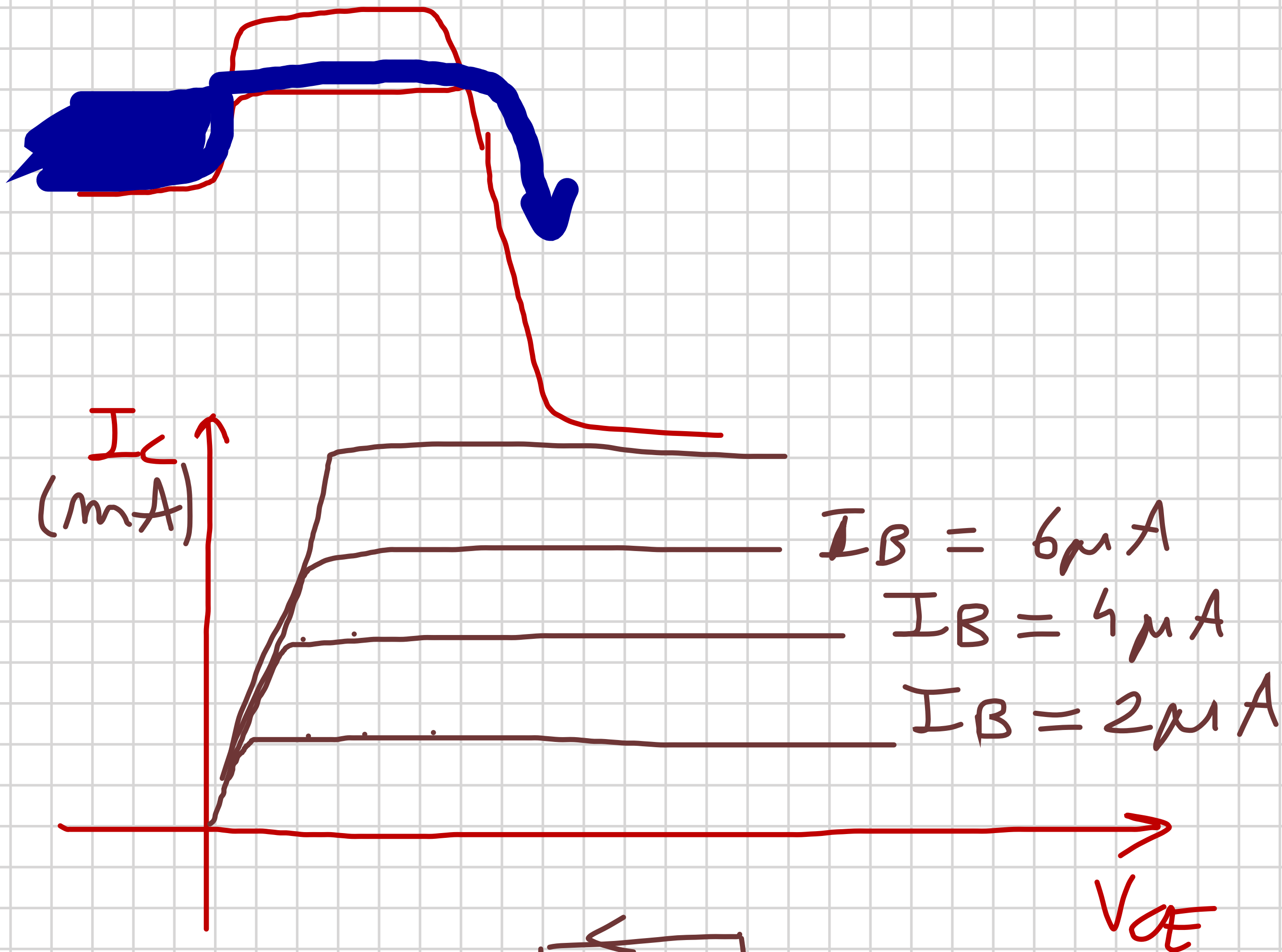




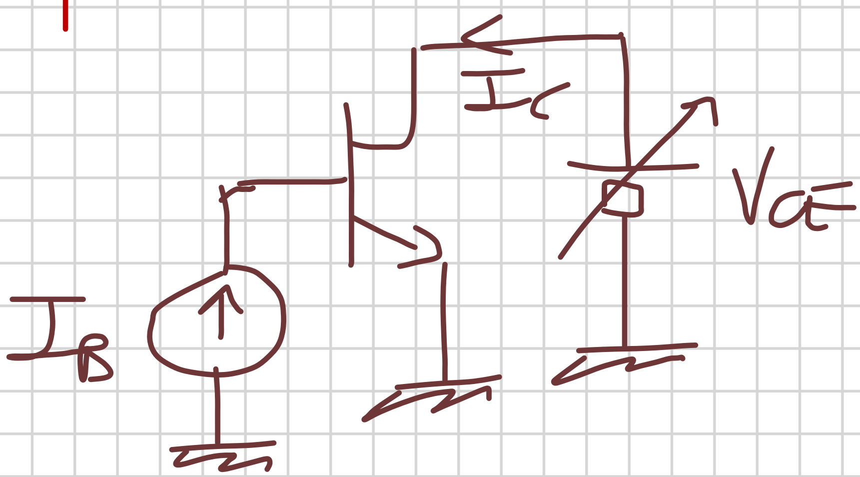




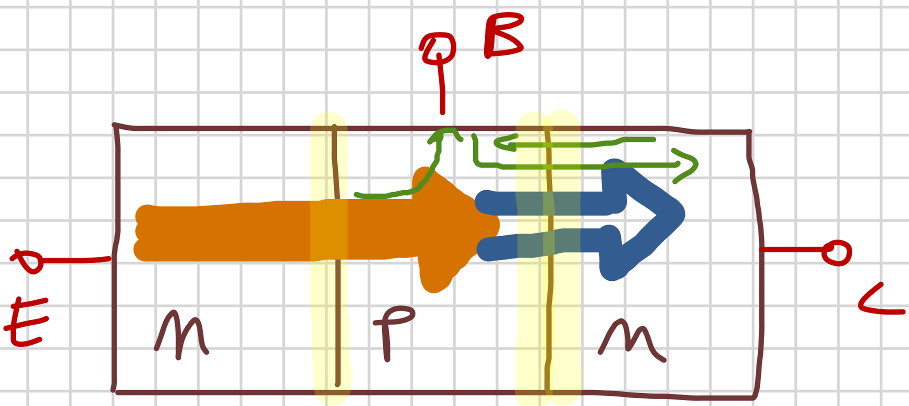




Ic
(mA)
IB = 6μA
IB = 4μA
IB = 2μA
VCE



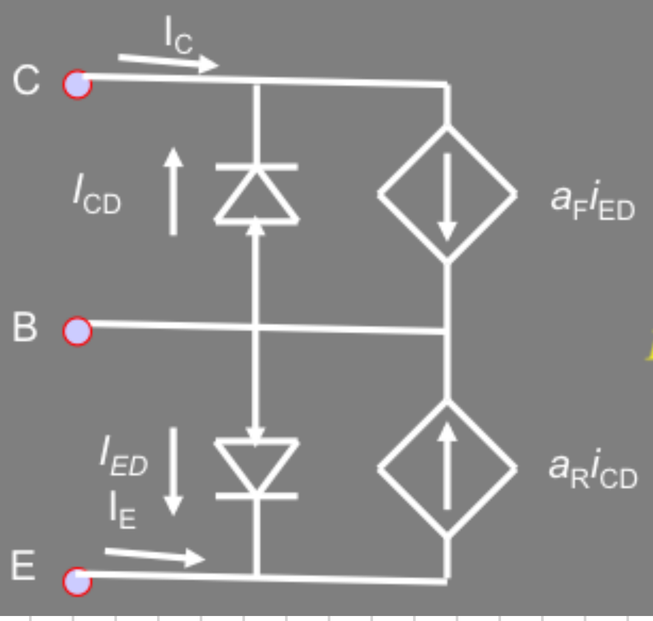
Ic
VCE
IB



B
E
C
n
p
n

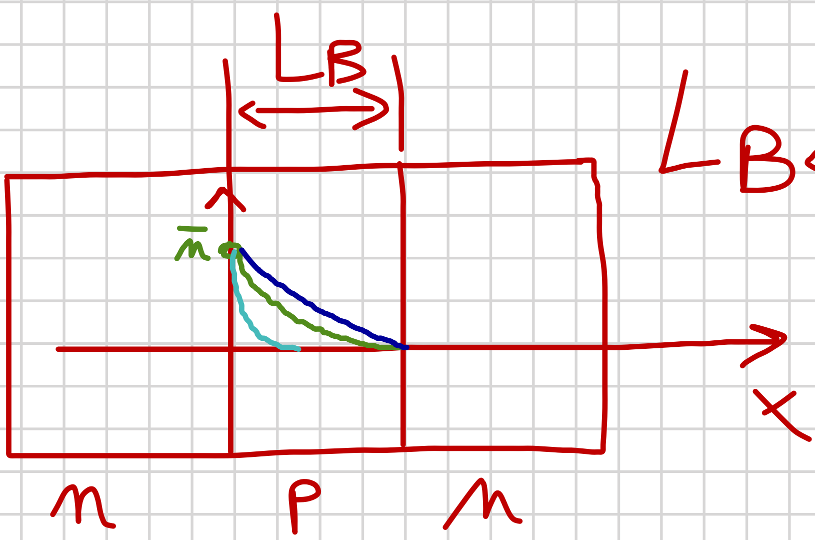
Modello di Ebers e Moll

- Occorre introdurre in parallelo ai diodi dei generatori di corrente
  - Proporzionali alla corrente nella giunzione opposta
    - I diodi seguono la legge di Schokley
    - Nel caso ideale si ha $a_R I_{SCB} = a_F I_{SEB}$

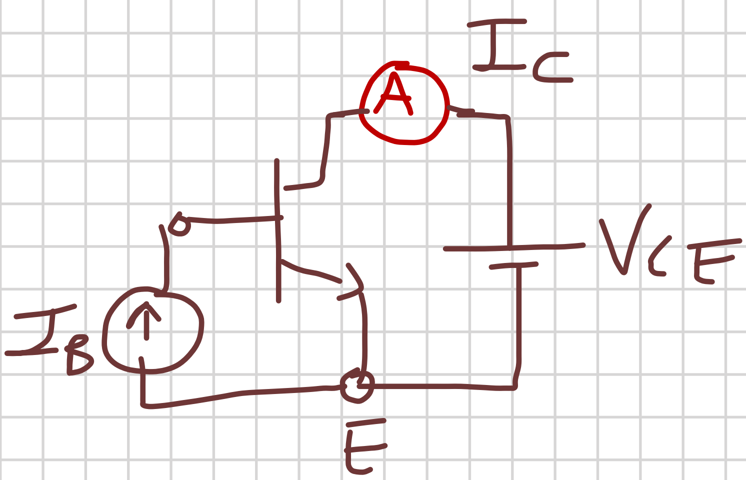


$$I_E = -I_{SEB}\left(e^{\frac{V_{BE}}{V_T}}-1\right)+a_R I_{SCB}\left(e^{\frac{V_{BC}}{V_T}}-1\right)$$

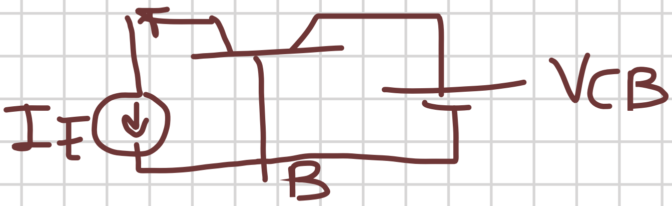
$$I_C = -I_{SCB}\left(e^{\frac{V_{BC}}{V_T}}-1\right)+a_F I_{SEB}\left(e^{\frac{V_{BE}}{V_T}}-1\right)$$



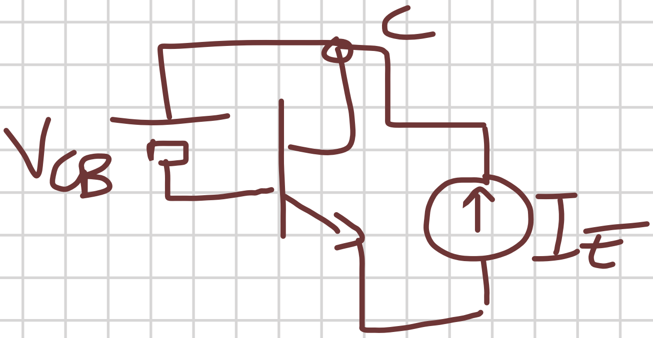
$L_B \ll L_D$



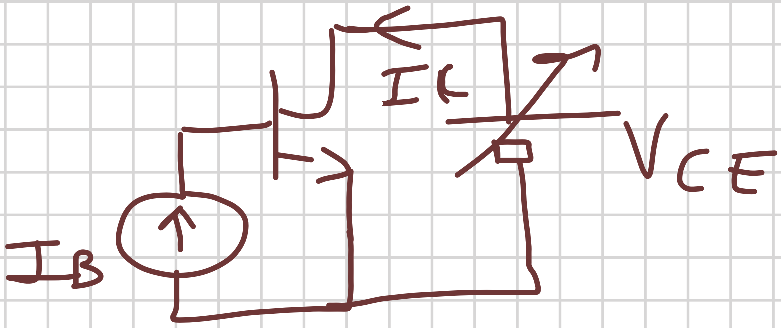
$I_C(I_B, V_{CE})$

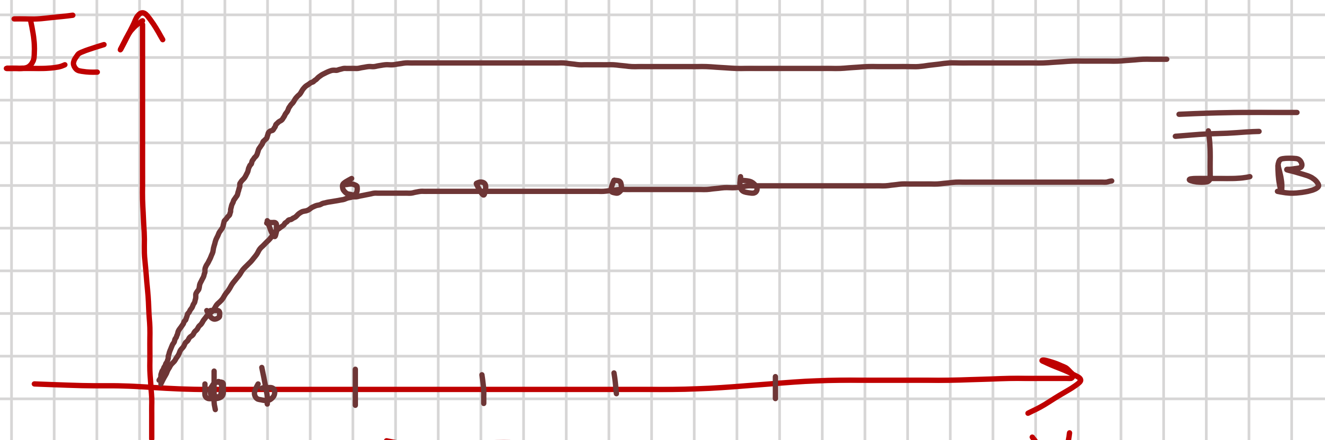


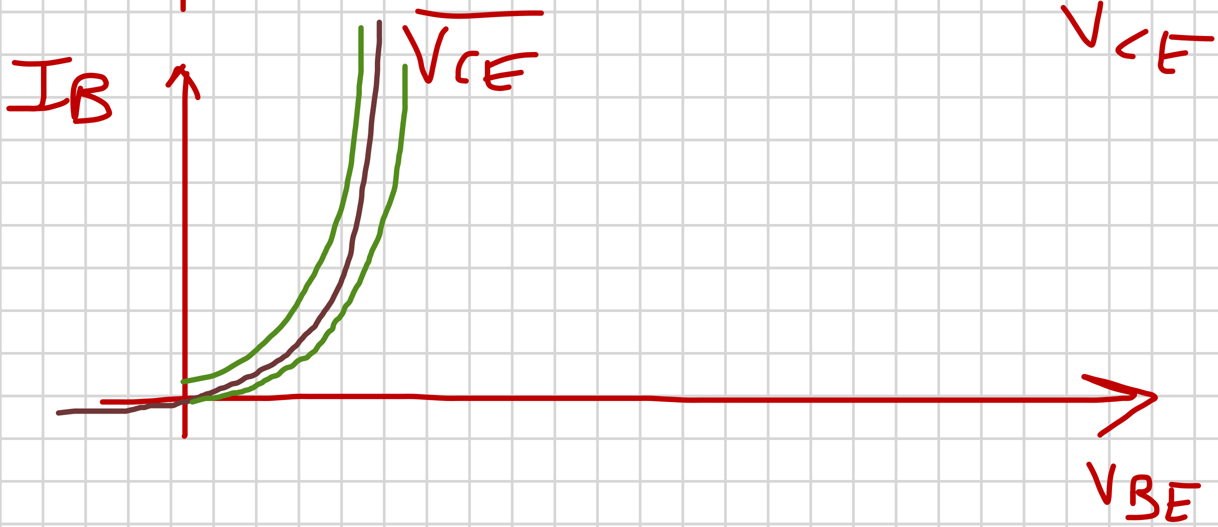
BC

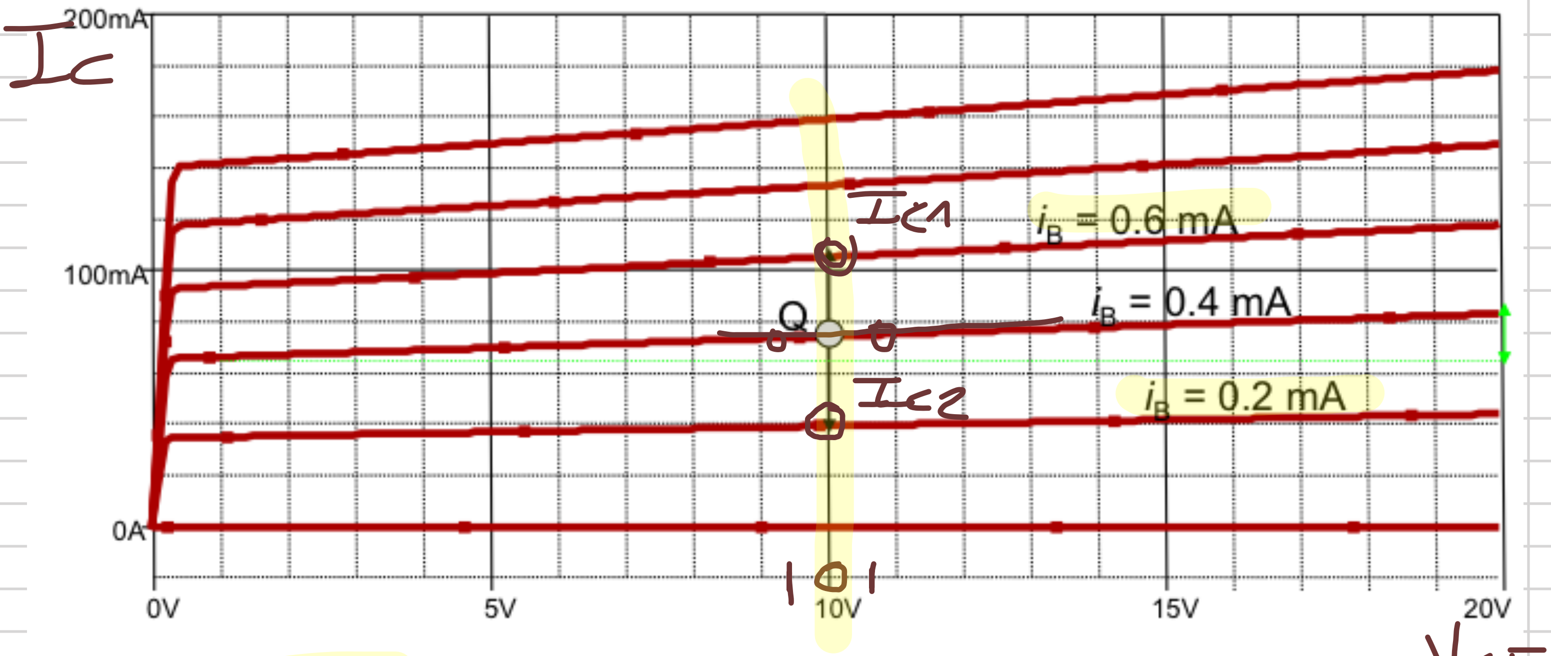


CC









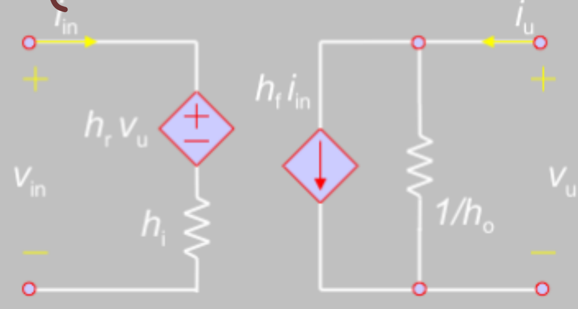
$\Delta i_C = 64$ mA $\Delta i_C = 9$ mA

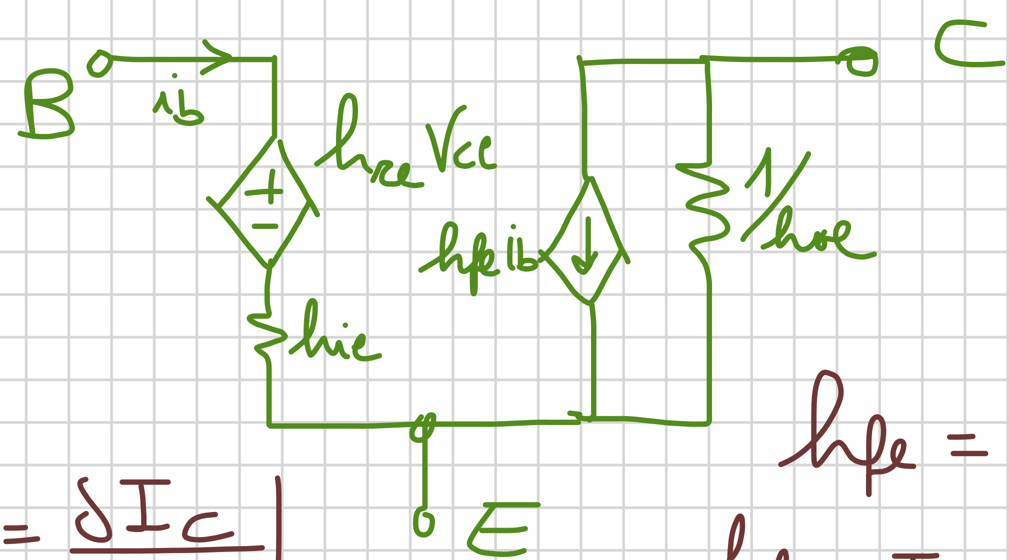
$\Delta i_B = 0.4$ mA $\Delta v_{CE} = 18$ V

$h_{fe} = 160$ $h_{oe} = 0.5$ mS

$$\begin{cases} i_u = h_f i_{in} + h_o v_u \\ v_{in} = h_i i_{in} + h_r v_u \end{cases}$$

$$\begin{cases} i_c = h_{fe}\, i_b + h_{oe} V_{ce} \\ V_{be} = h_{ie}\, i_b + h_{re} V_{ce} \end{cases}$$





$$h_{oe} = \frac{\delta I_C}{\delta V_{CE}}\Bigg|_{I_B = \text{cost}}$$

$$h_{fe} = \frac{\Delta I_C}{\Delta I_B}\Bigg|_{V_{CE}}$$

$$h_{fe} = \frac{I_{C1} - I_{C2}}{\Delta I_B}$$

$$\frac{1}{h_{ie}} = \frac{\Delta i_B}{\Delta V_{BE}}$$

$$i_C = I_S\left(e^{\frac{V_{BE}}{\eta V_T}} - 1\right) \simeq I_S e^{\frac{V_{BE}}{V_T}}$$

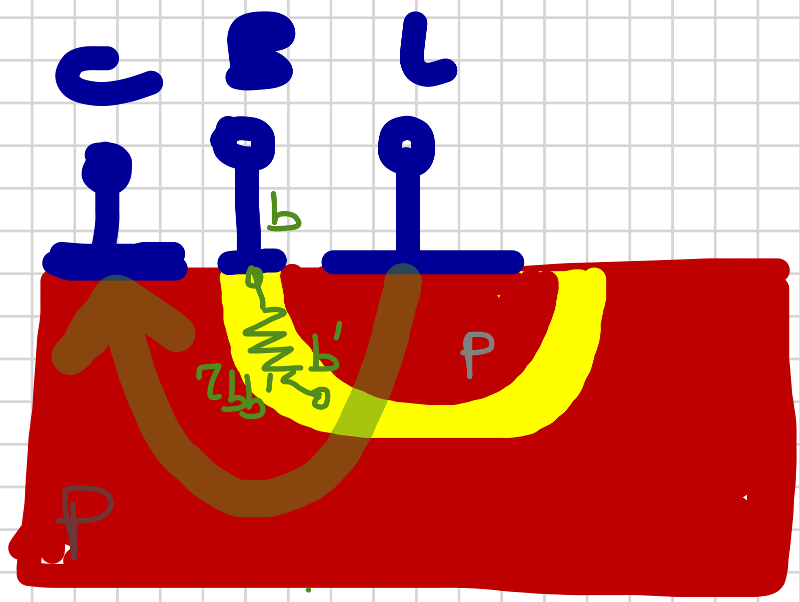
$$\boxed{\eta = 1}$$

$$i_C = \beta i_B = h_{FE} i_B$$

$$i_B = \frac{I_S}{\beta} e^{\frac{V_{BE}}{V_T}}$$

$$\frac{\Delta i_B}{\Delta V_{BE}} = \frac{i_C}{\beta V_T}$$

$$h_{ie} = r_{bb'} + r_{b'e} = r_{bb'} + \frac{\beta V_T}{I_C}$$

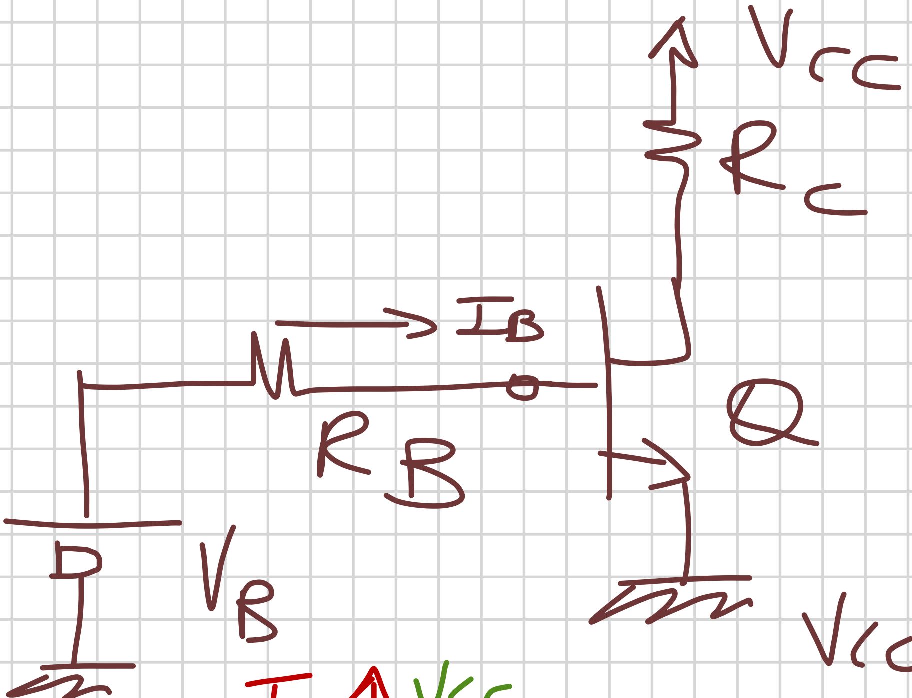


h_{ie}^* @ $I_C^* \wedge V_{CE}^*$

$$h_{ie}^* = r_{bb'} + \frac{h_{fe}^* V_T}{I_C^*}$$

$$r_{bb'} = h_{ie}^* - \frac{h_{fe}^* V_T}{I_C^*}$$

$$h_{ie}\Big|_Q = r_{bb'} + \frac{h_{fe} V_T}{I_{CQ}}$$

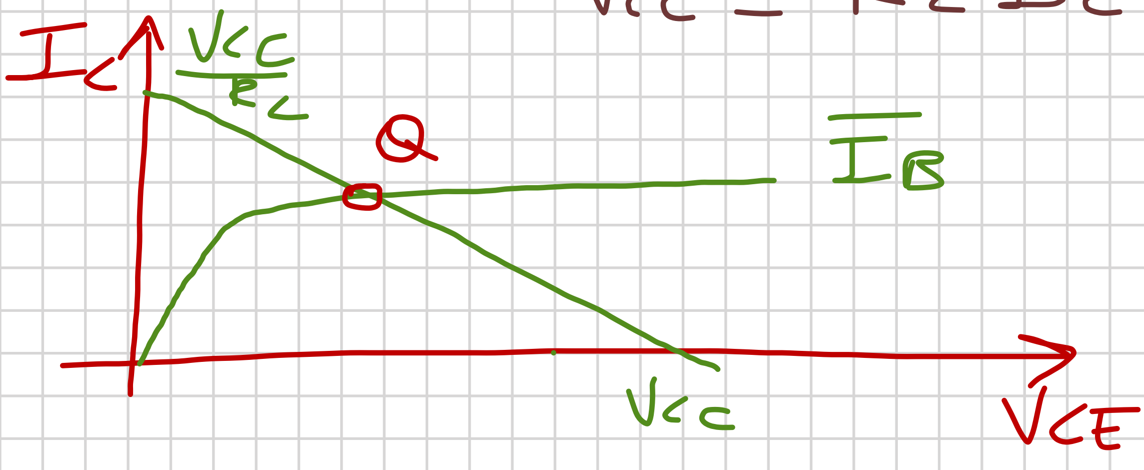


$V_{BE} = V_\gamma$

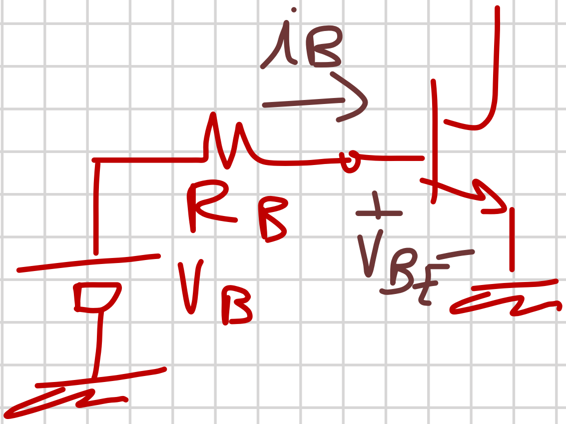
$V_B = R_B I_B + V_{BE}$

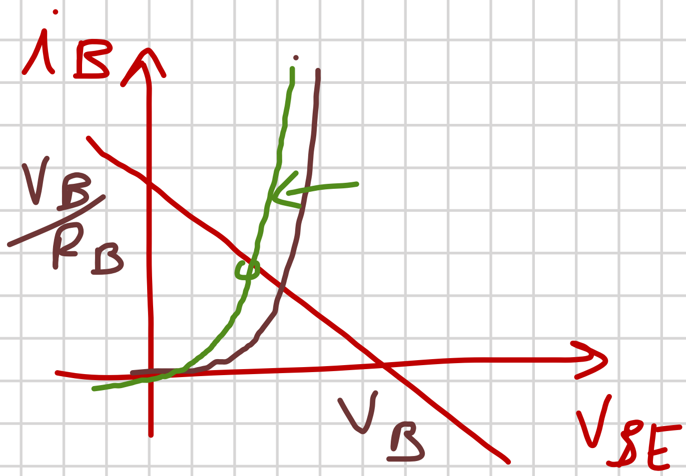
$$\frac{V_B - V_{BE}}{R_B} = \bar{I}_B$$

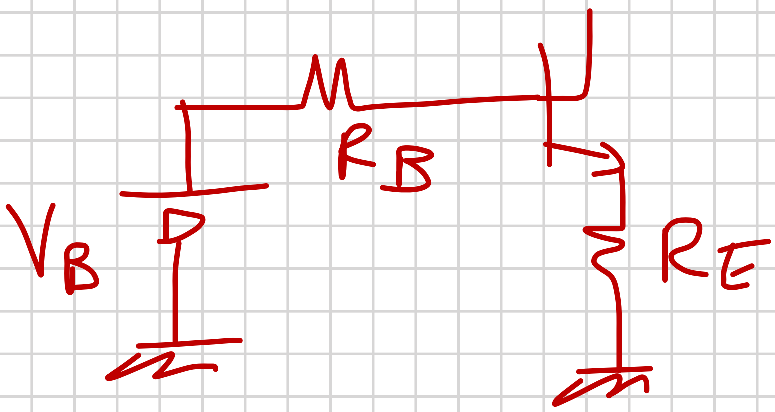
$V_{CC} = R_C I_C + V_{CE}$

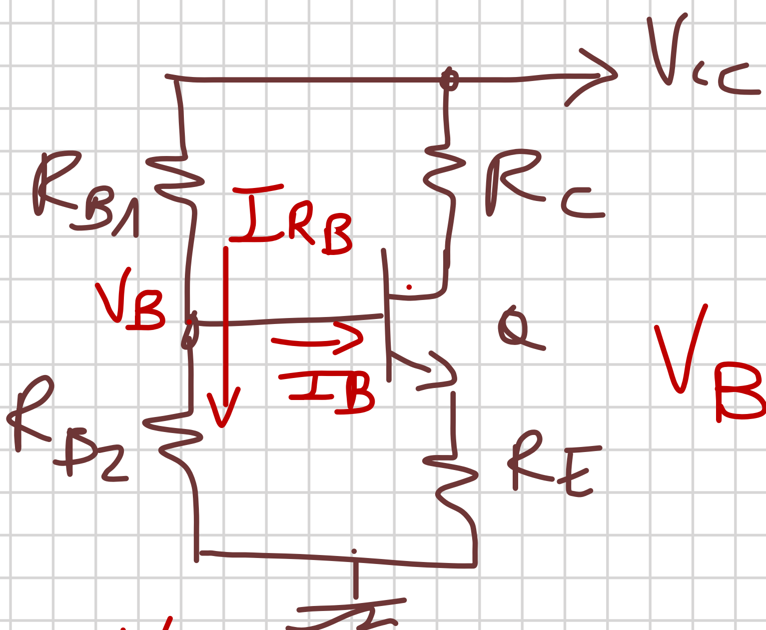


$$\frac{\partial V_\gamma}{\partial T} = \frac{V_\gamma}{T} - 0{,}072\,\eta\, V_T$$









Hp Partitore Pesante

$I_{R_B} >> I_B$

$$V_B = \frac{R_{B1}}{R_{B1}+R_{B2}} V_{CC}$$

$$V_B = V_\gamma + R_E I_E$$

$$I_E = \frac{V_B - V_\gamma}{R_E}$$

$$V_E = R_E I_C$$

$$I_C + I_B = I_E$$

$$I_B \ll I_C$$

$$\Downarrow$$

$$I_C \simeq I_E$$

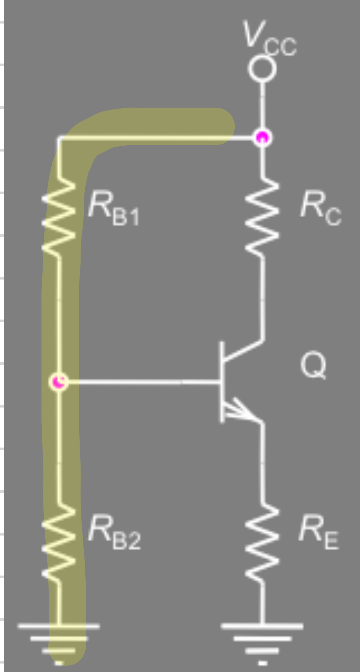
$$V_C = V_{CC} - R_C I_C$$

$$V_{CE} = V_{CC} - (R_C + R_E) I_C$$

Dalle caratteristiche mi ricavo I_B

$$\begin{cases} I_{R_B} = \dfrac{V_{CC}}{R_{B1} + R_{B2}} \gg I_B \\ \wedge \\ I_B \ll I_C \end{cases}$$

Polarizzazione con partitore



$$R_B = \frac{R_{B1} R_{B2}}{R_{B1} + R_{B2}}$$

$$V_B = V_{CC} \frac{R_{B2}}{R_{B1} + R_{B2}}$$

$$R_E i_E + v_{BE} + R_B i_B = V_B$$

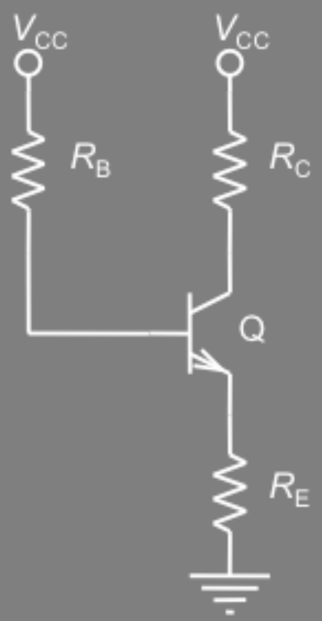
$$i_C = \beta i_B$$

$$i_E = (\beta + 1) i_B$$

$$i_B = \frac{V_B - v_{BE}}{R_B + (\beta + 1) R_E}$$

$$v_{CE} = V_{CC} - R_C i_C - R_E i_E$$

$$v_{CE} = V_{CC} - (\beta R_C + (\beta + 1) R_E) i_B$$



$$R_E i_E + v_{BE} + R_B i_B = V_{CC}$$

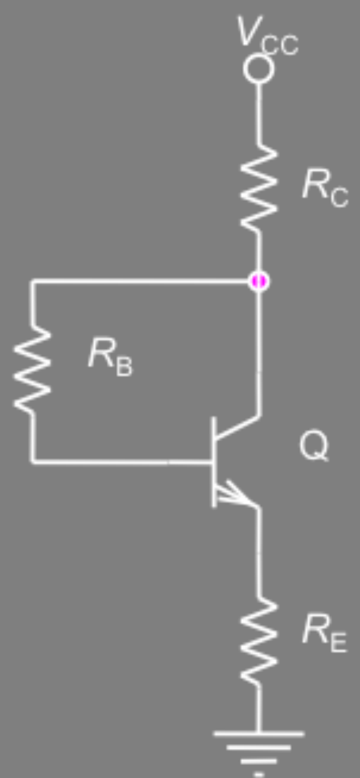
$$i_C = \beta i_B$$

$$i_E = (\beta + 1) i_B$$

$$i_B = \frac{V_{CC} - v_{BE}}{R_B + (\beta + 1) R_E}$$

$$v_{CE} = V_{CC} - R_C i_C - R_E i_E$$

$$v_{CE} = V_{CC} - (\beta R_C + (\beta + 1) R_E) i_B$$



$$(R_C + R_E) i_E + v_{BE} + R_B i_B = V_{CC}$$

$$i_C = \beta i_B$$

$$i_E = (\beta + 1) i_B$$

$$i_B = \frac{V_{CC} - v_{BE}}{R_B + (\beta + 1)(R_C + R_E)}$$

$$v_{CE} = V_{CC} - (R_C + R_E) i_E$$

$$v_{CE} = V_{CC} - (\beta + 1)(R_C + R_E) i_B$$