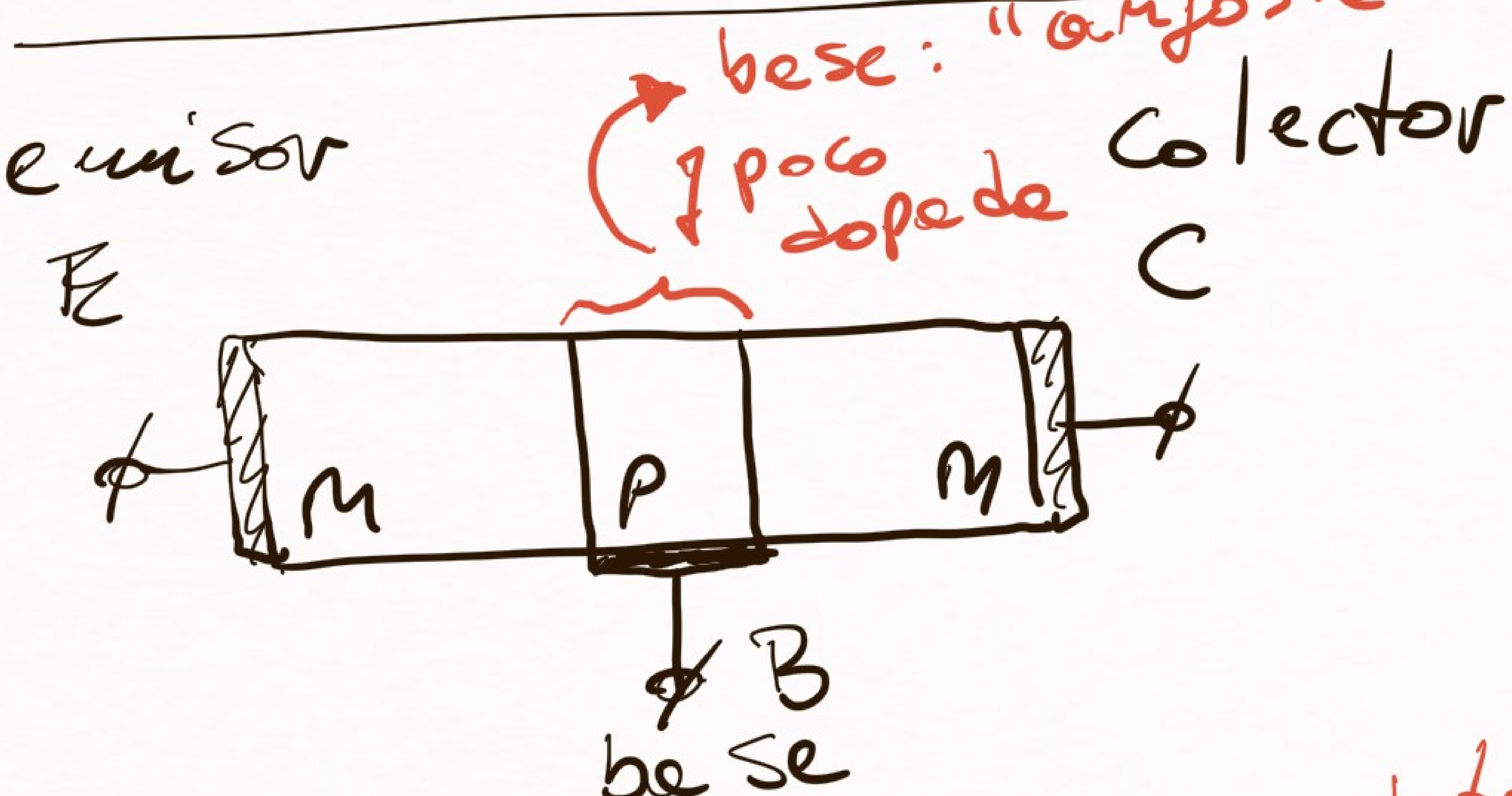
31/5/2021

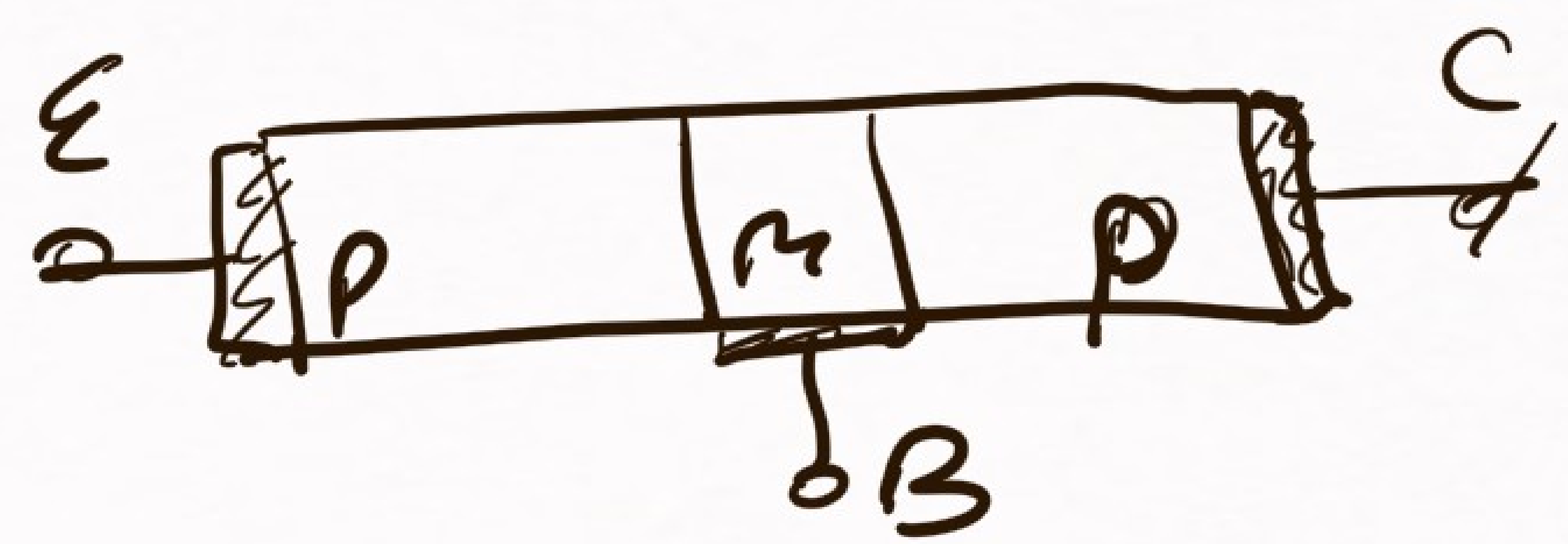
Transistor Bipolar

(Bipolar Junction Transistor)

BJT

2 tipos: npn y pnp



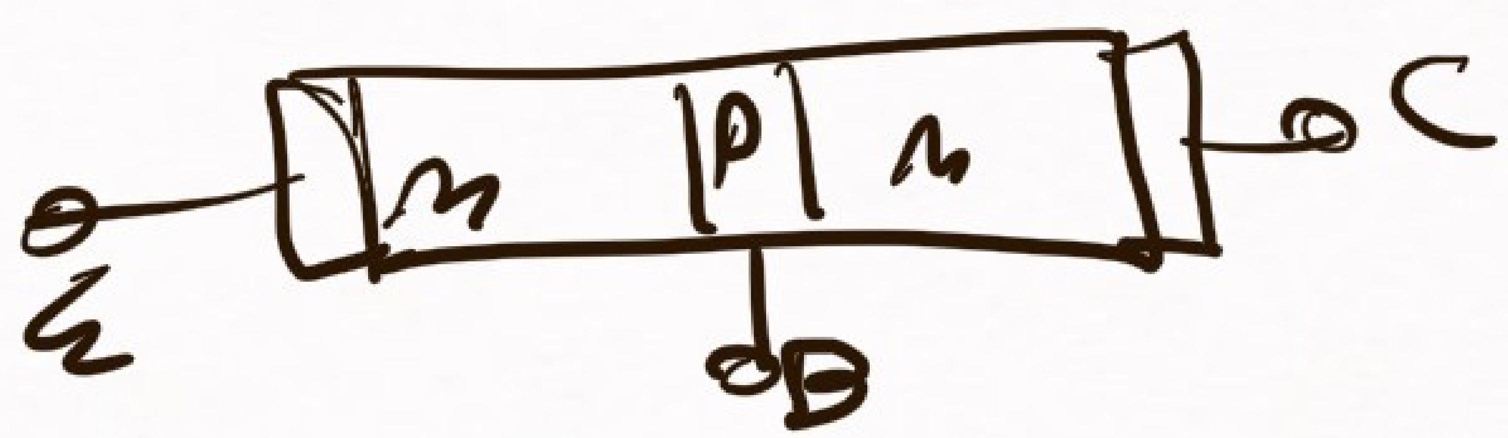


El dispositivo no es simétrico

$E \neq C$ (dopajes diferentes)

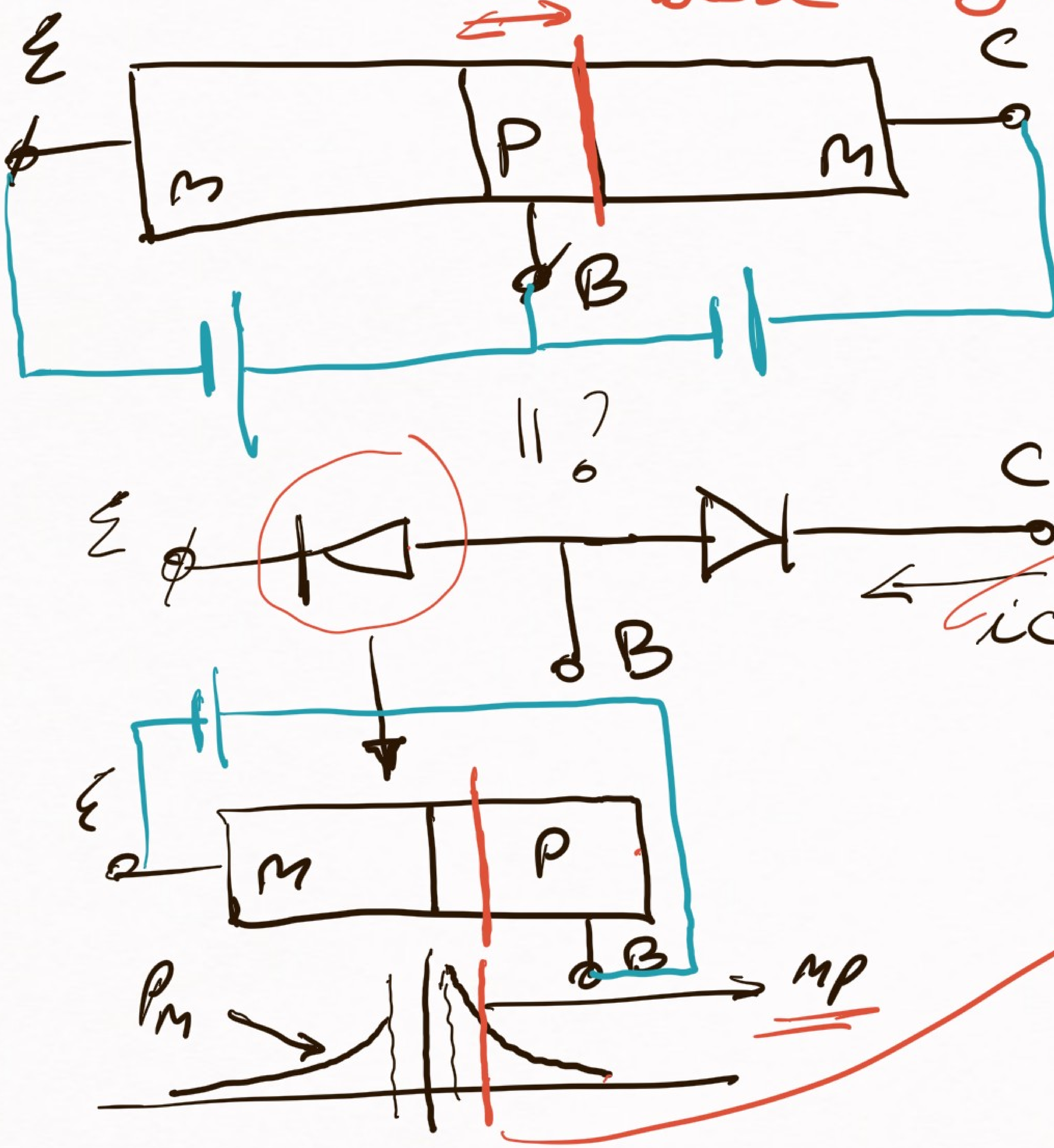
Modos de operación del BJT

Zona o Modo	Juntura B–E	Juntura B–C	Función
Corte	Inverso	Inverso	llave abierta
Activa	Directo	Inverso	Fuente de corriente (amplificador)
Saturación	Directo	Directo	~ llave cerrada
Activa inversa	Inverso	Directo	Casi no se usa "mal amplificador"



Zona Activa : B-E: Directo
B-C: Inverso

base angosta



(aunque B-C inverso)

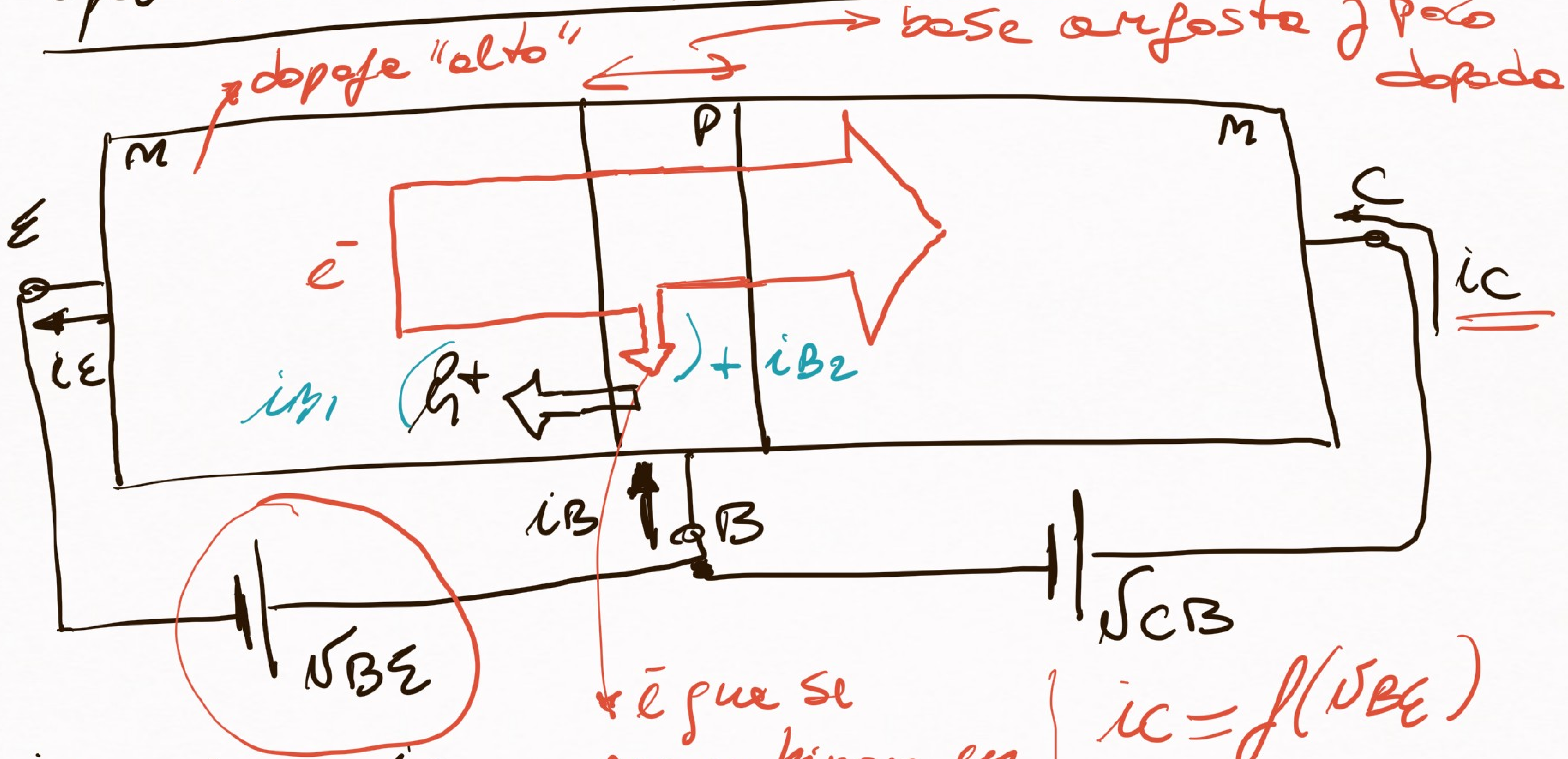
$i_C \neq 0$

$i_C \simeq 0$?

base termina por acá

⇒ en juntura B-C, se tienen muchos minoritarios del lado de la base.

Operación BJT npn en zona activa.



$$i_E = i_B + i_C$$

$$i_B = i_{B1} + i_{B2}$$

$i_C = f(v_{BE})$
e indep.
(en primera aprox.)
de v_{CB} → fuente de corriente

Ecs. y modelo del BJT npn en zona activa.

$$V_T = \frac{kT}{q}$$

$$i_E = i_C + i_B$$

$$i_C = I_S \cdot e^{v_{BE}/V_T}$$

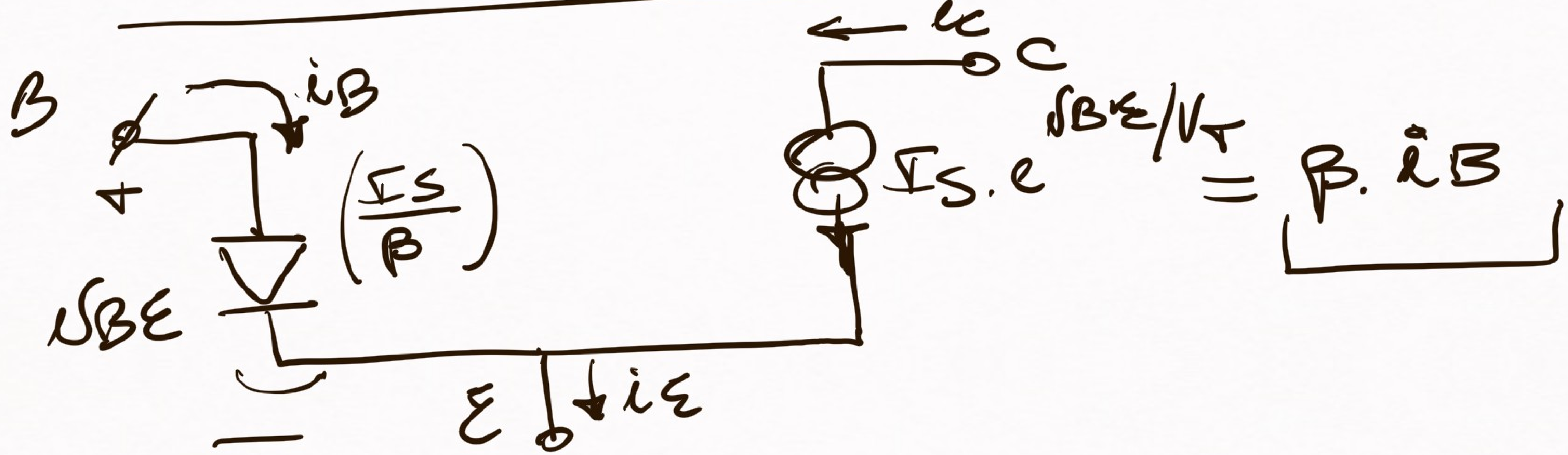
$$i_B = \frac{i_C}{\beta}$$

β: ganancia de corriente en emisor común

β: { 100 ... 200 ... 400 BJT de "señal"

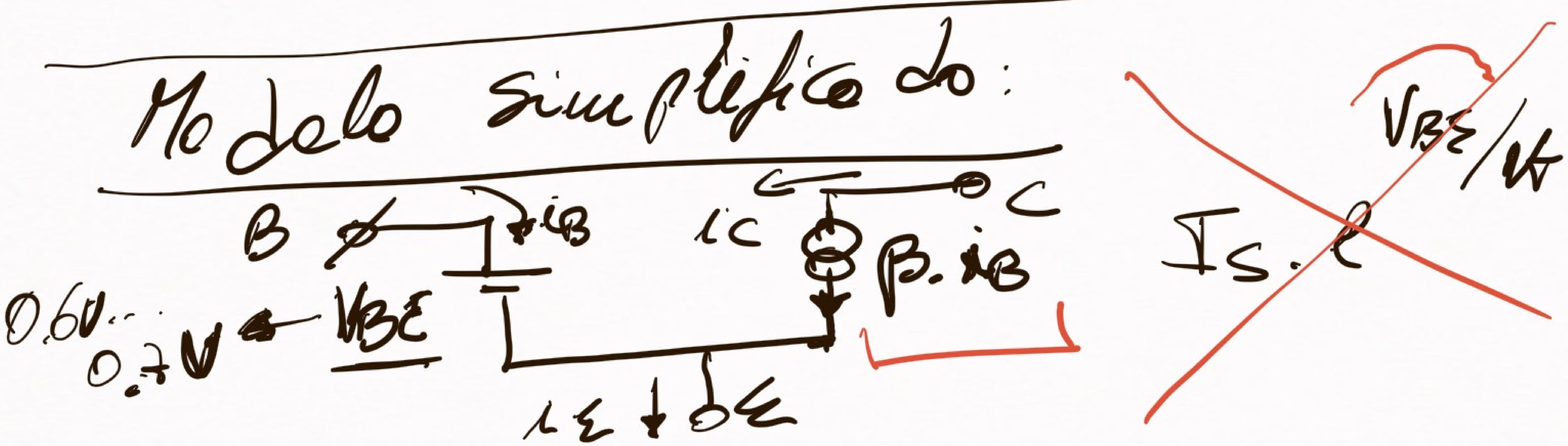
20 ... 50 ... BJT de potencia

Modelo BJT npn en zona activa

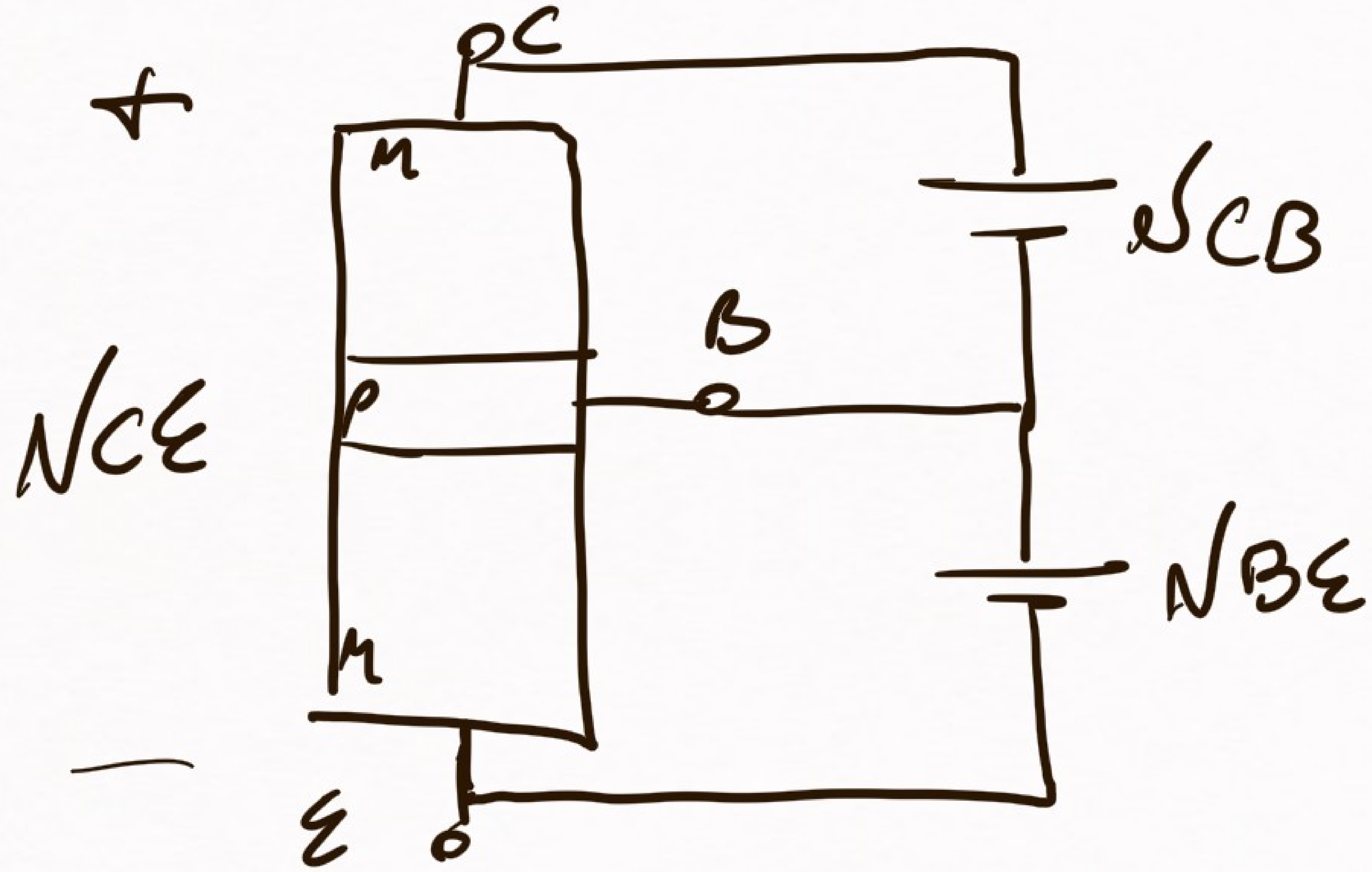


$$i_B = \frac{I_S}{\beta} \cdot e^{v_{BE}/V_T} = \frac{i_C}{\beta} \checkmark$$

Modelo simplificado:



$V_{BC} < 0.4V \dots 0.5V$



$V_{CE} = V_{CB} + V_{BE} =$

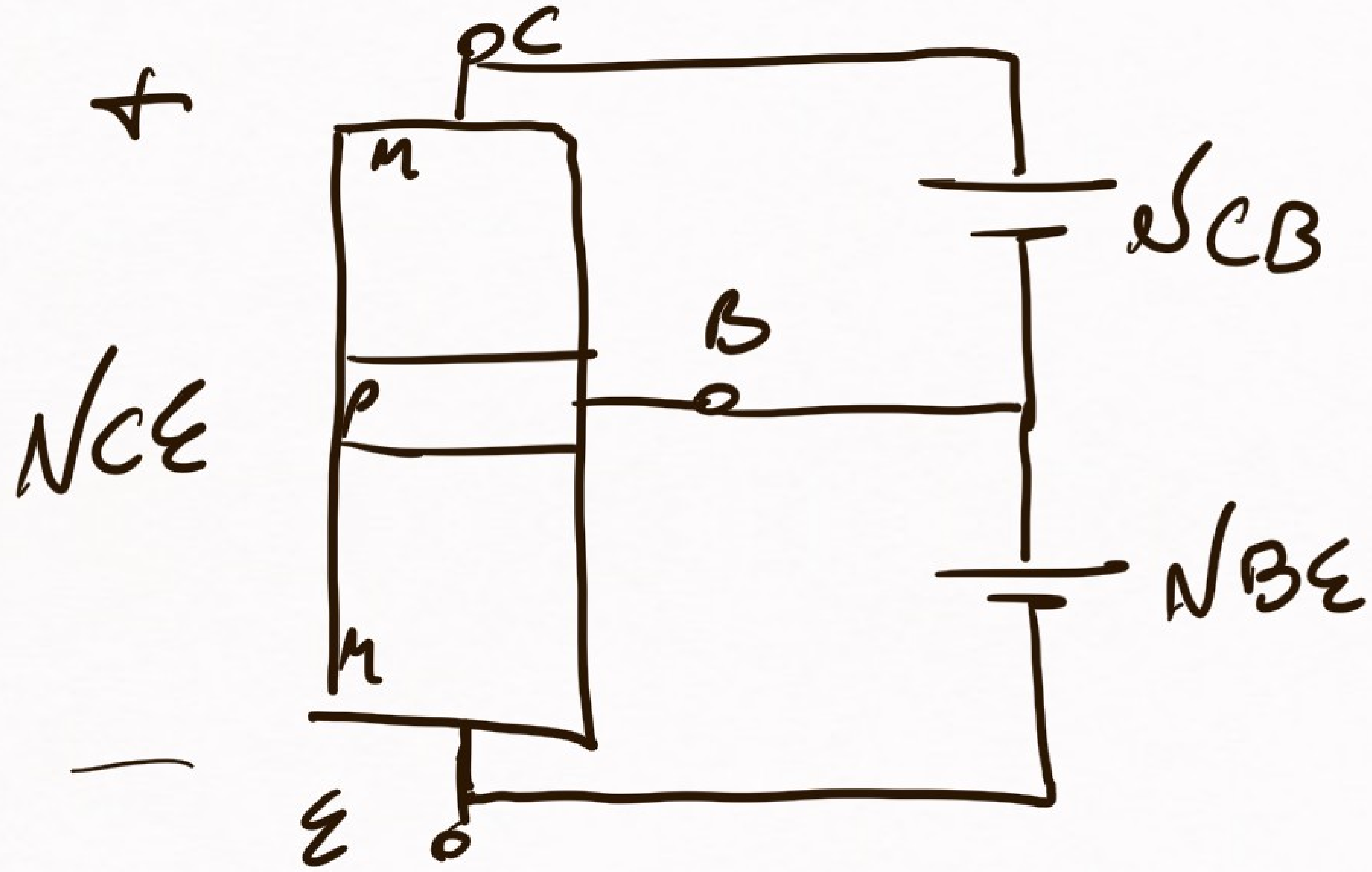
$= V_{BE} - V_{BC}$

$V_{BE} \approx 0.7V$, $V_{BC} < 0.4V \dots 0.5V$

$\Longleftrightarrow V_{CE} > V_{CESAT} = 0.3V \dots 0.2V.$ No saturación

$i_C > 0$ No corte

$V_{BC} < 0.4V \dots 0.5V$



$V_{CE} = V_{CB} + V_{BE} =$

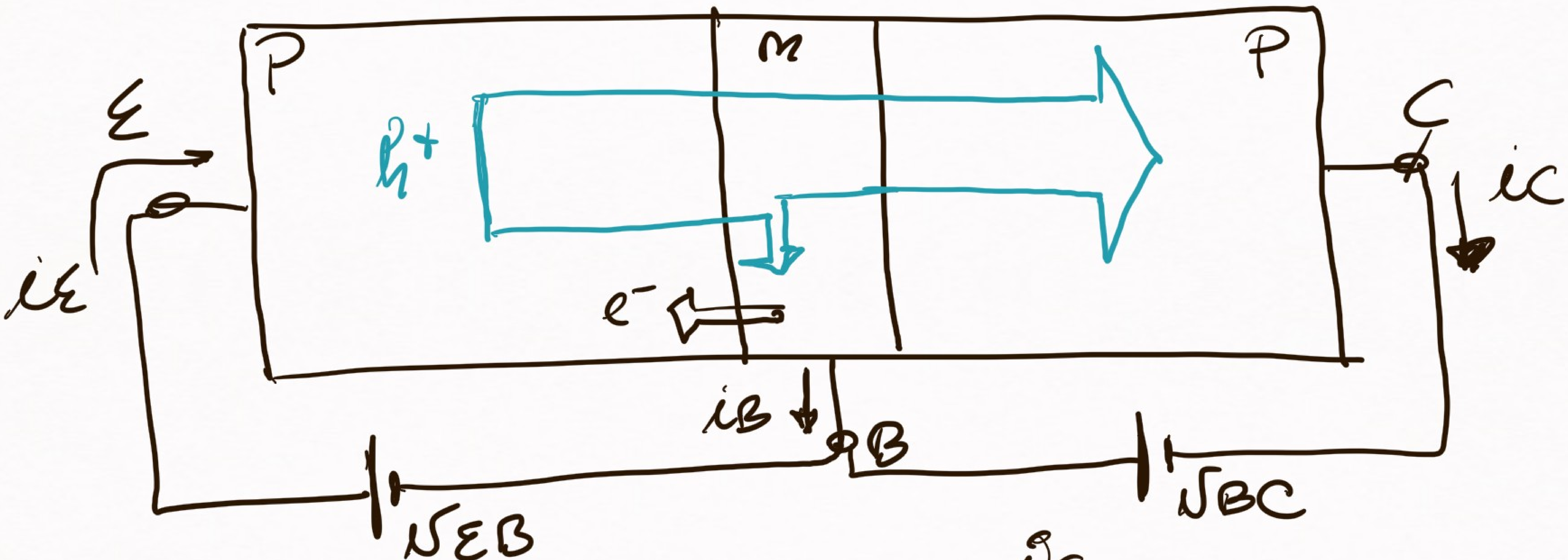
$= V_{BE} - V_{BC}$

$V_{BE} \approx 0.7V$, $V_{BC} < 0.4V \dots 0.5V$

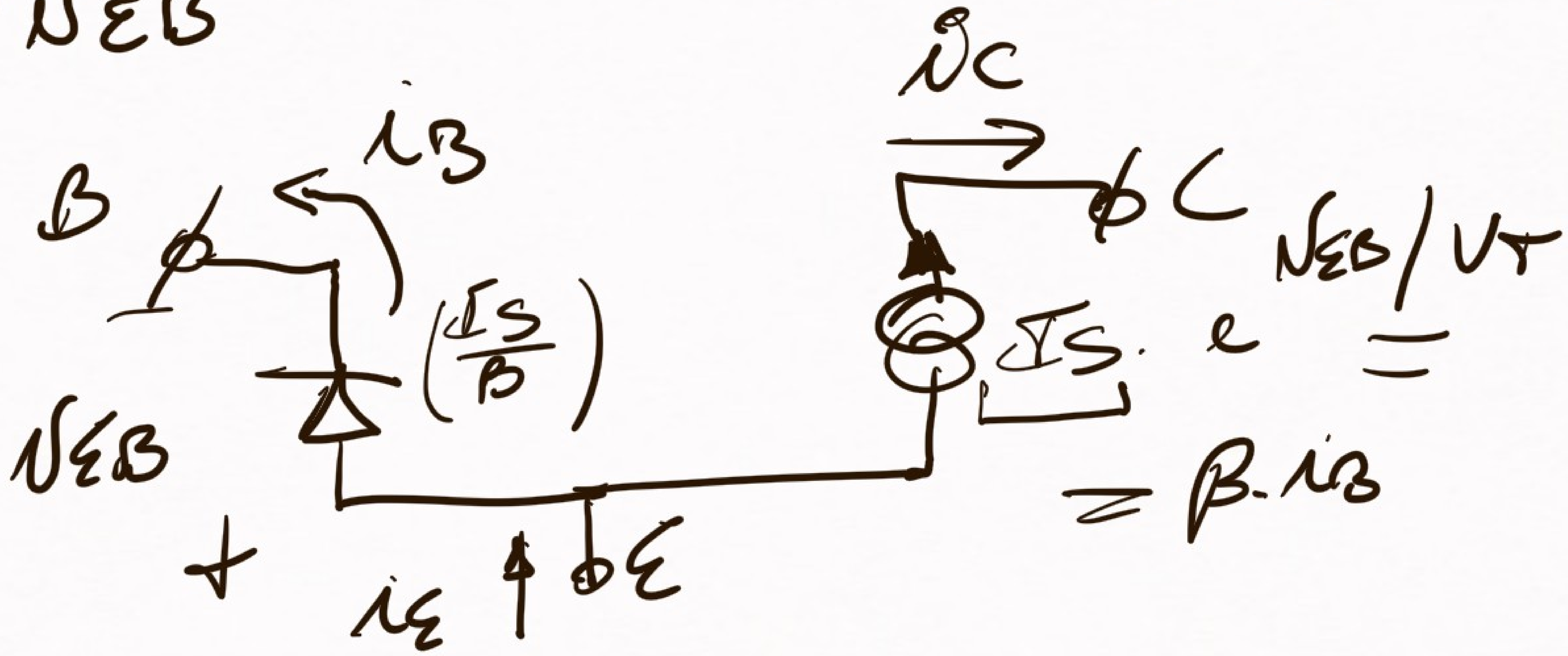
$\Leftrightarrow$ $V_{CE} > V_{CESAT} = 0.3V \dots 0.2V.$ No saturación

$i_C > 0$ No corte

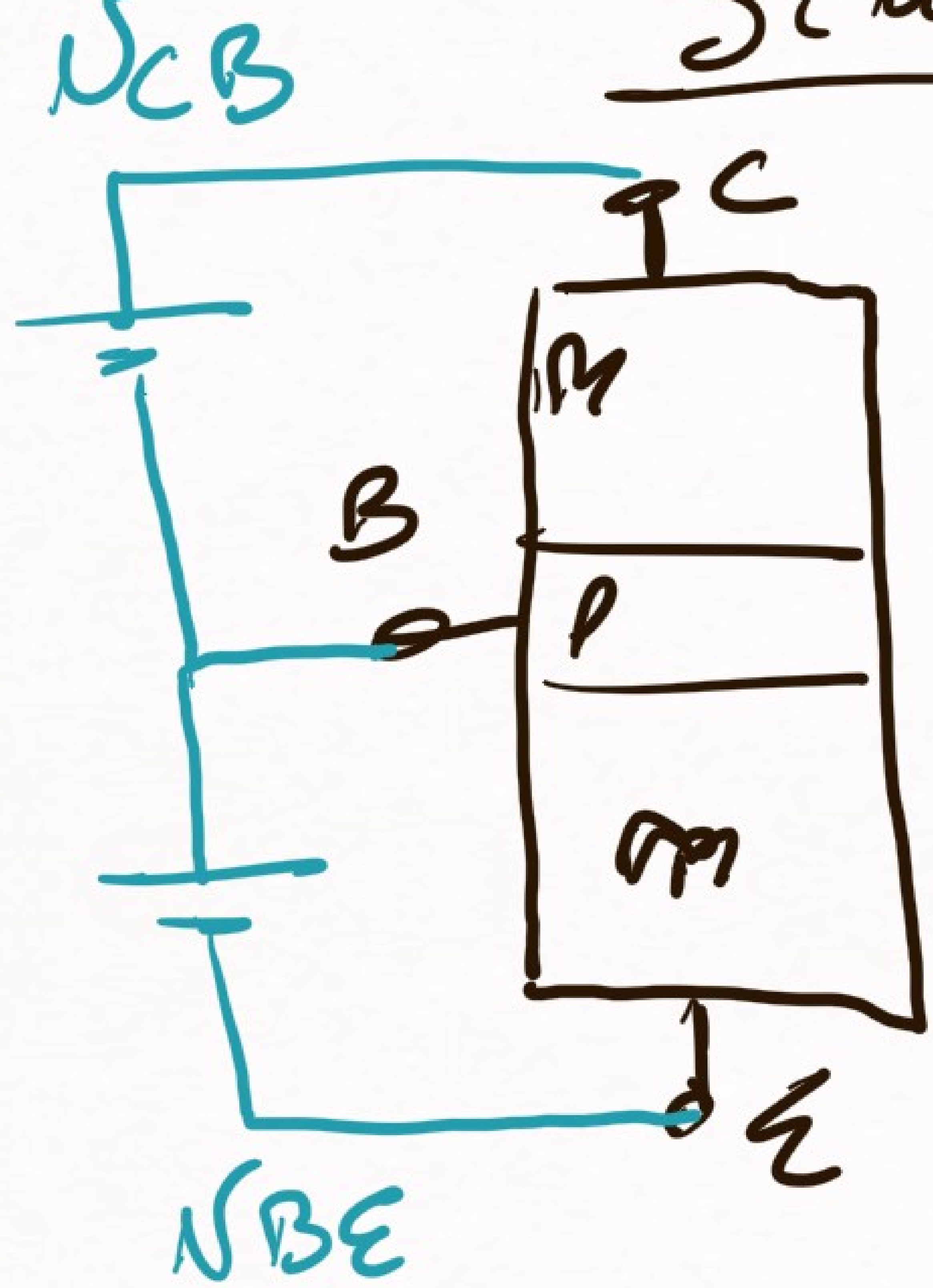
Transistor pnp (en z. Activa)

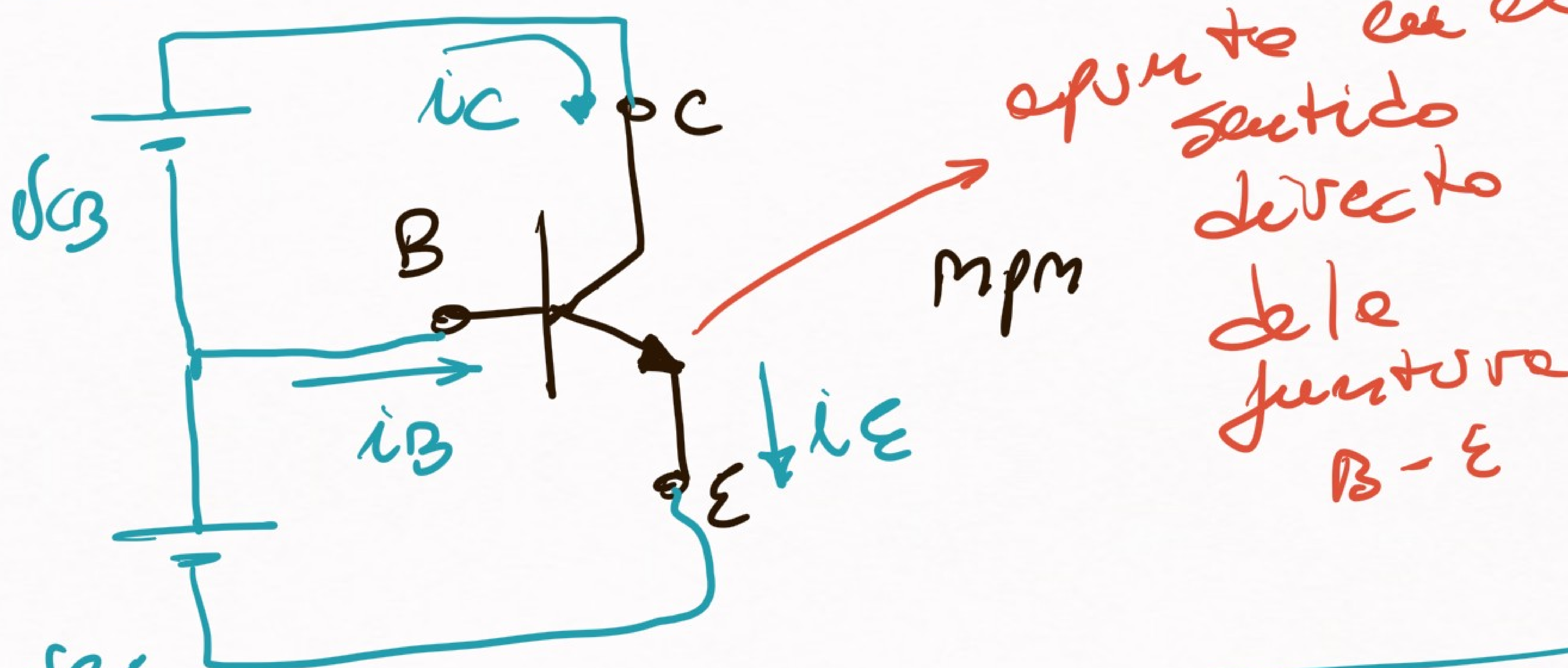


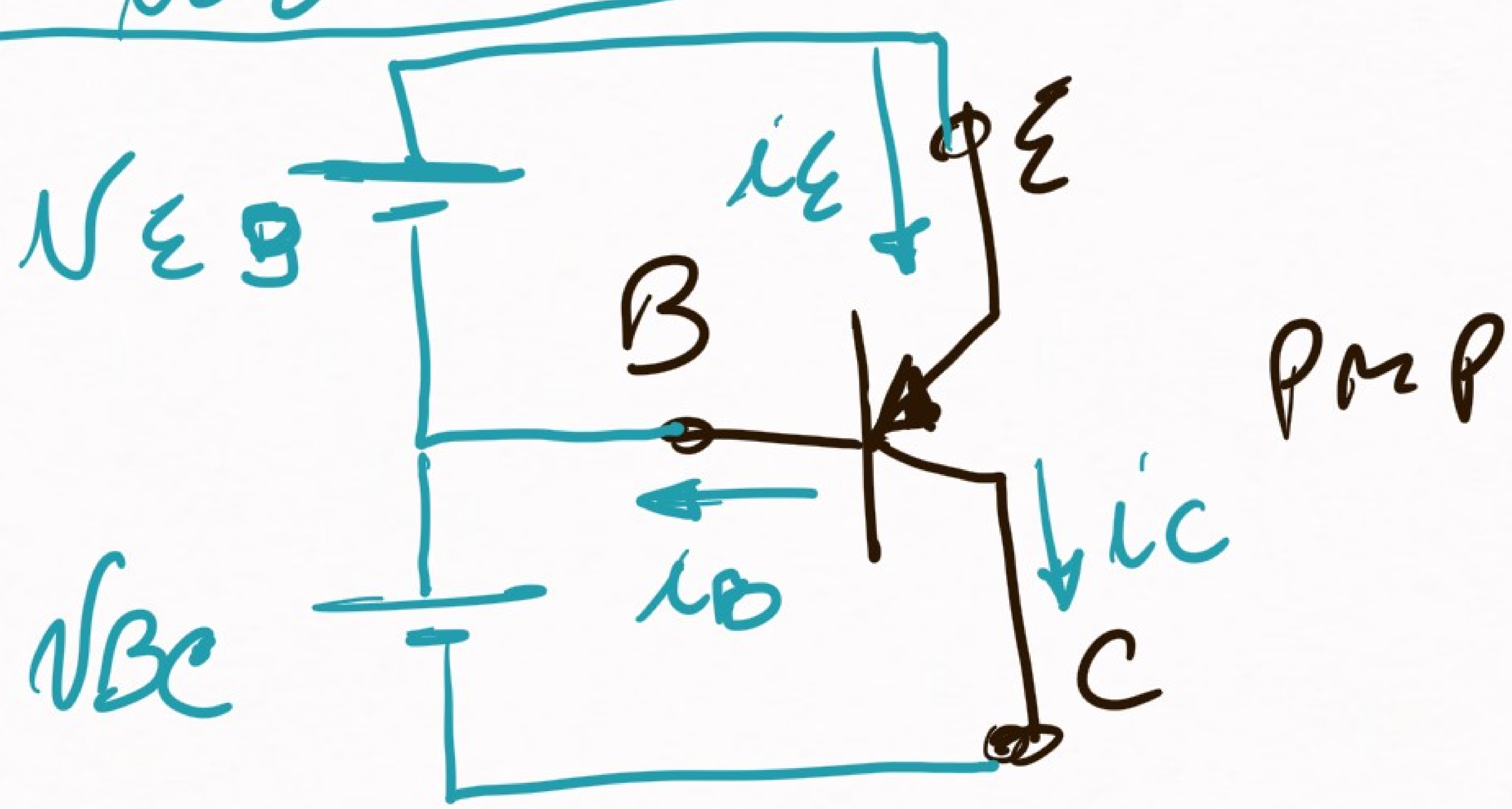
Modelo:



Símbolos de circuito

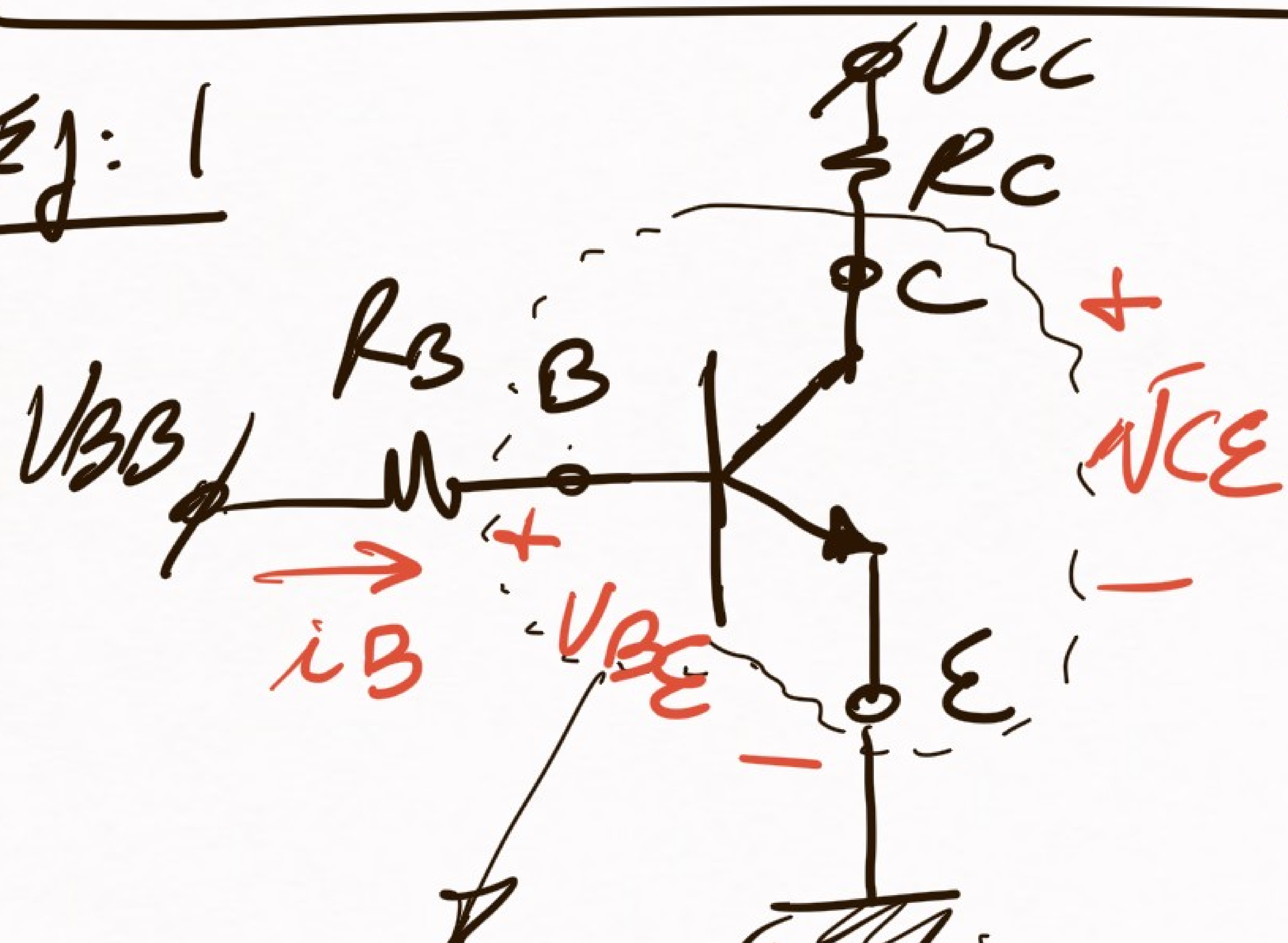






Ej. análisis circ. en DC con transistor npn en zona activa.

Ej: 1



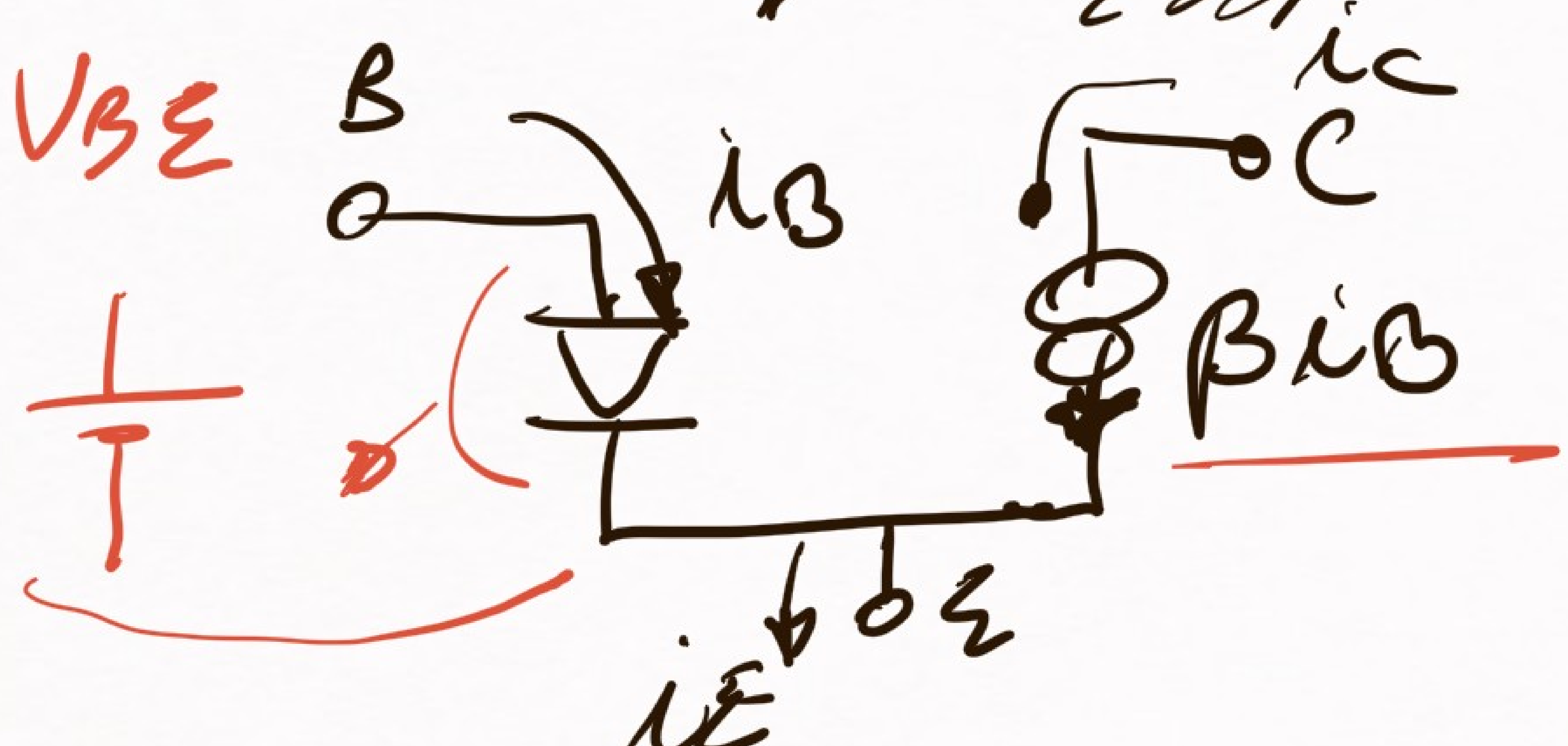
(H) Z. Activa, iC? iB?

$$i_B = \frac{V_{BB} - V_{BE}}{R_B}$$

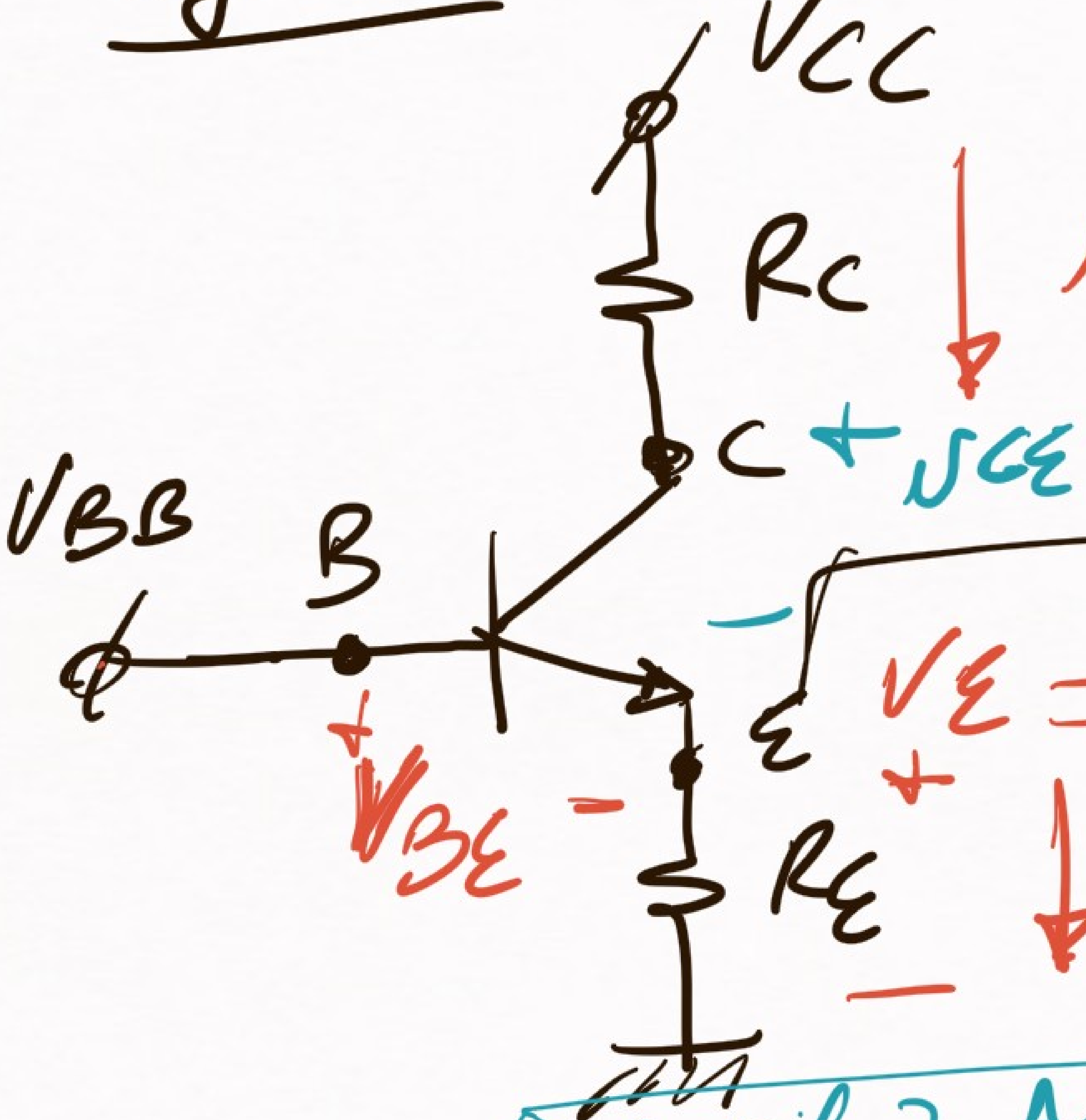
$$i_C = \beta \cdot i_B$$

$$i_E = i_B + i_C =$$
$$= i_B + \beta \cdot i_B =$$
$$= (\beta + 1)\, i_B$$

iC depende de β



Ej. 2:



$i_E = i_C + i_B = \left(\frac{i_C}{\beta}\right)$

$i_C = \frac{\beta \cdot i_E}{(\beta+1)} = \frac{\beta}{(\beta+1)} \cdot \left(\frac{V_{BB}-V_{BE}}{R_E}\right)$

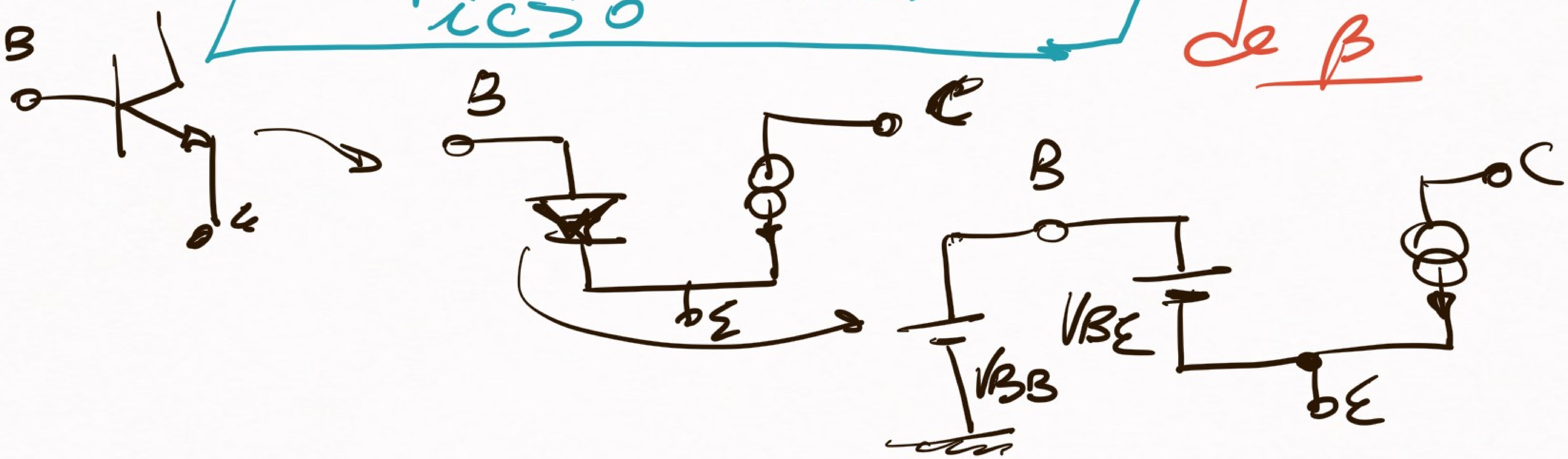
$\frac{\beta}{(\beta+1)} \approx 1$

$V_E = V_{BB} - V_{BE}$

$i_E = \frac{V_{BB}-V_{BE}}{R_E}$

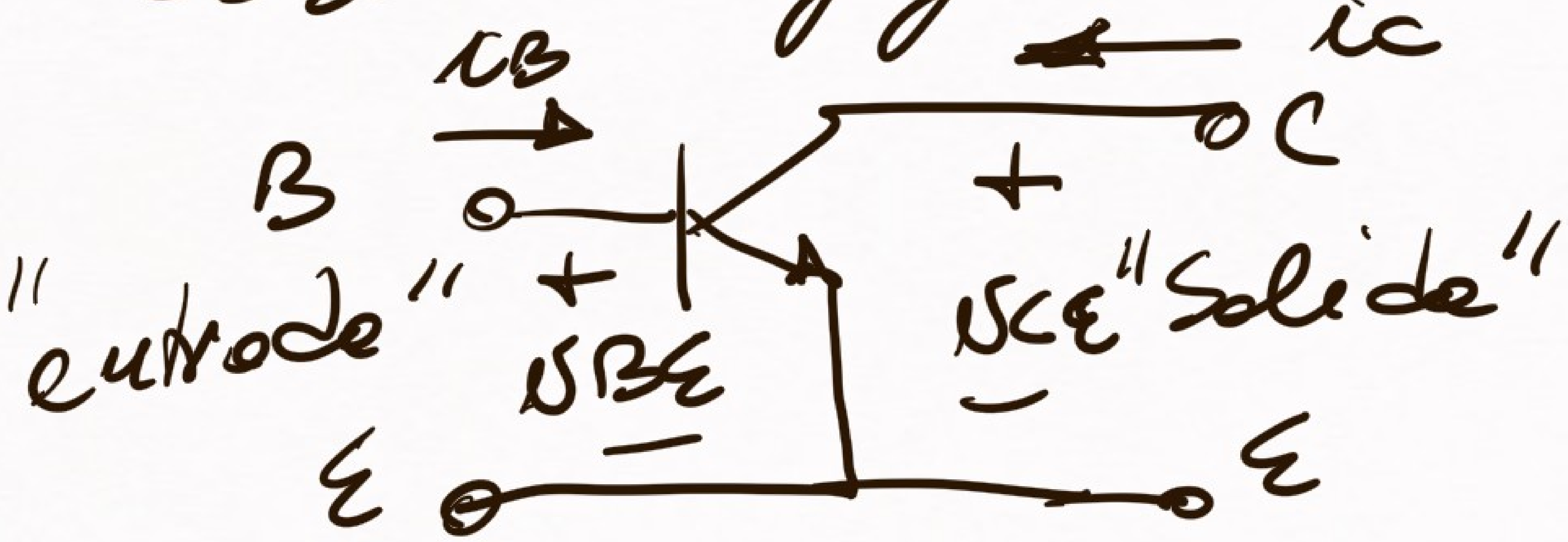
i_C es bastante independiente de β

Verif. Z-Activa: $i_C \overset{?}{>} 0$ $\quad v_{CE} \overset{?}{>} V_{CESAT}$

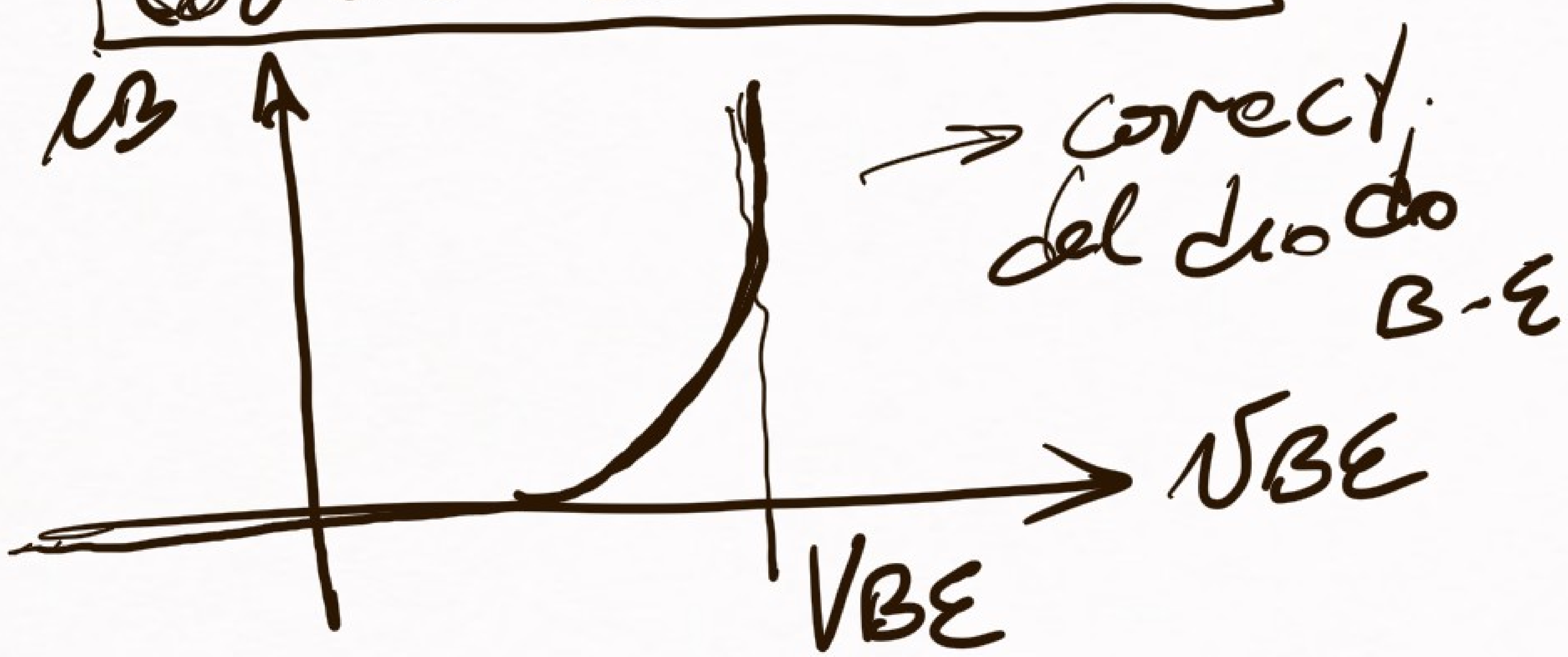


Características gráficas (I–V) del transistor npn

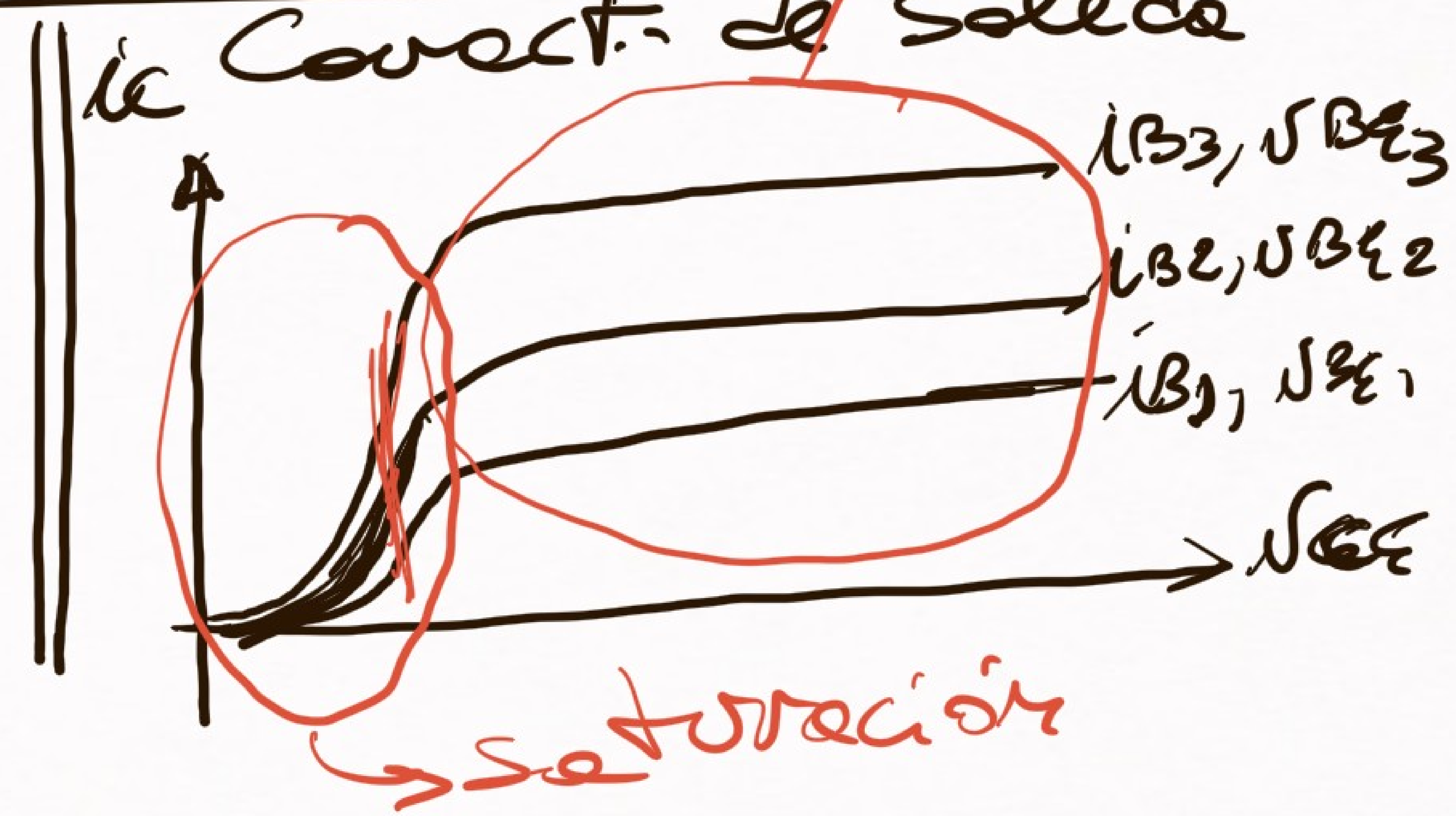
Caso: configuración emisor común



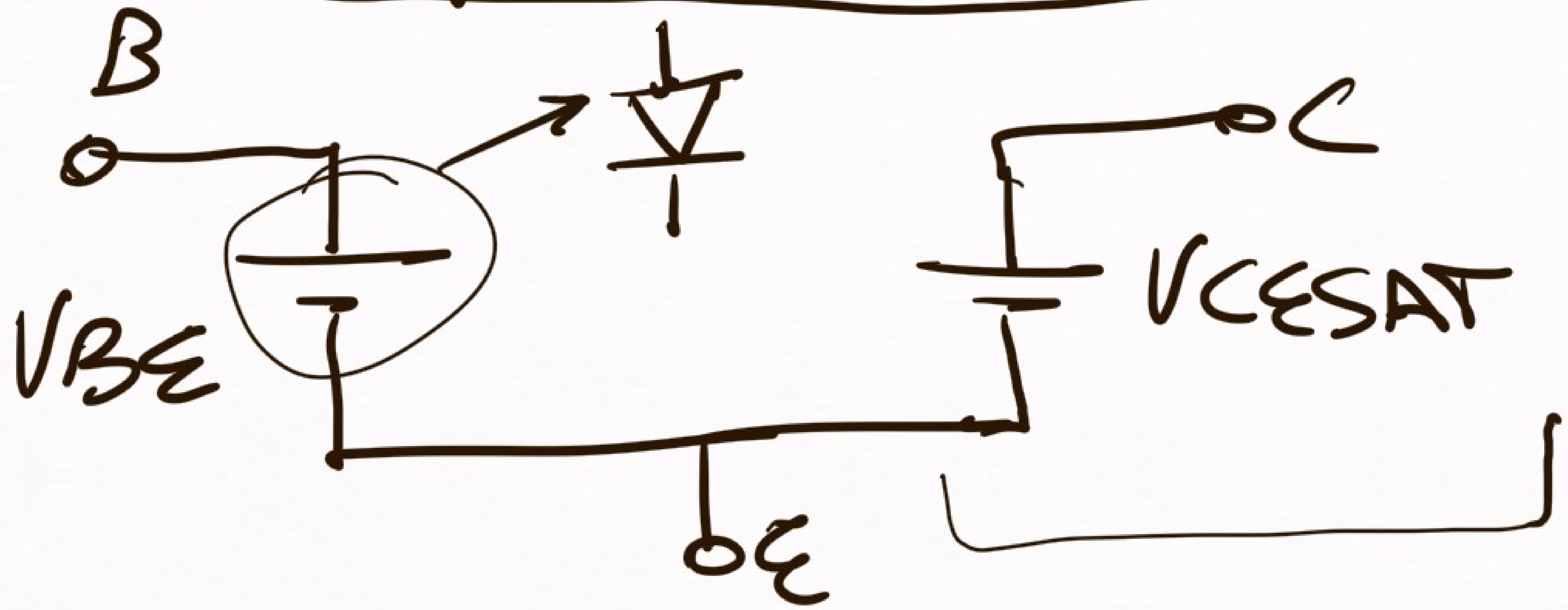
Carac. de entrada

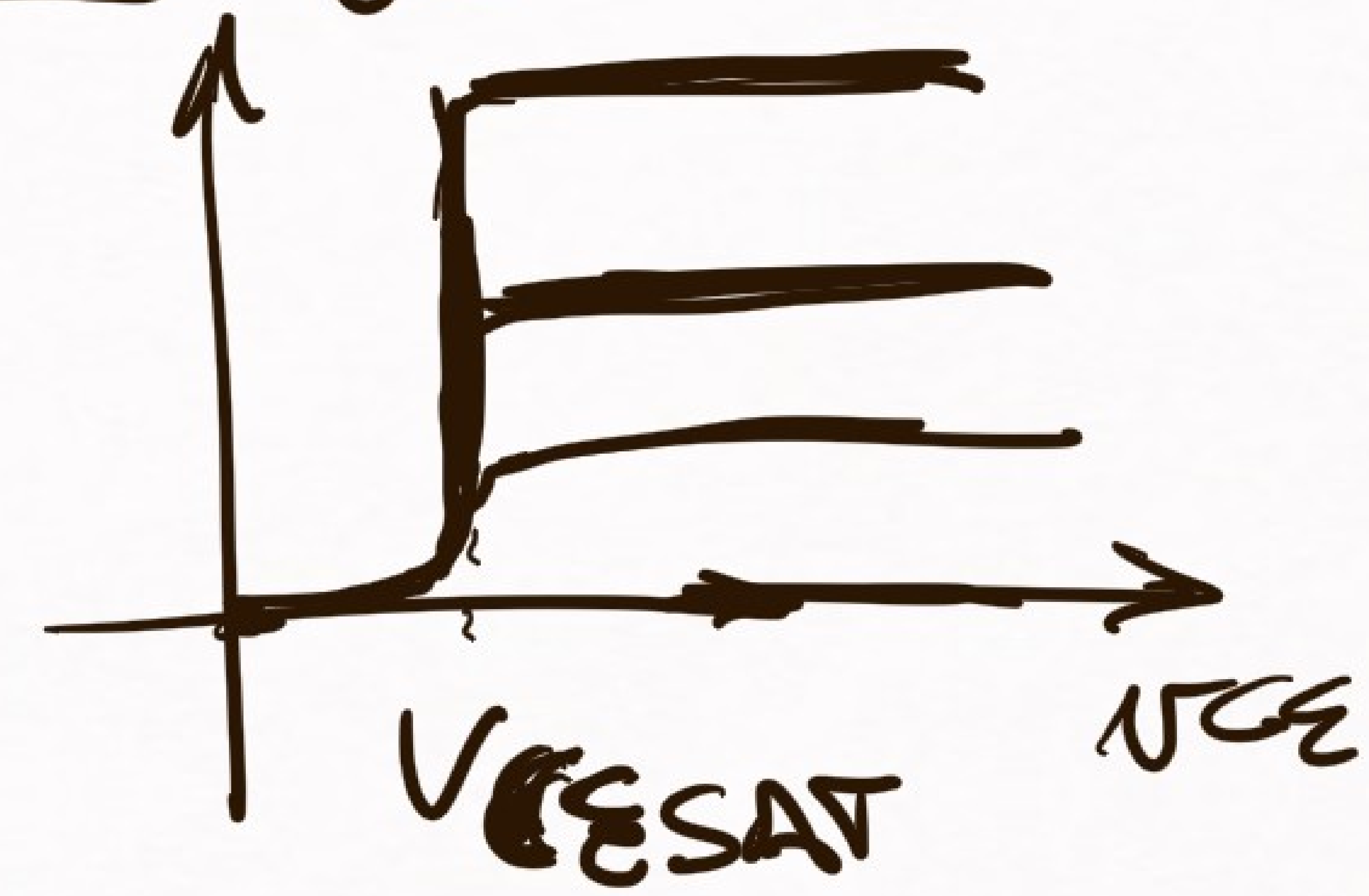


Carac. de salida



Modelo básico del transistor npn en saturación:





Condiciones:

$i_C > 0$ (no corte)

$i_C < \beta \cdot i_B$ (no zona activa)