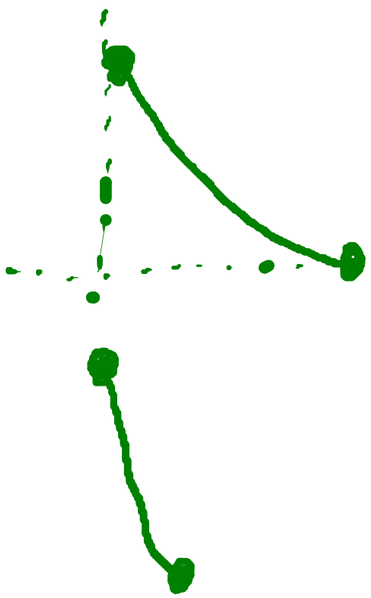
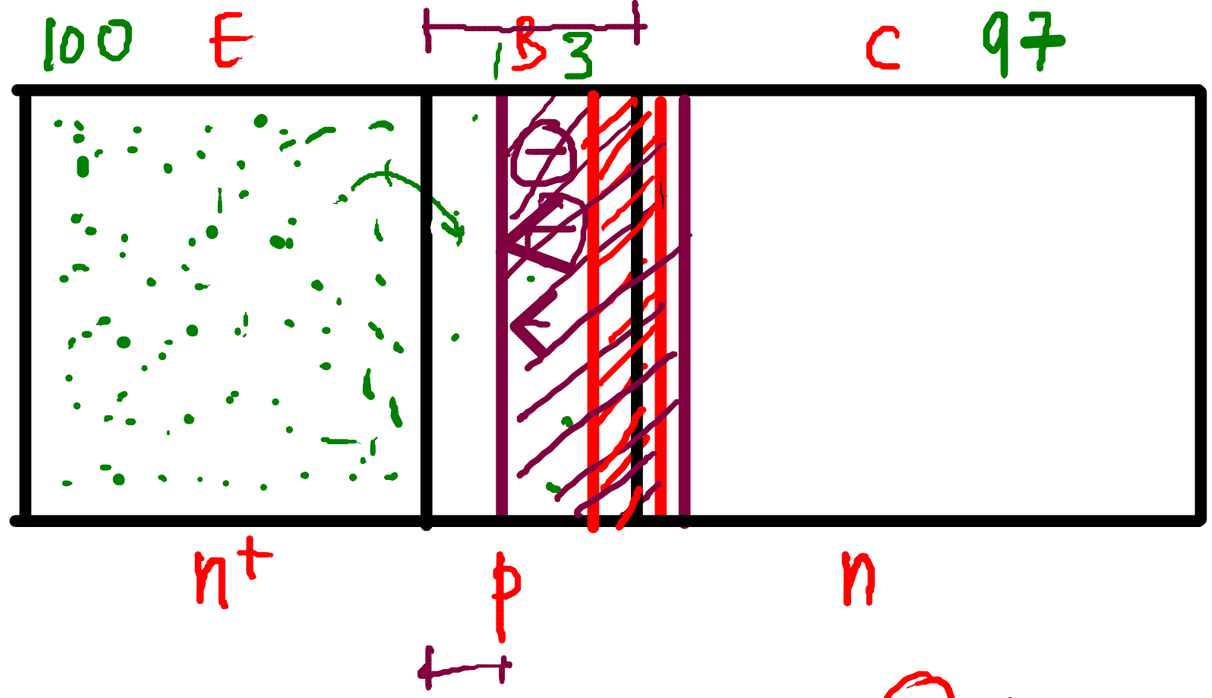
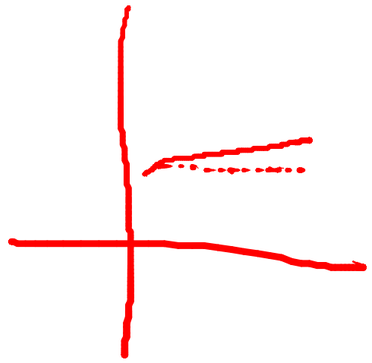






$$J_n = q n \frac{dn}{dx}$$

$$I_C = \alpha I_E + I_{CBO}\left[e^{V_{CB}/\eta V_T} - 1\right]$$

$$I_C = f\left(I_E, V_{CB}\right)$$

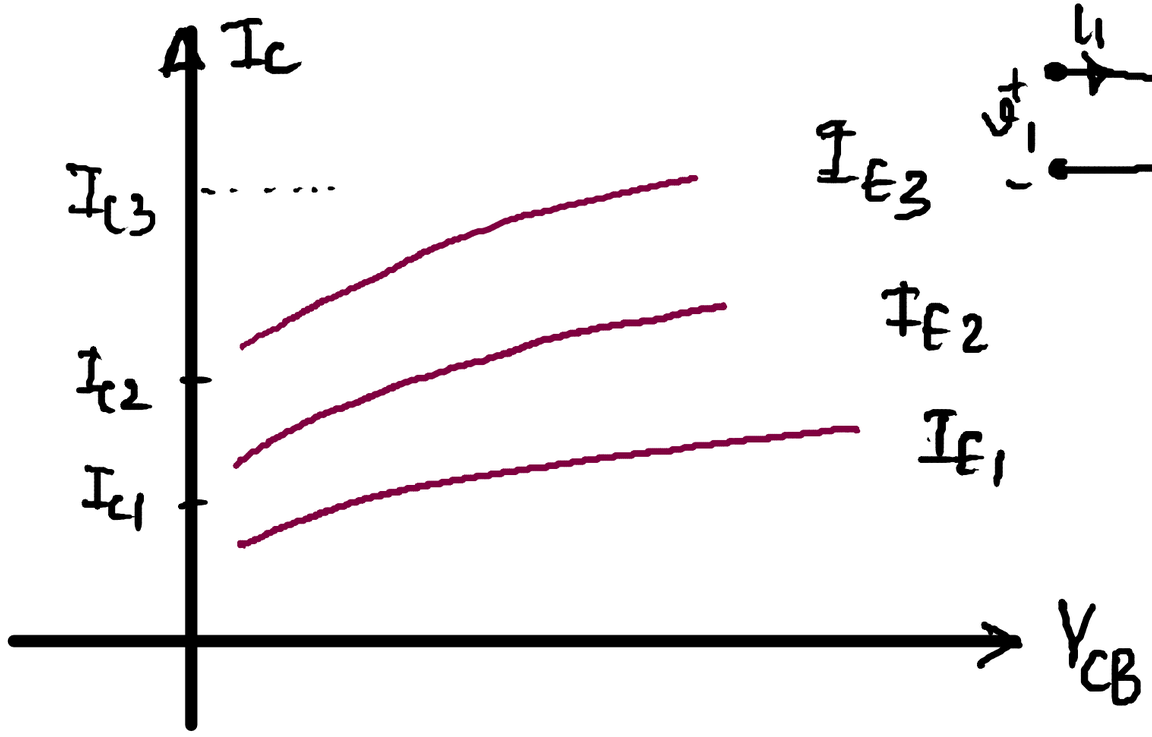
Why ? the rules Replacing of E & C doesn't work ?

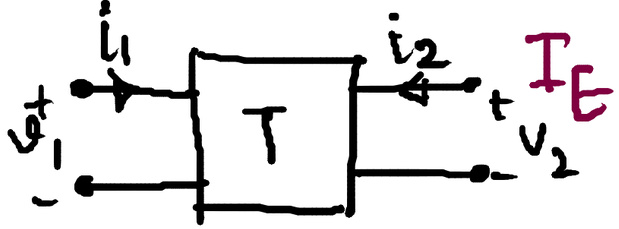
J M Early

Base-Width modulation

Early Effect

Reach - through Effect

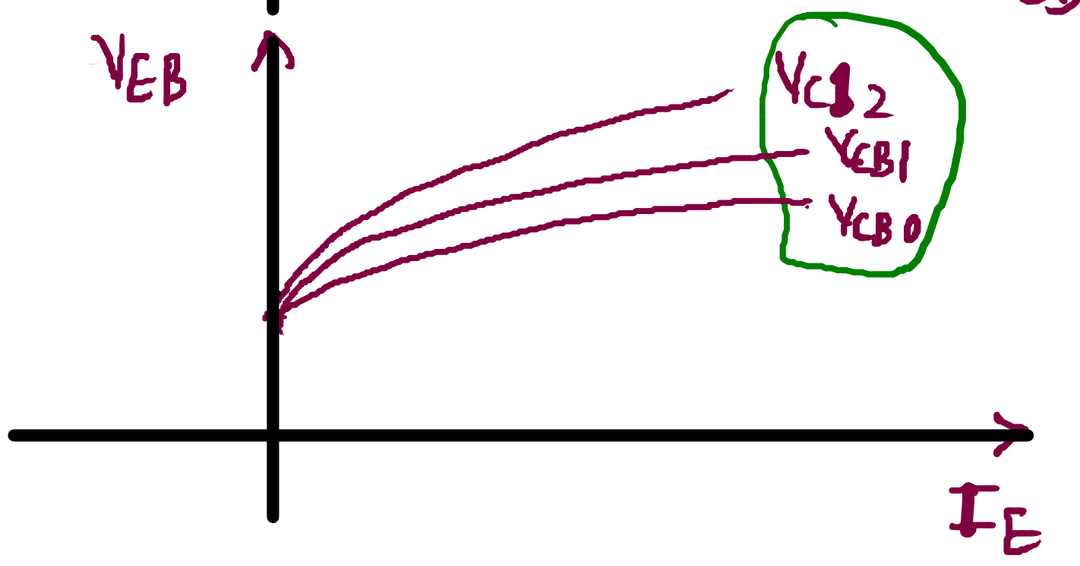


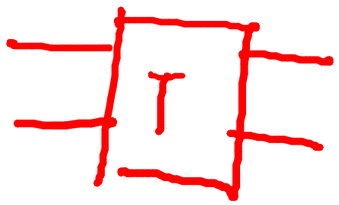


$$\text{Output Current} = f\left\{\begin{matrix}\text{Input Current}\\ ,\\ \text{Output Voltage}\end{matrix}\right\}$$

$$i_2 = f(i_1, v_2)$$

$$\text{Input voltage} = f\left\{\begin{matrix}\text{Input Current}\\ ,\\ \text{Output Voltage}\end{matrix}\right\}$$





$$v_1 = f(i_1, v_2)$$

$$i_2 = f(i_1, v_2)$$

$$\boxed{\begin{aligned} v_1 &= h_{11} i_1 + h_{12} v_2 \\ i_2 &= h_{21} i_1 + h_{22} v_2 \end{aligned}}$$

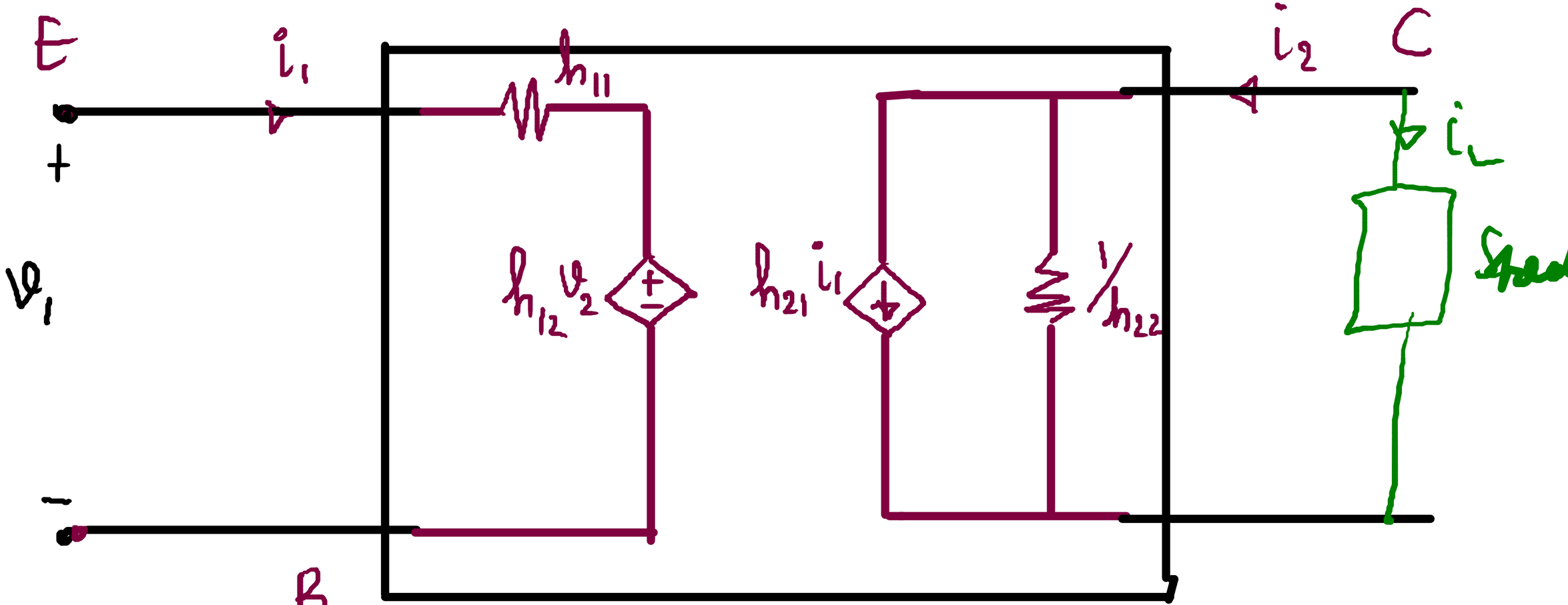
$$h_{11} = \left.\frac{v_1}{i_1}\right|_{v_2=0} = h_i \quad \left\{ \text{Input Impedance} \right. \quad (\text{Short circuit})$$

$$h_{12} = \left.\frac{v_1}{v_2}\right|_{i_1=0} = h_r \quad \left\{ \text{Reverse Voltage transfer Ratio} \right. \quad (\text{Unitless})$$

$$h_{21} = \left.\frac{i_2}{i_1}\right|_{v_2=0} = h_f \quad \left\{ \text{Forward Current transfer Ratio} \right.$$

$$h_{22} = \left.\frac{i_2}{v_2}\right|_{i_1=0} = h_o \quad \left\{ \text{Output Conductance} \right. \quad (\text{Open circuit})$$

$$\Delta v_1 =$$



$$v_1 = h_{11} i_1 + h_{12} v_2$$

$$i_2 = h_{21} i_1 + h_{22} v_2$$

$$\begin{bmatrix} v_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ v_2 \end{bmatrix}$$

h-parameters