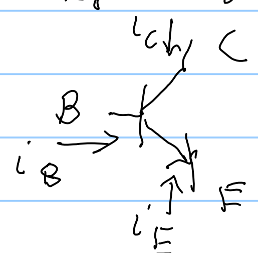
Note Title 2/17/2016

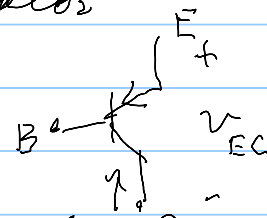
EE 307
02/17/16

BJT

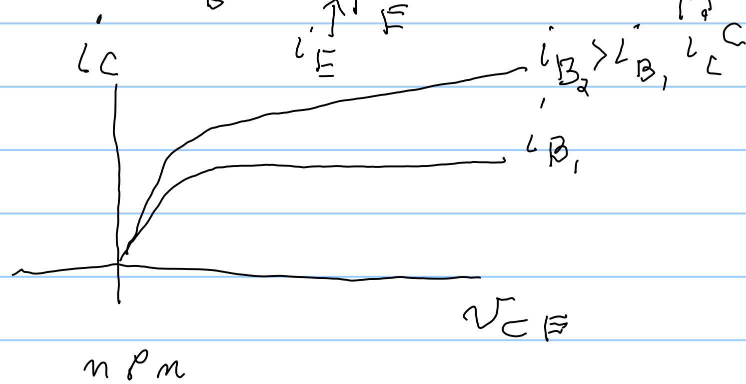
npn — Q 2N3904 ← Spice designator

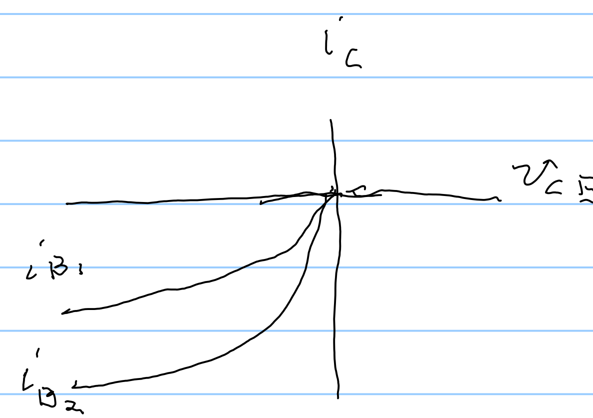
pnp — Q 2N306



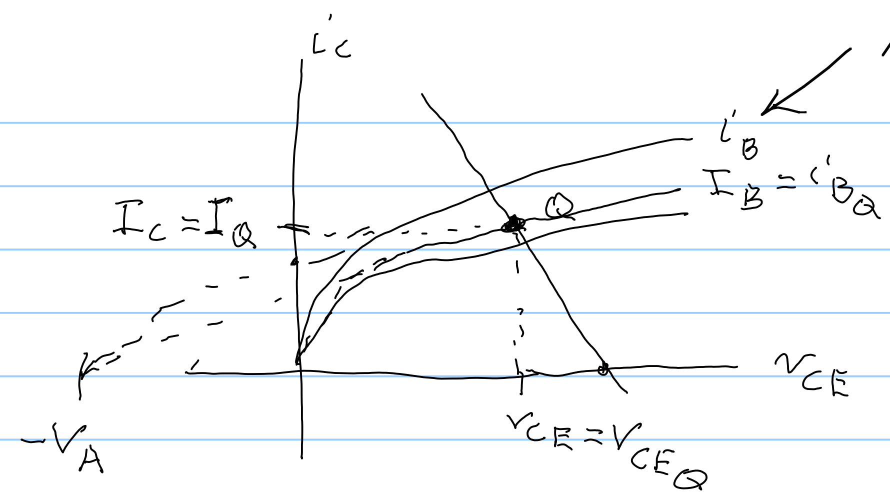


$i_B + i_E + i_C = 0$

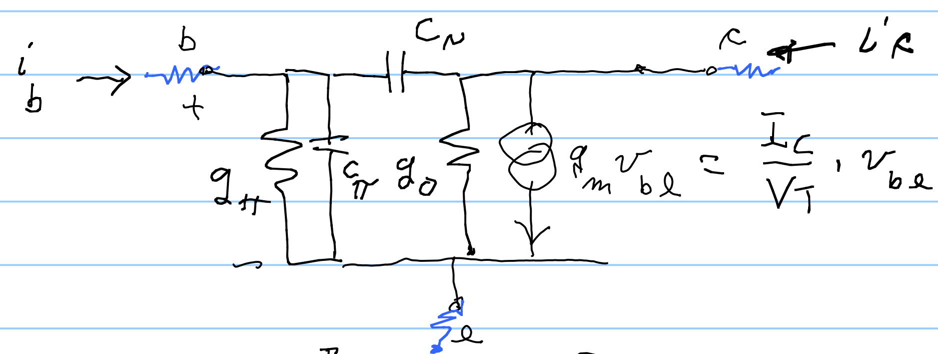




$$\text{slope} \approx \frac{I_C}{V_A} = \left.\frac{\partial i_C}{\partial v_{CE}}\right|_Q = g_o = \text{output conductance}$$



linearized $\quad i = Y v$



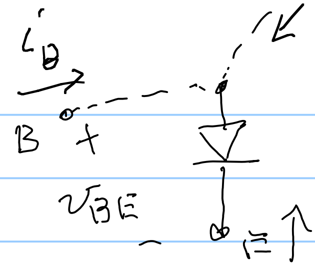
$g_m v_{be} = \frac{I_C}{V_T}\, v_{be}$

Hybrid

π equivalent circuit

$$g_\pi = \frac{I_C}{\beta V_T} \qquad g_o = \frac{I_C}{V_A}, \quad g_m = \frac{I_C}{V_T}$$

$v_{BE} \rightarrow i_E$



$i_C = \beta i_B$

$i_E = -I_S\left(e^{v_{BE}/V_T} - 1\right)$

$$\frac{\partial i_B}{\partial v_{BE}} = \frac{\partial i_B}{\partial i_C} \cdot \frac{\partial i_C}{\partial v_{BE}} = \frac{1}{\beta} \cdot \frac{I_C}{V_T} = g_{in} = g_\pi$$

$$-i_E = -i_E\Big|_Q \approx \frac{\partial i_E}{\partial v_{BE}}(v_{BE} - V_{BE}) + \underbrace{\frac{\partial^2}{\partial^2} \cdots}_{\text{ignore}}$$

$-i_E\Big|_Q = -I_E$

$i_E - I_E = i_e$ = signal =

$i_C = \beta i_B = \alpha(-i_E)$

$$-\frac{\partial i_E}{\partial v_{BE}} = I_S \cdot \frac{1}{V_T}\left(e^{v_{BE}/V_T}\right) \approx \frac{-I_E}{V_T} = \frac{\frac{1}{\alpha} i_C}{V_T}\Bigg|_Q \approx \frac{I_C}{V_T}$$ a conductance

$$i_c = -\alpha i_e = \alpha\left[\frac{I_C}{V_T}\right] v_{be} \Rightarrow i_c = g_m \cdot v_{be}, \quad g_m = \frac{I_C}{V_T}$$