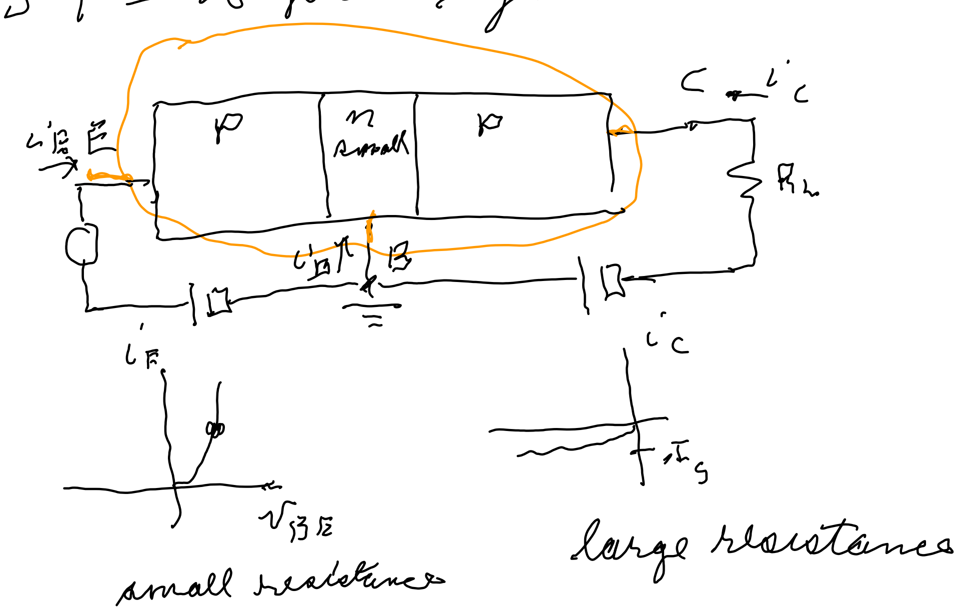
ENEE303
02/14/19

Note Title 2/14/2019

BJT = bipolar junction transistor

Chapter 6

transfer resistance



$i_C = -(\alpha\, i_E)$ $\quad \alpha \approx 0.999$ (1)

$i_B + i_C + i_E = 0$ $\quad$ KCL (2)

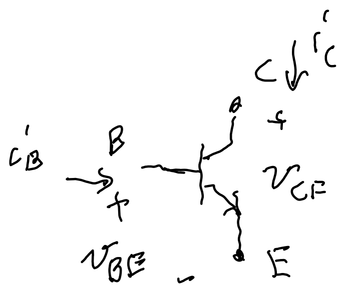
$i_E = -i_B - i_C$ (2a)

$i_C = -\alpha(-i_B - i_C)$ (3)

$(1-\alpha)\, i_C = \alpha\, i_B \Rightarrow i_C = \frac{\alpha}{1-\alpha} \cdot i_B = -\alpha\, i_E$

$\beta \triangleq \frac{\alpha}{1-\alpha}$ very large $= h_{fe}$ $\quad i_E = \frac{-1}{1-\alpha} \cdot i_B$

chapter 7



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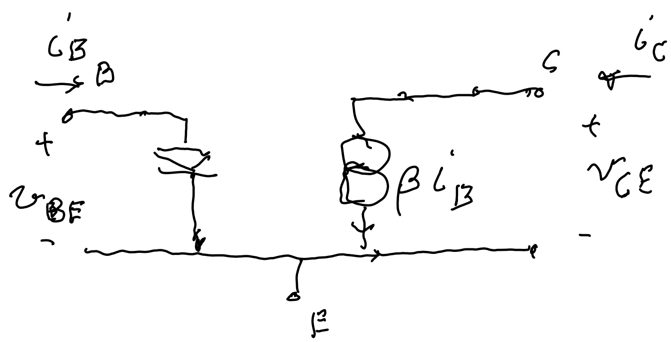
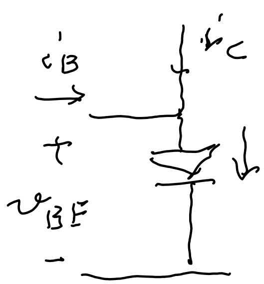


@ emitter



$i_E = I_S(e^{v_{BE}/V_T} - 1) \approx I_S e^{v_{BE}/V_T}$; I_S = base to emitter saturation current

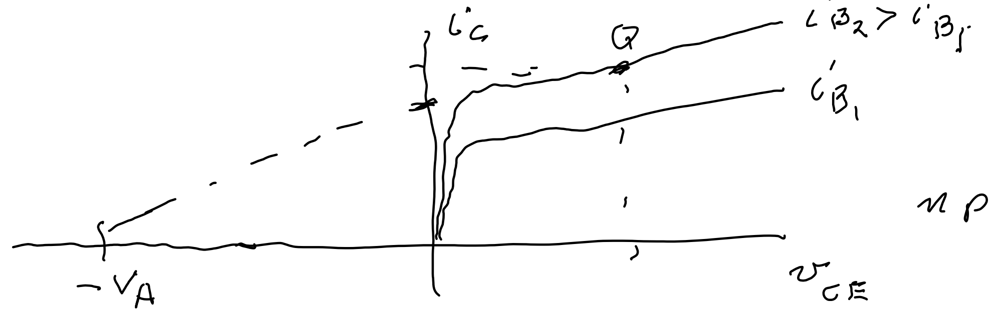
$i_B = \beta \cdot i_C = \frac{\alpha i_E}{\beta} = \frac{\alpha}{\beta}(I_S e^{v_{BE}/V_T})$ total desire $\begin{bmatrix} i_b \\ i_c \end{bmatrix} = i$, $\begin{bmatrix} v_{be} \\ v_{ce} \end{bmatrix} = v$, $\quad i = Y v \quad \begin{bmatrix} i_b \\ i_c \end{bmatrix} = \begin{bmatrix} & \\ y_{21} & \end{bmatrix} \begin{bmatrix} v_{be} \\ v_{ce} \end{bmatrix}$

$$y_{21} = \left.\frac{\partial i_c}{\partial v_{BE}}\right|_Q = \left.\frac{\partial i_c}{\partial i_B} \cdot \frac{\partial i_B}{\partial i_E} \cdot \frac{\partial i_E}{\partial v_{BE}}\right|_Q = \beta\left(-(1-\alpha)\right) \cdot \left(-\underbrace{\frac{\partial I_S e^{v_{BE}/V_T}}{\partial v_{BE}}}_{\frac{I_S e^{v_{BE}/V_T}}{V_T}}\right)$$

$$= \frac{\alpha \cdot I_S e^{V_{BE}/V_T}}{V_T} \approx \frac{I_C}{V_T} = \frac{\partial i_c}{\partial v_{BE}} = g_m$$

@ the B-C we see a diode $\frac{\partial i_B}{\partial v_{BE}} = \frac{\partial i_B}{\partial i_c} \cdot \frac{\partial i_c}{\partial v_{BE}} = \frac{1}{\beta} \cdot g_m = y_{11} = g_\pi$

$$Y = \begin{bmatrix} g_\pi & 0 \\ g_m & g_o \end{bmatrix}$$

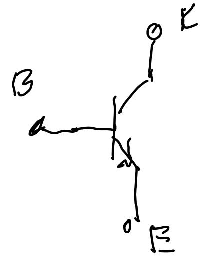


npn curves

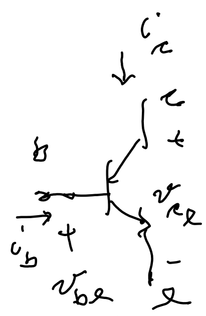
V_A = Early voltage

$$y_{22} = \left.\frac{\partial i_C}{\partial v_{CE}}\right|_{Q,\ i_B = I_B} \approx \frac{I_C}{|V_A|} = g_o$$

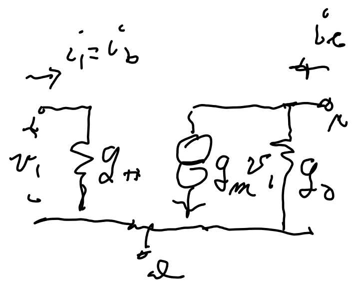
assume $\frac{\partial i_B}{\partial v_{CE}} \approx 0 = y_{12}$



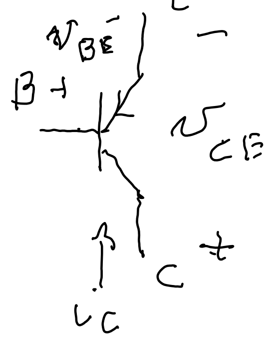
small signal

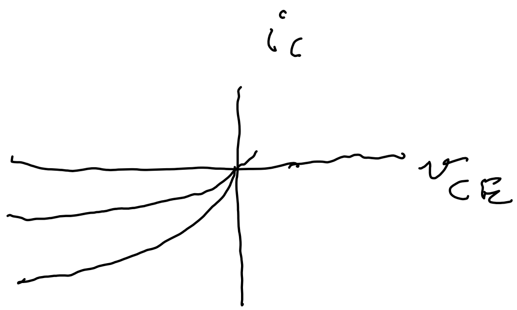


$$\Rightarrow Y = \begin{bmatrix} g_\pi & 0 \\ g_m & g_o \end{bmatrix} = \begin{bmatrix} \frac{I_C}{\beta V_T} & 0 \\ \frac{I_C}{V_T} & \frac{I_C}{V_A} \end{bmatrix}$$



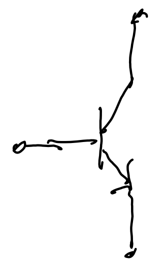
idealy if $\beta \to \infty$, $V_A \to \infty$ $\quad y = \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix} \Rightarrow A_v = \frac{v_{out}}{v_{in}} = \frac{v_{ce}}{v_{be}} = -g_m R_L$

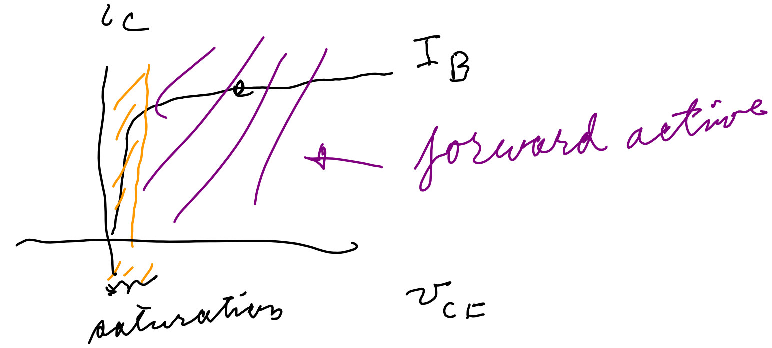


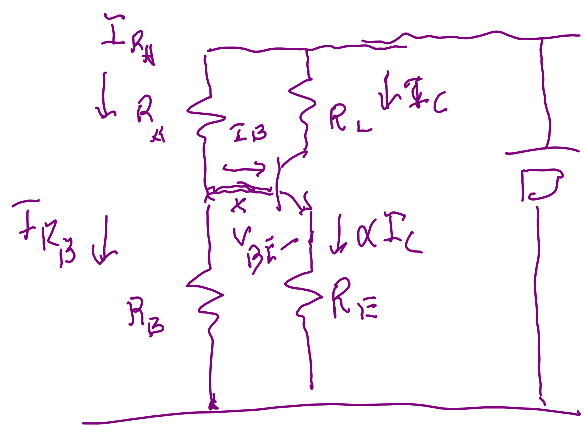


$g_m = \frac{|I_C|}{V_T}$, $g_\pi = \frac{g_m}{\beta}$, $g_o = \frac{I_C}{|V_A|}$

to get Q point:

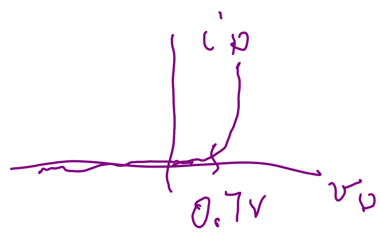


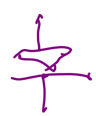




R_E needed to keep I_C independent of temperature changes

need v_{BE}





assume $V_{BE} = 0.7$