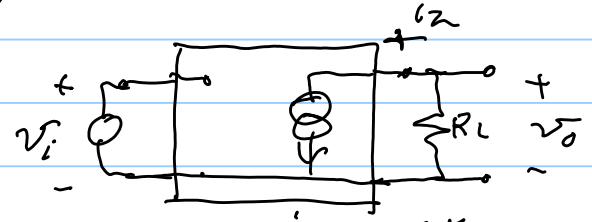
EE 307

02/12/18

Note Title 2/12/2018

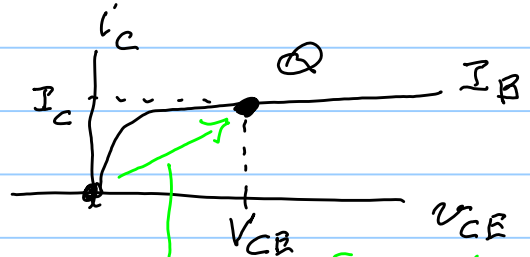
BJT amplifies



$$A_v = \frac{v_o}{v_i} = -g_m R_L$$

$$v_o = -g_m \cdot R_L \, v = -R_L i_2$$

2n3904 $\Rightarrow$ Q2n3904 in Spice library



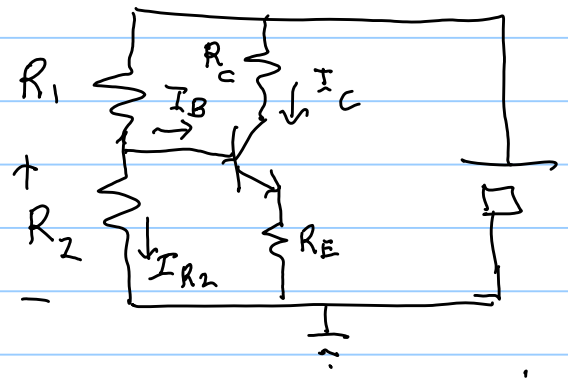
$$g_m = \frac{I_C}{V_T}, \quad V_T = \frac{kT}{Q}$$

$\times$ 26mV @ room T

move origin for small signal

forward bias BE junction

reverse bias CE junction



$$I_E = -I_S\left(e^{V_{BE}/V_T} - 1\right) \quad \text{ideal}$$

$$g_m = \frac{\partial i_C}{\partial v_{BE}}$$

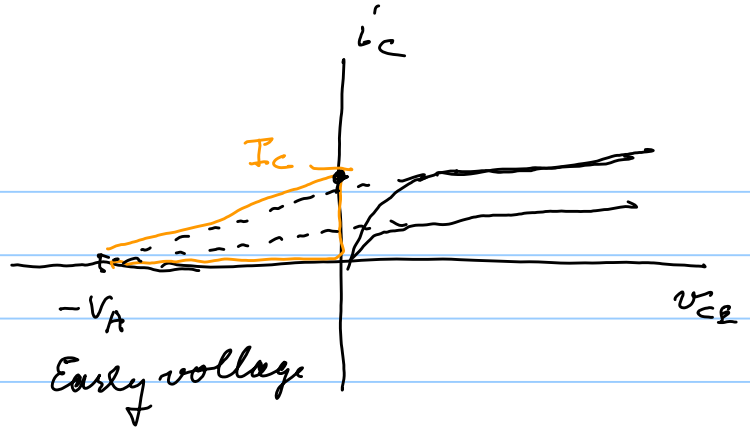
$$i_C = -\alpha i_E = \beta i_B$$

$$\frac{\partial i_C}{\partial v_{BE}} = -\alpha \frac{\partial i_E}{\partial v_{BE}} = -\alpha\left[-I_S \cdot \frac{1}{V_T} \cdot e^{v_{BE}/V_T}\right]$$

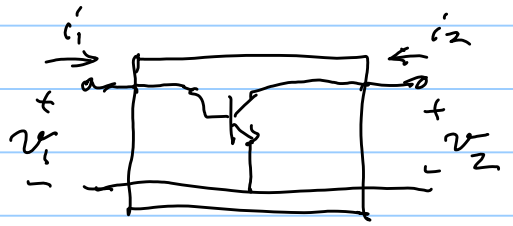
$$= \frac{\alpha I_S e^{v_{BE}/V_T}}{V_T} = \frac{I_C}{V_T} = g_m$$

$$g_m \approx \frac{1 \times 10^{-3}}{26 \times 10^{-3}} \approx \frac{1}{25} = 0.04 \frac{\text{amps}}{\text{volt}} \quad \text{for } 1\,\text{ma} = I_C$$

ideal gain is $-g_m R_L$ but have losses



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



at low frequencies

$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} g_\pi & 0 \\ g_m & g_o \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \Rightarrow i = Yv$$

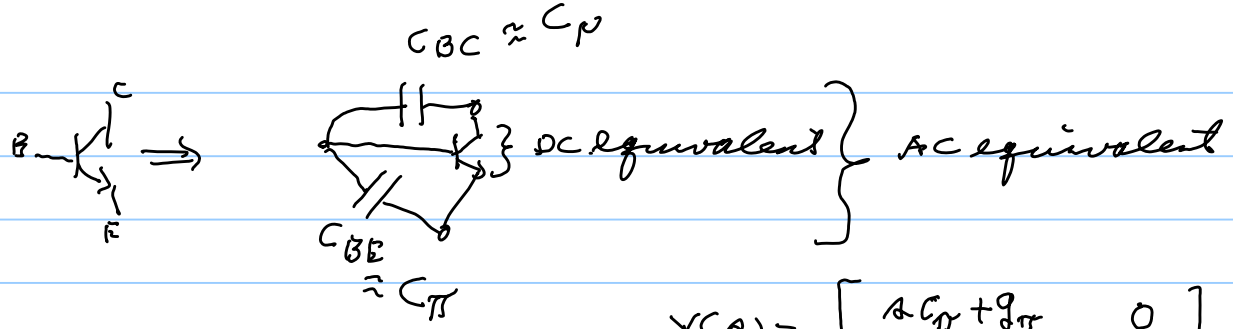
Y: admittance, small signal

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

$$y_{11} = \frac{\partial i_1}{\partial v_1} = \frac{\partial i_B}{\partial v_{BE}} = \left.\frac{1}{\beta}\frac{\partial i_C}{\partial v_{BE}}\right|_Q = \frac{g_m}{\beta} = \frac{I_C}{\beta V_T} = g_\pi$$

or $v_{BE} \simeq 0.6\,v$, $\Rightarrow$ almost constant

$\frac{\partial i_1}{\partial v_2} \approx 0$ as set I_B by R_1 & R_2



$$Y(s) = \begin{bmatrix} sC_\pi + g_\pi & 0 \\ g_m & g_o \end{bmatrix}$$

(plus terms with C_μ)