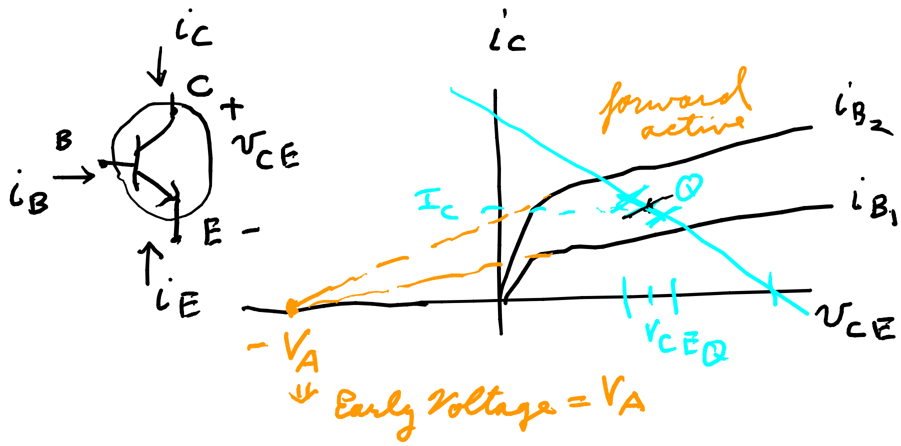
EE 303 H
02/05/09



defined via β

KCL $\quad i_B + i_C + i_E = 0 \qquad -i_C = \alpha i_E \qquad \alpha \approx 1, \alpha < 1$

$$i_B = -i_C - i_E = -(-\alpha + 1) i_E = -(-\alpha + 1)\left(-\frac{1}{\alpha}\right) i_C$$

$$i_C = \frac{\alpha}{1-\alpha} \cdot i_B = \beta i_B \Rightarrow \beta = \frac{\alpha}{1-\alpha}$$

also $\quad (1-\alpha)\beta = \alpha = \beta - \alpha\beta = \alpha \Rightarrow \beta = (1+\beta)\alpha \Rightarrow \alpha = \frac{\beta}{1+\beta}$

$$\alpha = \frac{\beta}{1+\beta}$$

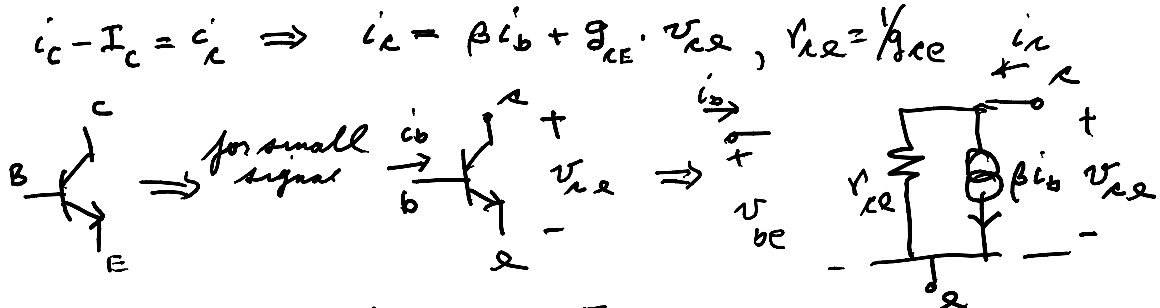
$i_C = f(v_{CE}, i_B)$ for small signals

$$= f(V_{CE_Q}, I_{B_Q}) + \left.\frac{\partial i_C}{\partial v_{CE}}\right|_Q (v_{CE} - V_{CE}) + \left.\frac{\partial i_C}{\partial i_B}\right|_Q (i_B - I_B) + \sim$$

ignore for small signal

$$= I_C + g_{CE} \cdot v_{ce} + \beta \cdot i_b$$

$i_C - I_C = i_c \Rightarrow i_c = \beta i_b + g_{ce} \cdot v_{ce}, \quad r_{ce} = 1/g_{ce}$

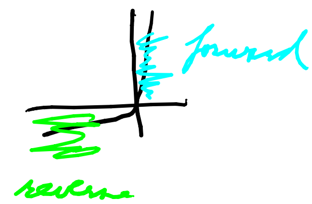


we need information on B-E on getting an equivalent circuit for forward active region

a 2-port
appendix B

here B–E ⇒ forward bias

B–C ⇒ reverse bias



for BE: $-i_E = I_S(e^{v_{BE}/V_T} - 1)$

$$\approx I_{S_{EB}} e^{v_{BE}/V_T}$$

$$-\frac{\partial i_E}{\partial v_{BE}} = \frac{I_S e^{v_{BE}/V_T}}{V_T} = \frac{-I_E}{V_T} = \frac{\frac{1}{\alpha} I_C}{V_T}$$ ⇒ input conductance seen at the emitter

$-I_C = \alpha I_E = -\beta I_B$ ⇒ $i_b \approx -\frac{\alpha}{\beta} \cdot i_e = -(1+\alpha) i_e$

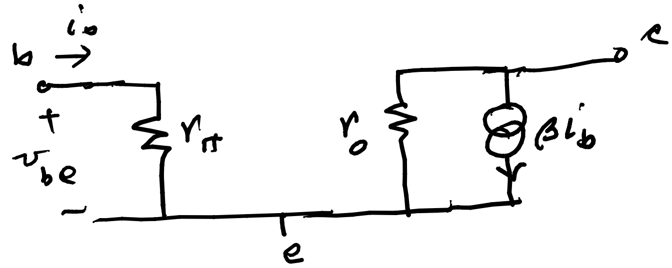
$-i_c = \alpha i_E = -\beta i_B$

$$= \frac{1}{\alpha} \frac{I_C}{V_T} \cdot (1+\alpha) \cdot v_{be}$$

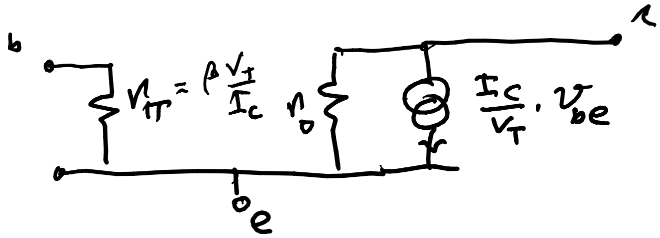
$\beta = \frac{\alpha}{\alpha+1}$

$$= \frac{1}{\beta} \cdot \frac{I_C}{V_T} \cdot v_{be} \Rightarrow g_{be} = \frac{1}{\beta} \cdot \frac{I_C}{V_T} = g_\pi$$

$$r_\pi = \frac{1}{g_\pi} = \frac{V_T}{I_C/\beta}$$

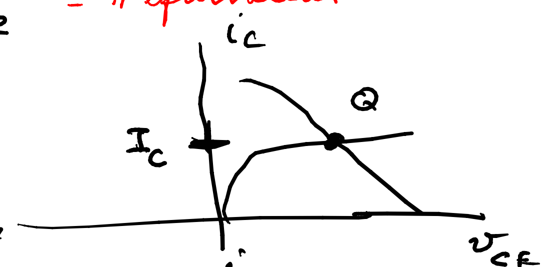


$$\beta \cdot i_b = \beta \cdot g_\pi \cdot v_{be}$$
$$= \frac{I_C}{V_T} \cdot v_{be}$$



= π equivalent circuit

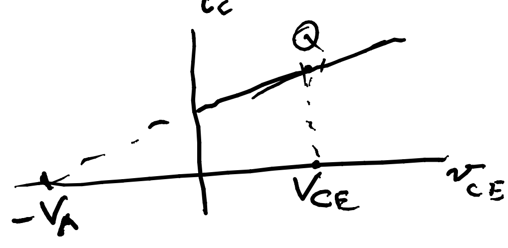
see p. 457 of text



∴ given a bias point Q we know the equivalent circuit if can find r_o

$$g_o = \frac{\partial i_C}{\partial v_{CE}} = \frac{I_C - 0}{(V_{CE} - (-V_A))}$$

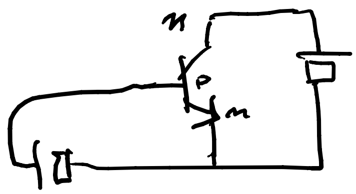
$$\approx \frac{I_C}{V_A}$$

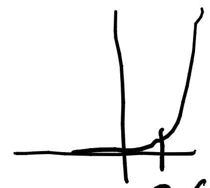


∴ knowing the bias I_C & spice β & V_A (& $V_T = \frac{kT}{|q|}$)

we know the small signal equivalent circuit of a BJT.

To use need to bias B-E forward
B-C reverse





not easy to do with just one battery

For MOS — main laws