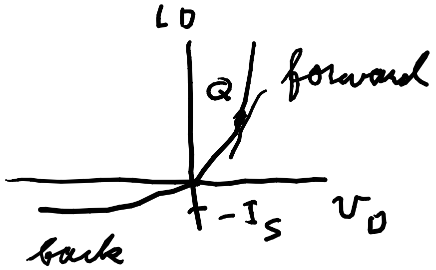
EE303H
09/13/11

Note Title 9/11/2011

i_D = total, I_D = bias, i_d = signal

$$i_D = I_S\left(e^{+v_D/V_T} - 1\right) \; ; \quad \left.\frac{\partial i_D}{\partial v_D}\right|_{Q,\; v_D = V_D} = \frac{I_S}{V_T} \cdot e^{V_D/V_T} = g_D$$

= diode conductance



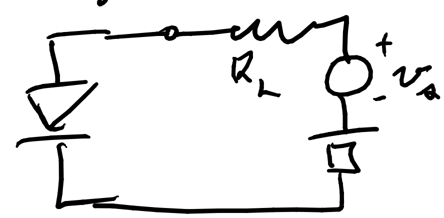
in forward region

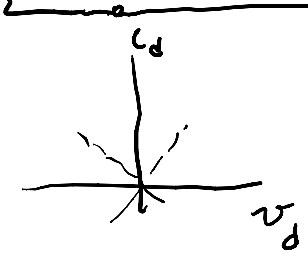
$$g_D = \frac{I_S}{V_T} e^{V_D/V_T} \approx \frac{I_D}{V_T}, \quad V_T = \text{thermal voltage} = kT/|q| \approx 26\,mV \text{ @ room T}$$

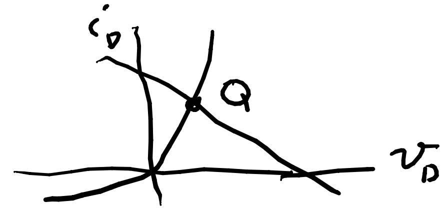
circuit for signal

⇐

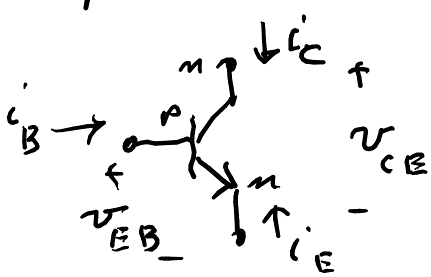
full circuit

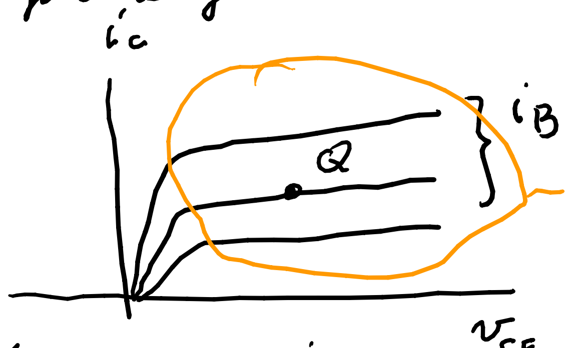






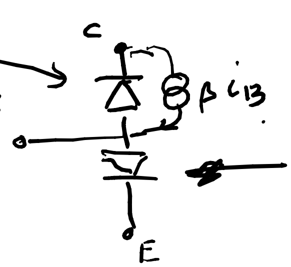
Chapter 6 ⇒ BJT = bipolar junction transistor





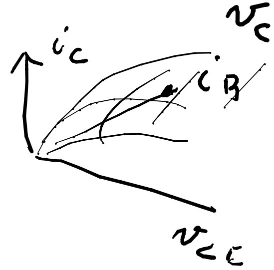
forward active region

reverse bias CB diode



for forward active

forward BE diode



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

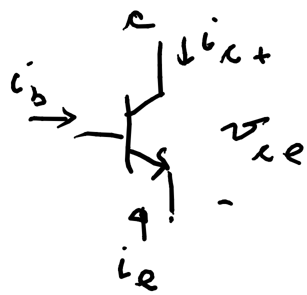
total — bias — Taylor series — signals

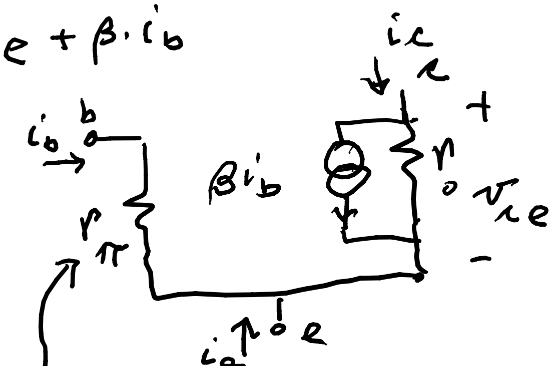
$$+ \frac{\partial^2}{\partial v_{CE}\,\partial i_B} \cdots \text{ higher order}$$

$$i_C = I_C + g_o v_{ce} + \left.\frac{\partial i_C}{\partial i_B}\right|_Q \cdot i_b + \cdots \doteq I_C + g_o v_{ce} + \beta \cdot i_b$$

(ignore higher-order terms)

$$i_c = g_o v_{ce} + \beta \cdot i_b$$





this has i_b in it

small signal equivalent circuit of an npn

see p. 374 fig. 6-18

BE diode has emitter current i_E, use I_E

$$\frac{|I_E|}{V_T} = g_{D_{BE}}$$

$$I_B + I_C + I_E = 0$$

$$I_B + \alpha(-I_E) + I_E = I_B + I_C + \frac{-I_C}{\alpha} = I_B + \left(\frac{\alpha - 1}{\alpha}\right) I_C$$

@ Q, $I_C = \beta I_B$; $\quad I_B + \left(\frac{\alpha-1}{\alpha}\right) \cdot \beta I_B = 0$

$$I_B + (1-\alpha) I_E = 0 \Rightarrow I_E = \frac{1}{\alpha - 1} I_B$$

$$\therefore \quad \frac{|I_E|}{V_T} \cdot V_{BE} = \left(\frac{1}{1-\alpha} \cdot \frac{1}{V_T} \cdot I_B\right) V_{BE} = g_\pi \cdot V_{BE}$$

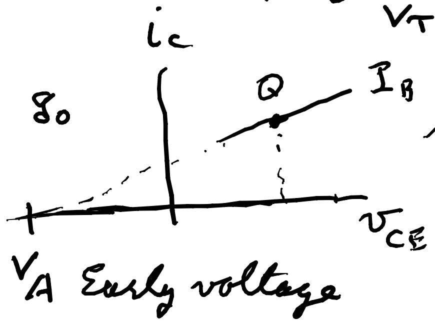
$$I_C = \beta I_B = -\alpha I_E$$

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

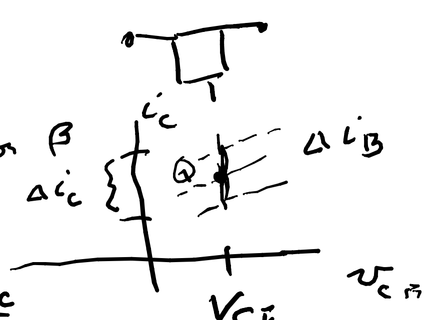
$$\Rightarrow g_\pi = \frac{I_B}{1-\alpha} \cdot \frac{1}{V_T} = \frac{\alpha}{1-\alpha} \cdot I_B \cdot \frac{1}{\alpha V_T}$$

$$\approx \beta I_B \cdot \frac{1}{V_T} = \frac{I_C}{V_T} = g_\pi$$

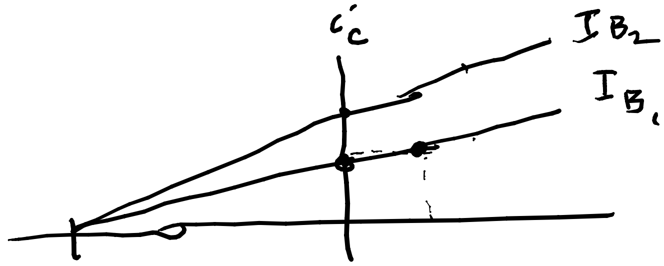
For g_o



For β



$$\beta = \frac{\Delta i_C}{\Delta i_B}$$



} slopes in forward active regions

$-V_A$ same for all I_B

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

$$= \frac{I_C}{V_A + V_{CE}}$$