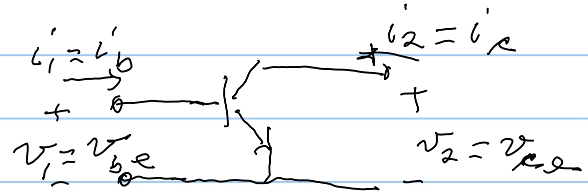
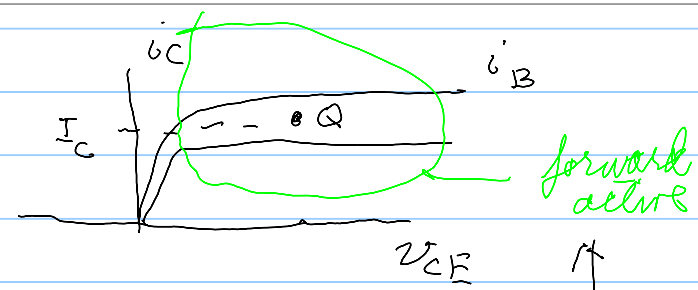
Note Title

09/20/16
303H

9/20/2016



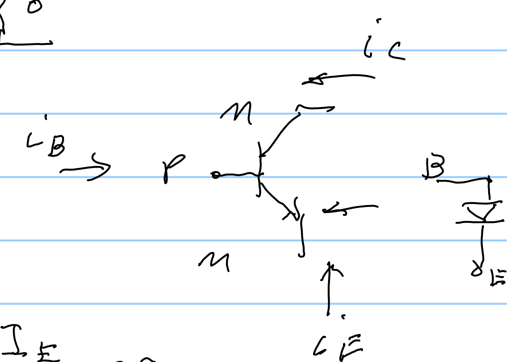
grounded emitter



↑

v_{CB} reverse bias

v_{BE} forward biases



$i_D = I_S e^{v_{BE}/V_T} \approx -i_E$

$$\left.\frac{\partial i_D}{\partial v_{BE}}\right|_Q = \frac{1}{V_T} I_S e^{v_{BE}/V_T}\Big|_Q = \frac{-I_E}{V_T} \approx g_{diode} = \frac{I_C}{\alpha V_T}$$

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

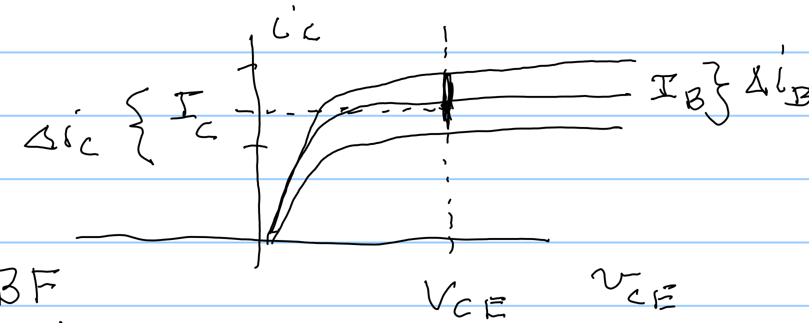
$i_c = -\alpha i_e = \beta i_b$

desire $r_\pi \Rightarrow v_{be}$ vs i_b

$-i_e = g_{diode} \cdot v_{be}$ desire $i_b = g_\pi v_{be}$

$= -\left(-\frac{\beta}{\alpha} i_b\right) = g_{diode} \cdot v_{be} = \frac{I_C}{\alpha V_T} \cdot v_{be} \Rightarrow i_b = \frac{1}{\beta} \frac{I_C}{V_T} \cdot v_{be}$

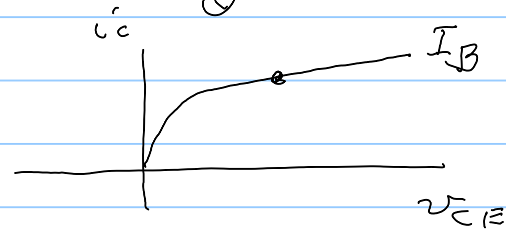
$\Rightarrow g_\pi = \frac{1}{r_\pi} = \frac{1}{\beta} \cdot \frac{I_C}{V_T}$

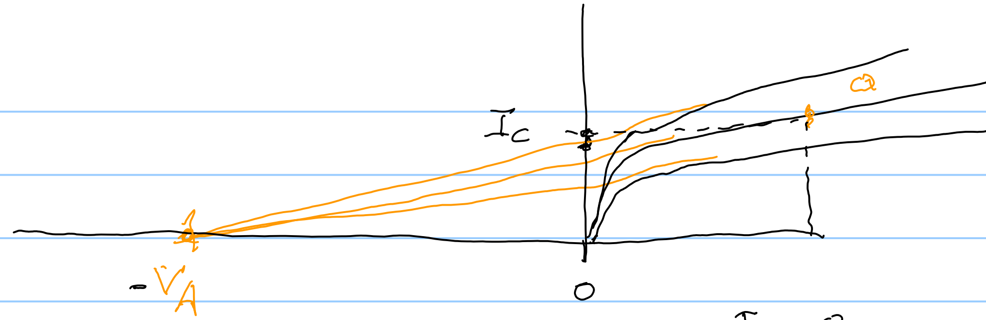


$\beta = \left.\frac{\partial i_C}{\partial i_B}\right|_Q \Rightarrow \beta_{forward} = BF$ (Spice)

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

For $r_o = 1/g_o$,



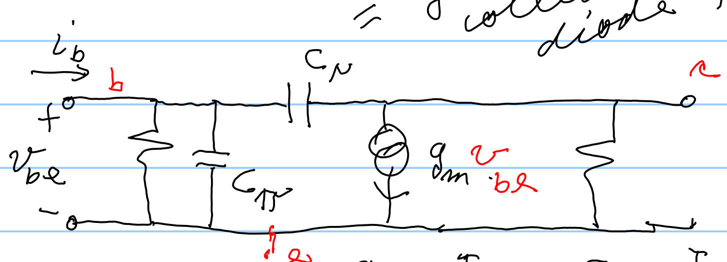


$-V_A$ = Early Voltage

slope $\approx \frac{I_C - 0}{0-(-V_A)} = \frac{I_C}{V_A} = g_o$

$= \left.\frac{\partial i_C}{\partial v_{CE}}\right|_{Q \Rightarrow i_B = I_B}$

C_μ = capacitance of base to collector diode $\approx \frac{C_\pi}{10\text{-}100}$



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

$g_m = \frac{I_C}{V_T}$

$g_o = \frac{I_C}{V_A} = \frac{V_T}{V_A} \cdot g_m$

$V_T = \frac{kT}{|Q|}$

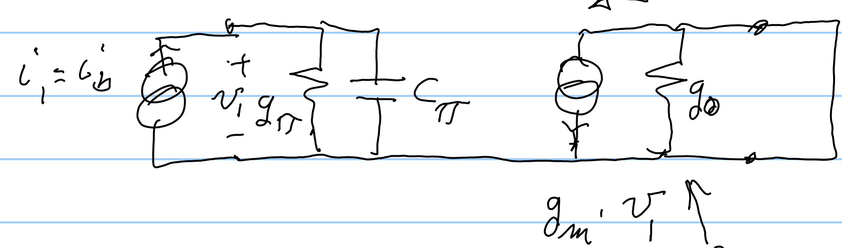
C_π = capacitance of (junction) base to emitter diode

$\beta = h_{fe}$

f = forward, e = grounded emitter

f_T = transition frequency.

i_2 vs. i_1 as a function of $s = \sigma + j\omega$ when $v_2 = 0$



$i_2 = i_c \big|_{\text{short circuit}} = g_m v_1$

$v_1 = z_\pi i_1 = \frac{1}{y_\pi} i_1$

$= \frac{1}{g_\pi + sC_\pi} \cdot i_1$

$$i_2 = g_m \cdot \frac{1/C_\pi}{s + (g_\pi / C_\pi)} \cdot i_1 \Rightarrow i_c = \beta(s) \cdot i_b$$

@ DC, $s = 0$; $\beta(s) = \frac{g_m / C_\pi}{s + (g_\pi / C_\pi)} = \frac{g_m / g_\pi}{\frac{C_\pi}{g_\pi} s + 1}$ @ DC $= \beta = \beta_0$

If $|\beta(s)|\big|_{s=j\omega} = 1$ then the transistor is not of much use

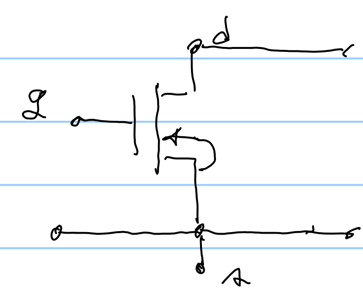
$$\omega = 2\pi f$$

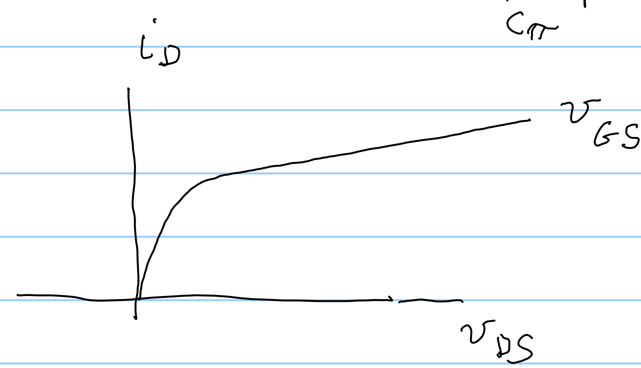
$$|\beta(j\omega)| = \frac{(g_m/C_\pi)}{|j\omega + (g_\pi/C_\pi)|} = \frac{g_m}{C_\pi} \cdot \frac{1}{\sqrt{(g_\pi/C_\pi)^2 + \omega^2}} \Rightarrow 1 \text{ @ what } \omega = \omega_T$$

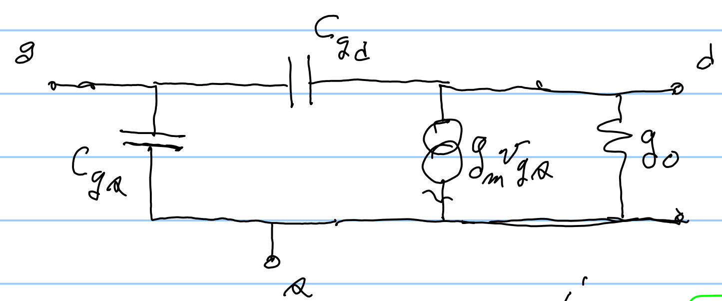
$$\Rightarrow 1 \cdot \left[(g_\pi/C_\pi)^2 + \omega^2\right] = (g_m/C_\pi)^2 \Rightarrow \omega_T = \sqrt{(g_m/C_\pi)^2 - \left(\frac{g_\pi}{C_\pi}\right)^2}$$

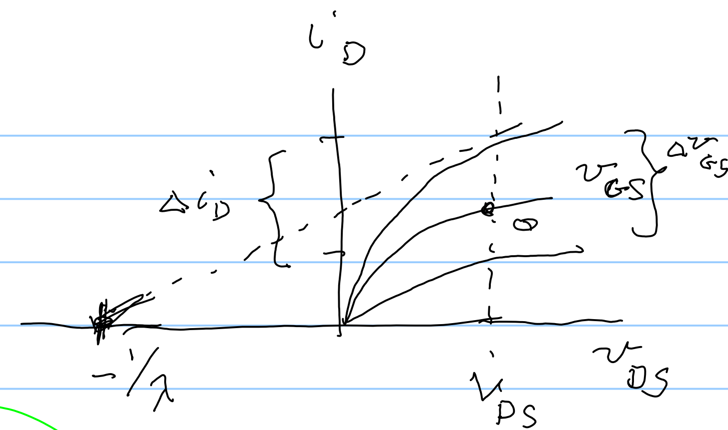
$$= \frac{g_m}{C_\pi}\sqrt{1 - (1/\beta)^2} \simeq \frac{g_m}{C_\pi}$$

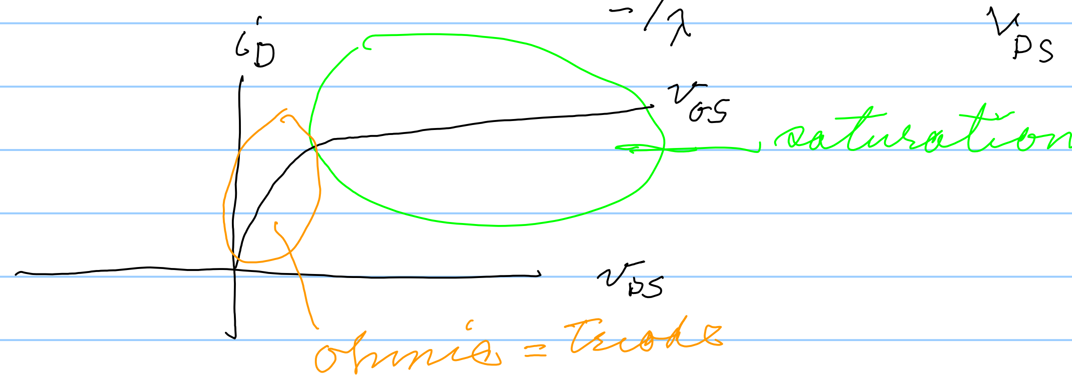
MOS











$$g_m = \frac{\partial i_D}{\partial v_{GS}} \Bigg|_{Q \Rightarrow v_{DS} = V_{DS}}$$