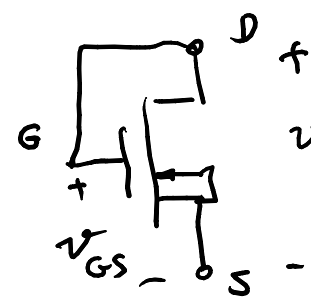
Note Title

02/14/11

EE 303

2/10/2011

diode connected MOS



$v_{DS} = v_{GS}$

$v_{DS} \geq v_{GS} - VTO$

$\quad \| \qquad\qquad\qquad \|$

$v_{GS} \qquad\qquad VTO > 0$

for diode connection

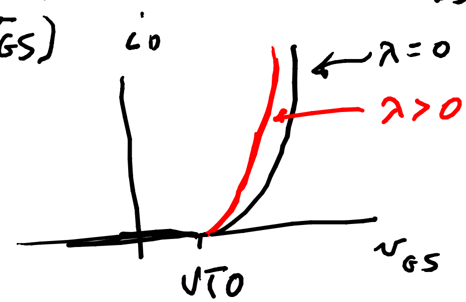
if enhancement mode NMOS

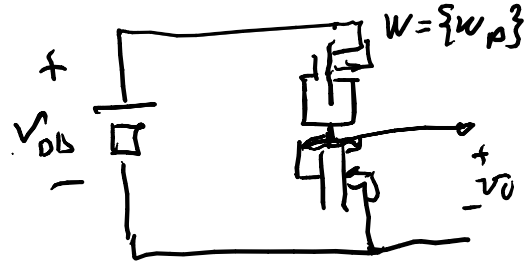
$\Rightarrow$ in saturation

in square law region

$$i_D = \frac{KP}{2} \cdot \frac{W}{L} (v_{GS} - VTO)^2 (1 + \lambda v_{GS})$$

$(v_{GS} \geq VTO)$





$i_{D_n} = -i_{D_p}$
have this eq. &
if W_p is unknown
then can solve for it

in PSpice can adjust W_p as a parameter from the special library

for BJT's

$g_m = \frac{I_C}{V_T}$ p. 405 (6.45)

g_m = mutual conductance

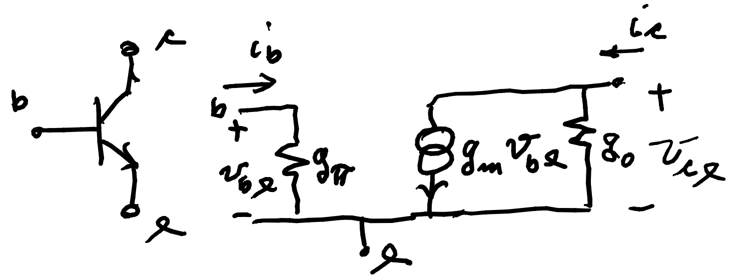
$g_\pi = \frac{g_m}{\beta}$ p. 407 (6.51)

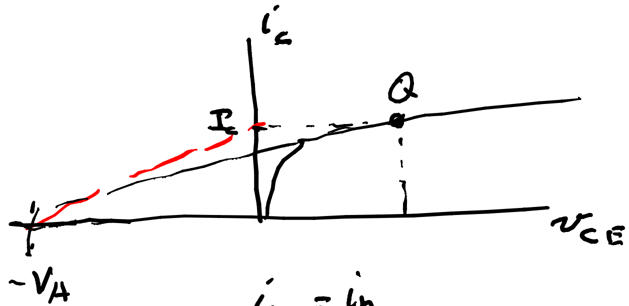
g_π = input conductance

$\beta = \frac{I_C}{I_B} = \left.\frac{\partial i_C}{\partial i_B}\right|_Q$ = current gain

$= h_{fe}$

f = forward, e = grounded emitter

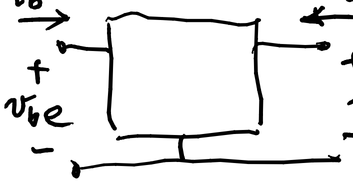




$$\text{slope} = \frac{\partial i_c}{\partial v_{ce}}$$

$$g_o = \frac{I_c - 0}{0-(-V_A)} = \frac{I_c}{V_A}$$

$i_1 = i_b$ $\quad$ $i_c = i_2$

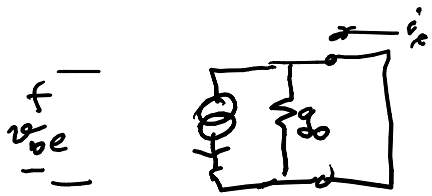


$v_1 = v_{be}$ $\quad$ $v_{ce} = v_2$

$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = i = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = Yv$$

$i_1 = i_b = y_{11} v_1 \Big|_{v_2 = 0 = \text{short}} = g_\pi v_1$ $\qquad y_{11} = g_\pi \qquad y_{12} = 0$

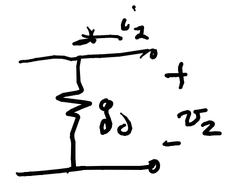
$i_2 = i_c = y_{21} v_1 \Big|_{v_2 = 0}$



$g_m v_{be} = i_c$ when $v_2 = v_{ce} = 0$

$\Rightarrow \; y_{21} = g_m$

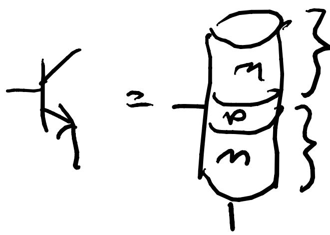
$i_2 = i_c = y_{22} v_2 \Big|_{v_1 = v_{be} = 0 \Rightarrow i \text{ in } g_m = 0} = g_o$



$$Y = \begin{bmatrix} g_\pi & 0 \\ g_m & g_o \end{bmatrix} \Rightarrow \text{small signal description}$$

$$i = \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} i_b \\ i_c \end{bmatrix}$$

KCL: $i_e = -i_b - i_c$



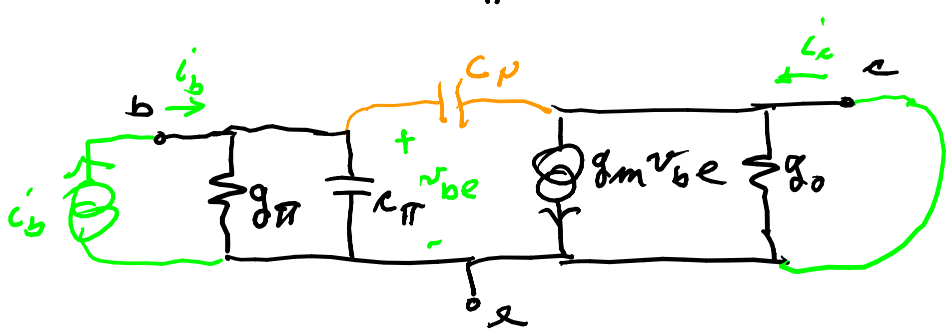
back biased $\Rightarrow r_\mu << r_\pi$

forward bias $\Rightarrow$ looks like a capacitor on the diode

$\shortparallel$

r_π

p. 107 at bottom



$$\left.\frac{i_c}{i_b}\right|_{v_{ce}=0} = \text{short the port ce}$$

$$i_b = (g_\pi + s[c_\pi + c_\mu])\, v_{be} \Rightarrow v_{be} = \frac{i_b}{g_\pi + s[c_\mu + c_\pi]}$$

$$g_m v_{be} = \frac{g_m}{g_\pi + s[c_\mu + c_\pi]} \cdot i_b$$

if ignore i in $c_\mu \Rightarrow$ $\quad i_c = g_m v_{be} \Rightarrow \dfrac{i_c}{i_b} \simeq \dfrac{g_m / g_\pi}{1 + s\dfrac{[c_\pi + c_\mu]}{g_\pi}}$

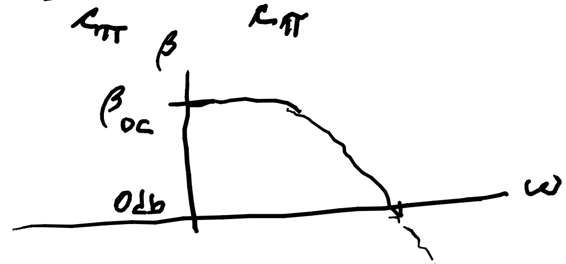
$$\simeq \frac{\beta_{oc}}{1 + s\, c_\pi / g_\pi}$$

if $s = j\omega \Rightarrow$ if ω is very large

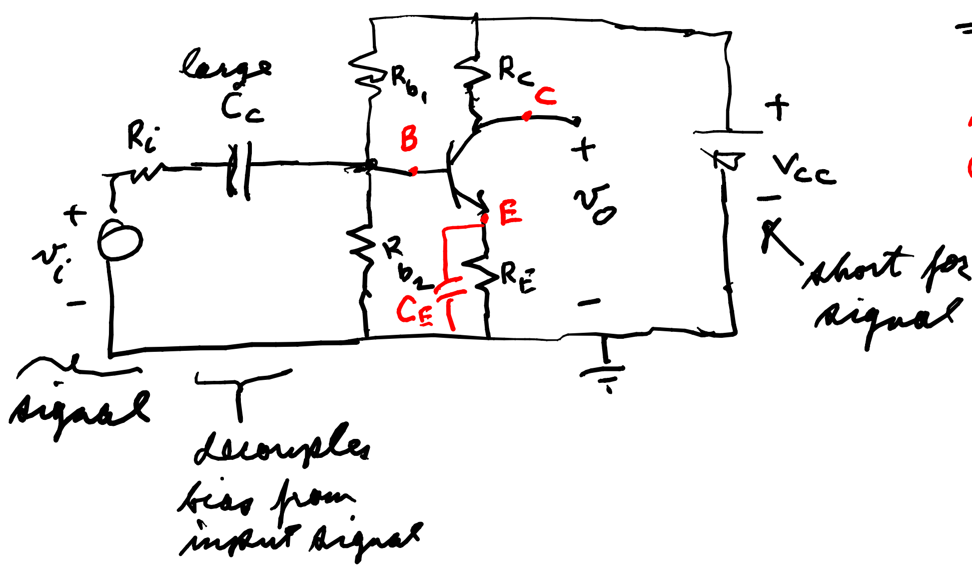
$$\left|\frac{i_c}{i_b}\right|\Bigg|_{\omega\ \text{large}} \simeq \frac{\beta_{oc}}{\frac{c_\pi}{g_\pi} \cdot \omega}$$ $\Rightarrow$ if $= 1$ then transistor becomes useless

that frequency is $\omega_t = 2\pi f_t$, transistion frequency

$$1 = \frac{\beta_{oc}}{\frac{c_\pi}{g_\pi} \cdot \omega_t} \Rightarrow \omega_t = \frac{g_\pi \beta_{oc}}{c_\pi} = \frac{g_m}{c_\pi}$$



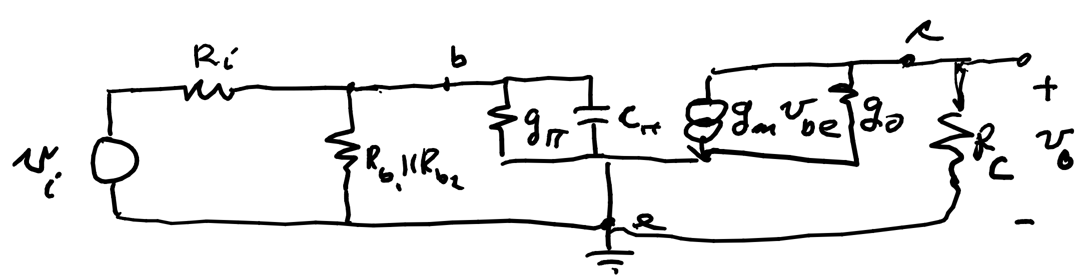
go to an amplifier



$Z_c = \frac{1}{sC_c} \Rightarrow \frac{1}{j\omega C_c}$

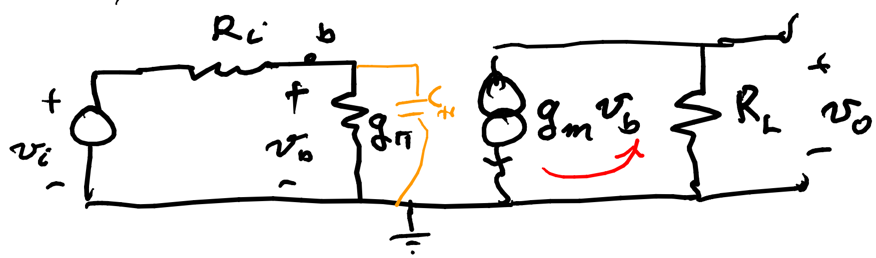
$\Rightarrow 0$ for C_c large

do also for C_E (bypass of R_E



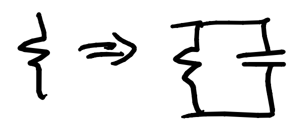
We are interested in $\frac{v_o}{v_i}$

1st approximation



$$\frac{v_o}{v_b} = -g_m R_L \qquad \text{here } R_L = \frac{R_c r_o}{R_c + r_o}$$

To get $\frac{v_o}{v_i}$ use $g_\pi \Rightarrow g_\pi + sC_\pi = y_\pi$



$$y_\pi v_b = i_b \Rightarrow v_b = \frac{i_b}{g_\pi + sC_\pi}$$

$$-v_i + R_i i_b + v_b = 0 \Rightarrow -v_i + R_i \cdot y_\pi v_b + v_b = 0$$

$$v_b = \frac{v_i}{1 + R_i y_\pi} \Rightarrow \frac{v_o}{v_i} = \frac{-g_m R_L}{1 + R_i (g_\pi + sC_\pi)}$$