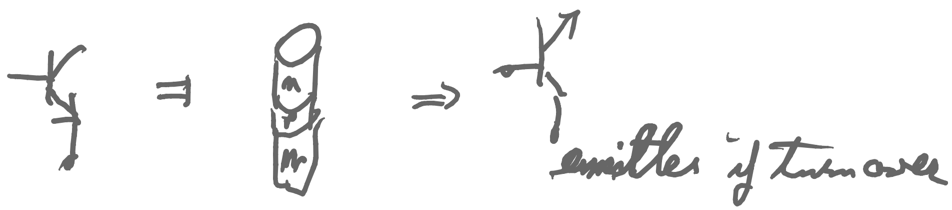
02/16/11
EE303

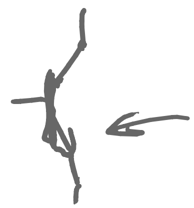
Note Title 2/10/2011

p. 705 = MOS equiv. circ.
p. 703 = C's for
p. 528 = current mirror
p. 595 = MOS differential pair
p. 613 = BJT " " "

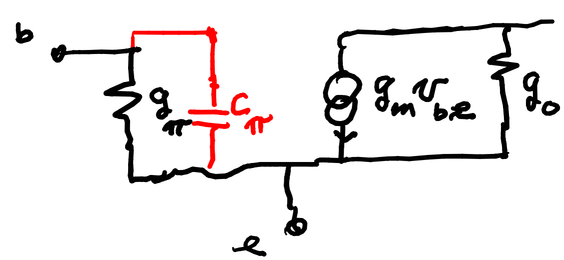


$\beta \Rightarrow$ BF, BR beta forward ≈ 100
beta reverse ≈ 1

$V_A \Rightarrow$ VAF, VAR Early voltage forward
" " reverse



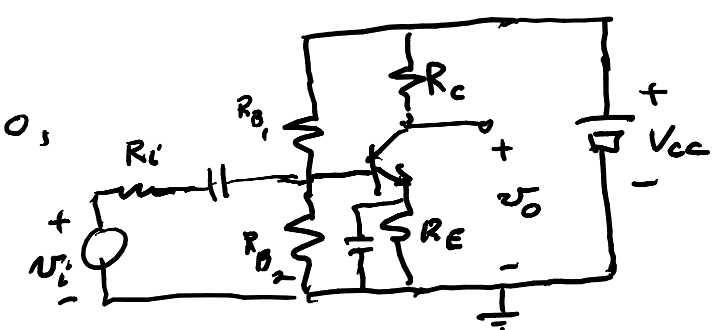
small signal



$\beta = \left.\frac{\partial i_C}{\partial i_B}\right|_Q$ also $i_C = \beta i_B$

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

for biasing of p. 390,



$I_C = 1.28\,mA \Rightarrow g_m = \frac{1.28\times10^{-3}}{26\times10^{-3}} = 0.0492 = 49.2\,m℧$

$V_T = \frac{kT}{|q|} \approx 26\,mV$ @ room T

for $\beta = 100 = h_{fe}$
(BF of Spice)

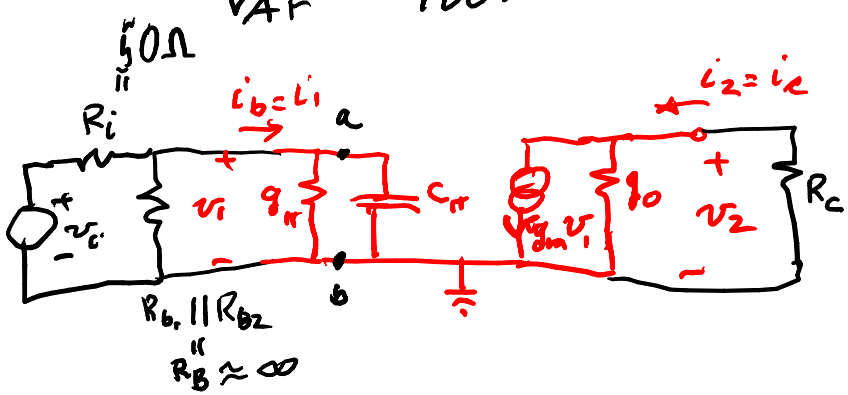
$g_\pi = \frac{g_m}{\beta} = 49.2\times10^{-5}$

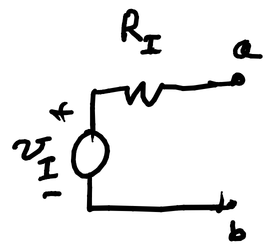
$r_\pi = \frac{1}{g_\pi} \approx \frac{10^5}{49.2} = \frac{10\times10^4}{4.92\times10} = 2.03\times10^3\,\Omega$

$= 2\times10^3 = 2\,K\Omega$

If VAF = 100 =

$g_o = \frac{I_C}{VAF} = \frac{1.28\,mA}{100\,V} = 1.28\times10^{-5}\,℧$, $r_o = \frac{1}{g_o} = 0.78\times10^5 = 78\times10^3 = 78\,K\Omega$





R_I = parallel combination of R_i, R_B, r_π = Thevenin's equivalent

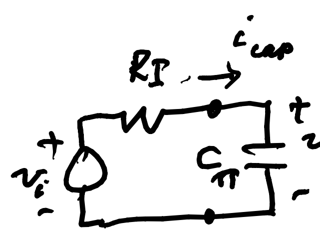
$$R_I = \frac{50\times 2\times 10^3}{50+2000} = \frac{10^5}{2050} = \frac{100}{2.05} \approx 50\,\Omega$$

$$v_I = v_i\left(\frac{R_B \| r_\pi}{R_i + R_B \| r_\pi}\right)$$

= Thevenin's eq.

$$v_I = v_i \cdot \frac{r_\pi}{R_i + r_\pi} = v_i \times \frac{2\times 10^3}{2{,}050} = v_i \times \frac{2}{2.05}$$

$$\approx v_i$$



$v_1 = v_{be}$

$$i_{cap} = C_\pi \frac{dv_1}{dt} \quad 1)$$

$$v_i - v_1 = v_{R_I} = R_I \cdot i_{cap} \quad 2)$$

solve 2) for i_{cap} ⇒ 1)

$$i_{cap} = G_I(v_i - v_1) = C_\pi \frac{dv_1}{dt}$$

$$C_\pi \frac{dv_1}{dt} + G_I v_1 = G_I v_i$$

$$C_\pi s V_1(s) + G_I V_1(s) = G_I V_i(s)$$

$$V_1(s) = \frac{G_I}{C_\pi s + G_I} \cdot V_i(s) = (\text{transfer function}) V_i$$

here $G_I = \frac{1}{50}$, choose $C_\pi = 10\,pFd = 10 \times 10^{-12}\,Fd$

$$T_v(s) = \frac{G_I/C_\pi}{s + G_I/C_\pi} =$$

$$\frac{1}{50 \times 10 \times 10^{-12}} = \frac{G_I}{C_\pi}$$

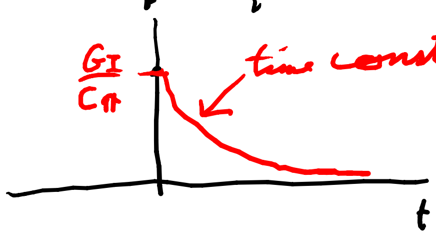
$$\frac{10^3 \times 10^9}{500} = 2 \times 10^9$$

pole at $s = -\frac{G_I}{C_\pi} = -2 \times 10^9$

zero at $s = \infty$; impulse response $= \mathcal{L}^{-1}(T_v(s))$

$$= \frac{G_I}{C_\pi} e^{-t \cdot G_I/C_\pi} 1(t)$$

time constant $= \frac{1}{G_I/C_\pi}$



for small signal $v_i(t)$, $v_1(t) = \int_0^t \frac{G_I}{C_\pi} e^{-(t-\tau) \cdot G_I/C_\pi} \cdot v_i(\tau)\, d\tau$

if $v_i(t) = V_i \cdot 1(t)$; $\mathcal{L}[v_i] = \frac{V_i}{s}$; $\mathcal{L}[g(t)] = \int_0^{\infty} e^{-st} g(t)\,dt$

$$\frac{dv_1}{dt} + \frac{G_I}{C_\pi} v_1 = \frac{G_I}{C_\pi} v_i$$

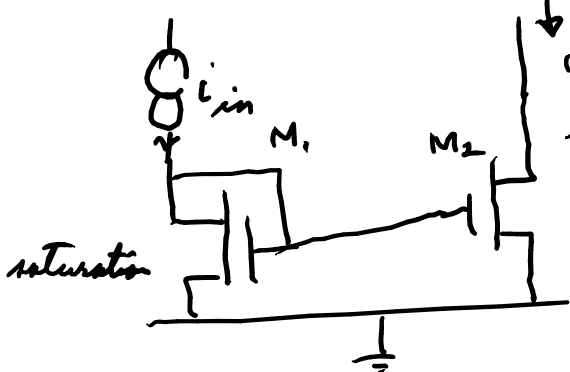
$$s V_1 + \frac{G_I}{C_\pi} V_1 = \frac{G_I}{C_\pi} V_i \cdot \frac{1}{s} \Rightarrow V_1 = \frac{1}{s} \cdot \frac{G_I/C_\pi}{s + \frac{G_I}{C_\pi}} V_i$$

$$= \left(\frac{k_0}{s} + \frac{k_1}{s + G_I/C_\pi}\right) V_i = \left(\frac{1}{s} + \frac{-1}{s + \frac{G_I}{C_\pi}}\right) V_i$$

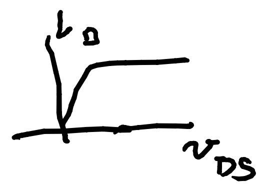
$$\therefore \mathcal{L}[V_1] = v_1(t) = V_i 1(t) - e^{-t\frac{G_I}{C_\pi}} V_i 1(t)$$

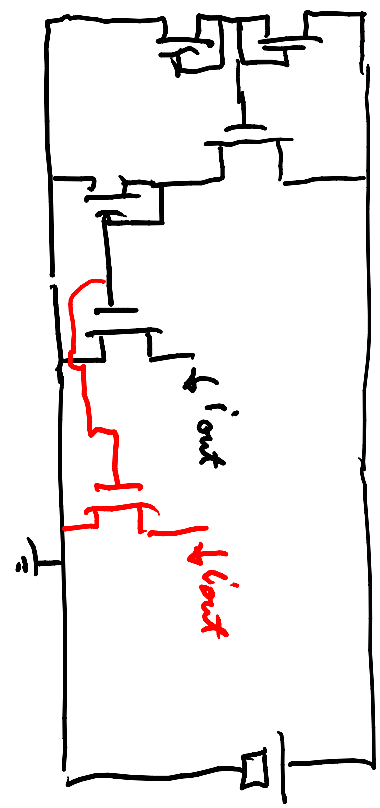
- - -

Current mirrors



$i_{out} = i_{in}$ if M_2 is in saturation





i'out
i'out