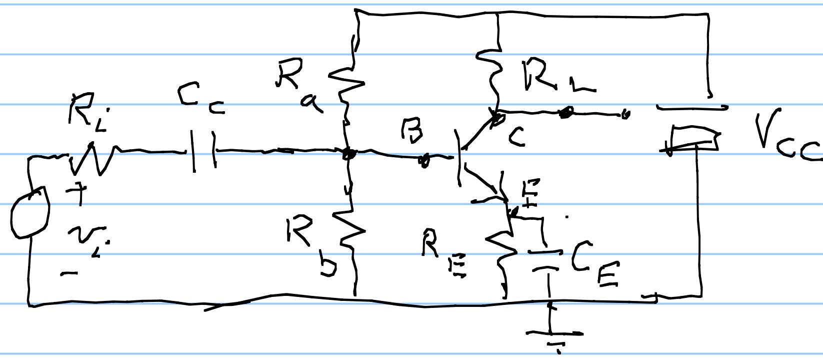
Note Title 9/20/2014

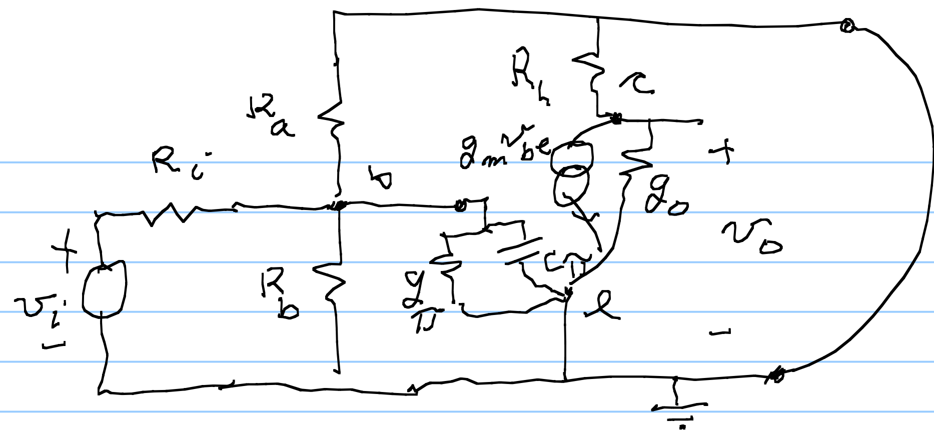
EE303H
09/23/14



choose C_c & C_E large so they are shorts at signal frequencies & open at bias

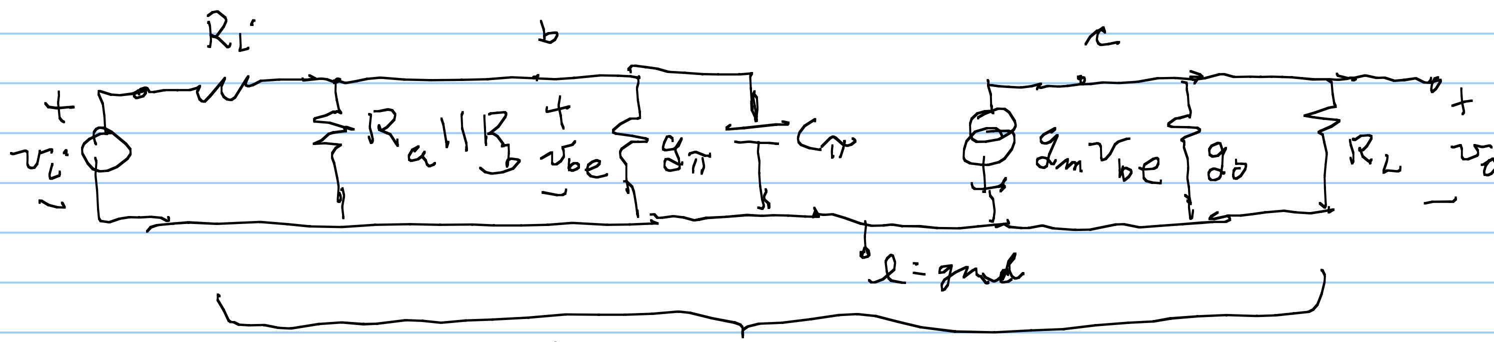
$\frac{v_o}{v_i}(\omega) \Rightarrow$ go to small signal equivalents

(at frequencies where C_c & C_E are shorts)



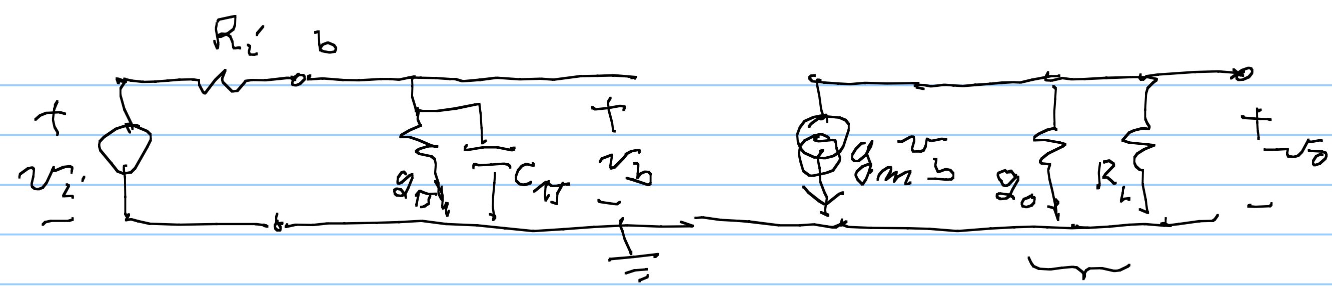
R_i
R_a
R_L
R_b
b
c
e
$g_m v_{be}$
g_o
g_π
C_π
v_i
v_o
+
-

⇓



R_i
b
c
$R_a \| R_b$
v_{be}
g_π
C_π
$g_m v_{be}$
g_o
R_L
v_i
v_o
+
-
e = gnd

hybrid-π



$r_o \| R_L$, $r_o = 1/g_o$

$$v_o = -g_m v_b \left(\frac{r_o R_L}{r_o + R_L} \right)$$

$$\Longrightarrow -g_m R_L v_b \text{ if } r_o = \frac{1}{g_o} \to \infty$$

$$v_b = \frac{z_\pi}{R_i + z_\pi} v_i \quad \text{as a voltage divider}$$

$$z_\pi = \frac{1}{y_\pi} = \frac{1}{g_\pi + sC_\pi}$$

$$= \frac{\frac{1}{g_\pi + sC_\pi}}{R_i' + \frac{1}{g_\pi + sC_\pi}} v_i = \frac{1}{1 + g_\pi R_i' + sC_\pi R_i'} v_i$$

$$= \frac{1}{sC_\pi R_i' + (1 + g_\pi R_i')} v_i$$

$$A_v(s) = \frac{v_o}{v_i} = -g_m \frac{r_o R_L}{r_o + R_L} \times \frac{1}{s C_\pi R_i + (1 + g_\pi R_i)} = -g_m \frac{r_o R_L}{r_o + R_L} \cdot \frac{(1 + g_\pi R_i)}{\frac{s C_\pi R_i}{1 + g_\pi R_i} + 1}$$

$A_v(s=0)$ = low frequency gain

$$= -g_m \frac{r_o R_L}{r_o + R_L} \cdot (1 + g_\pi R_i)$$

$$A_v(0)\Big|_{\substack{r_o \to \infty \\ R_i \to 0}} \approx -g_m R_L \quad \text{ideal voltage gain}$$

& gain goes down as $s = j\omega$ has ω increasing

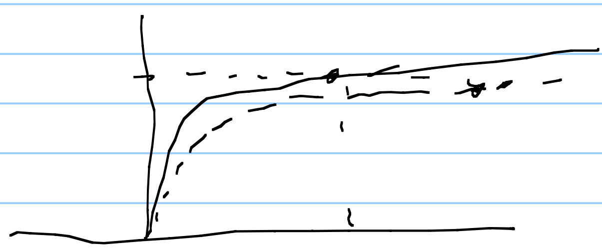
& a pole @ $s = -\frac{1}{\frac{C_\pi R_i}{1 + g_\pi R_i}} = -\left(\frac{1 + g_\pi R_i}{C_\pi R_i}\right) = -\left(\frac{1}{C_\pi R_i} + \frac{g_\pi}{C_\pi}\right)$

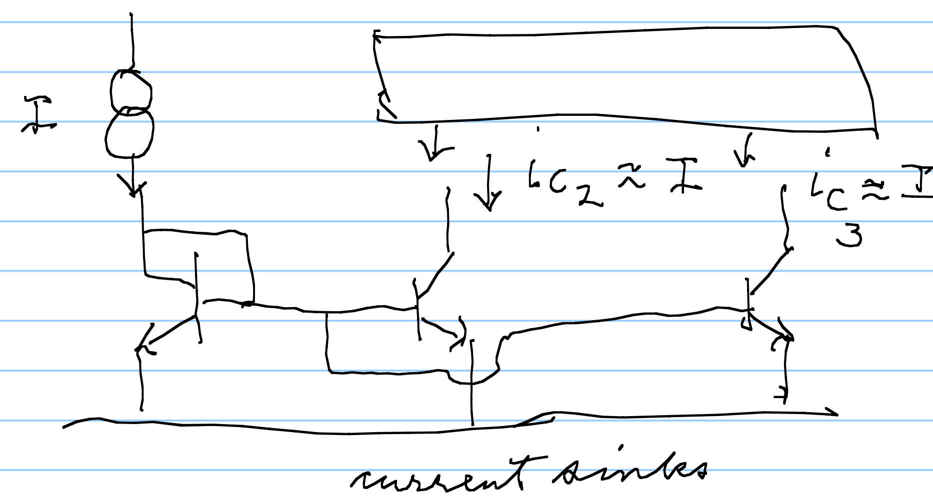
$C_\pi \approx 4 \times 10^{-12}$, $g_\pi = \frac{I_C}{\beta V_T} \approx \frac{10^{-3}}{10^2 \times 26 \times 10^{-3}} \approx \frac{100}{25} \frac{\times 10^{-2} \times 10^{-3}}{10^2 \times 10^{-3}}$

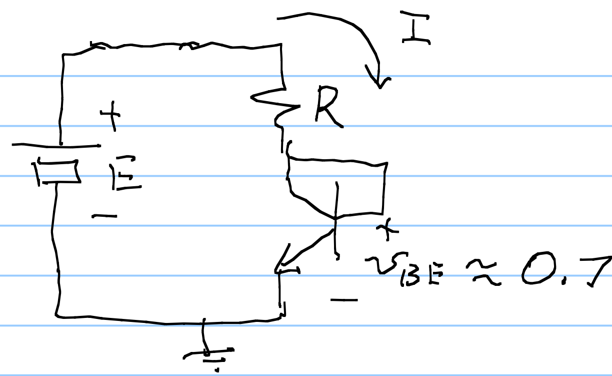
$\approx 4 \times 10^{-4}$

$\frac{g_\pi}{C_\pi} \approx \frac{4 \times 10^{-4}}{4 \times 10^{-12}} \simeq 10^{+8} = 0.1\ GHz$

Current Mirrors:
" " Sources







KVL: $E = RI + V_{BE} \Rightarrow R = \frac{E - 0.7}{I}$

$I \approx I_S e^{V_{BE}/V_T}$

for "sourced" currents