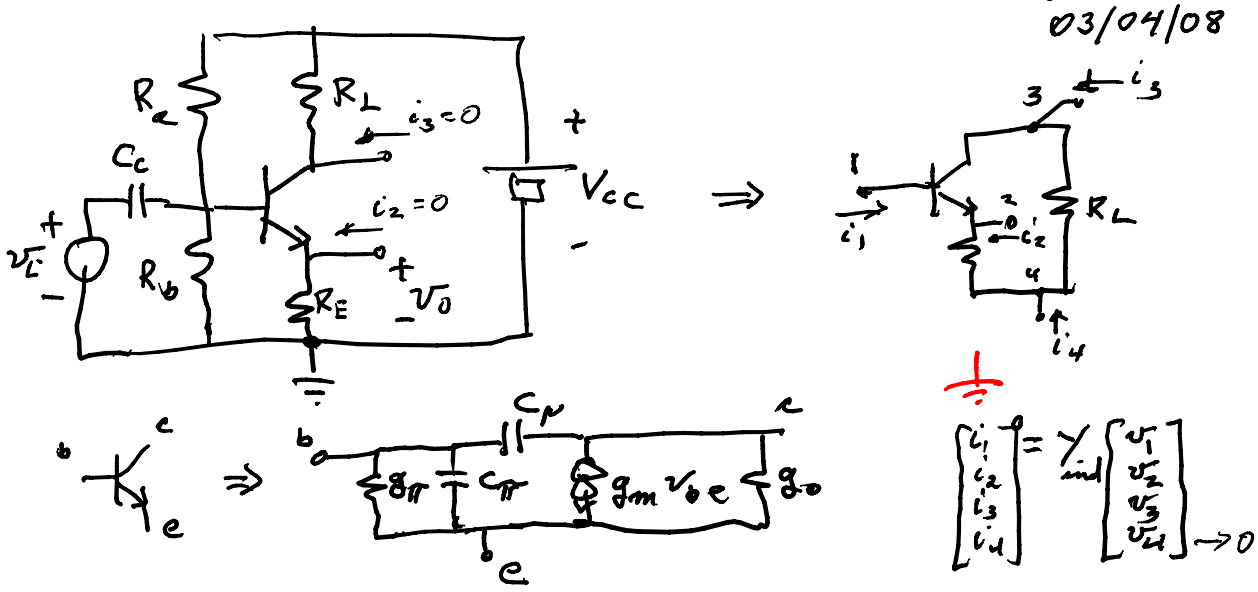
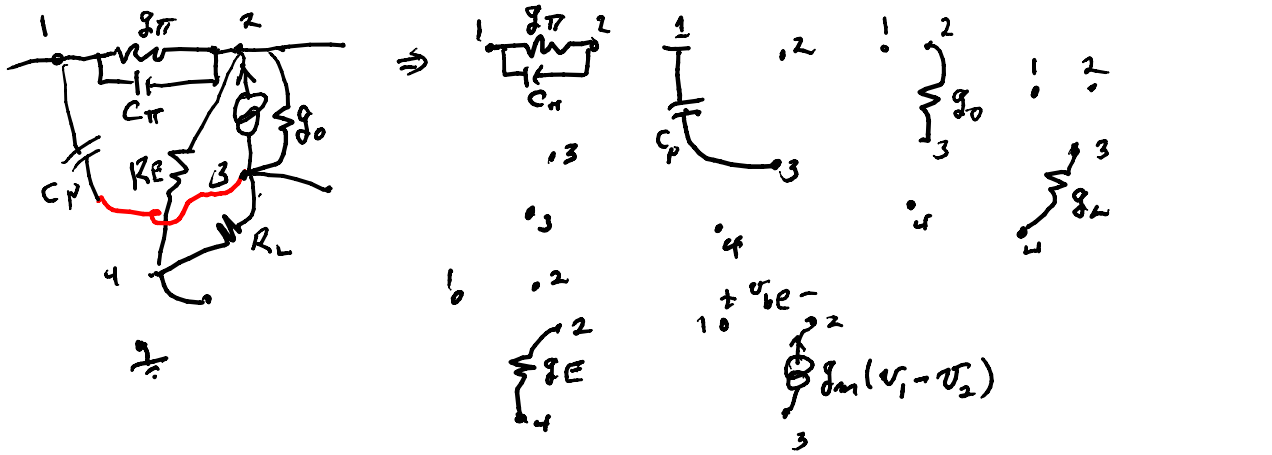
EE303
03/04/08





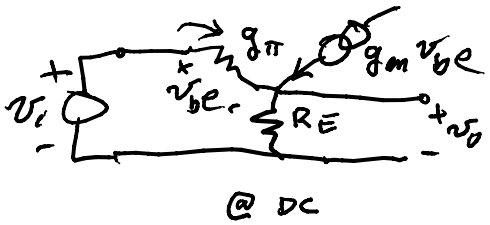
$$Y_{ind} = \begin{bmatrix} g_\pi+sC_\pi & -(g_\pi+sC_\pi) & 0 & 0 \\ -(g_\pi+sC_\pi) & g_\pi+sC_\pi & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} sC_\mu & 0 & -sC_\mu & 0 \\ 0 & 0 & 0 & 0 \\ -sC_\mu & 0 & sC_\mu & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & g_o & -g_o & 0 \\ 0 & -g_o & g_o & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & g_L & -g_L \\ 0 & 0 & -g_L & g_L \end{bmatrix}$$

$$+ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & g_E & 0 & -g_E \\ 0 & 0 & 0 & 0 \\ 0 & -g_E & 0 & g_E \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & 0 \\ -g_m & g_m & 0 & 0 \\ g_m & -g_m & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} g_\pi+sC_\mu+sC_\pi & -g_\pi-sC_\pi & -sC_\mu & 0 \\ -g_\pi-sC_\pi-g_m & g_o+g_\pi+g_m+g_E+sC_\pi & -g_o & -g_E \\ -sC_\mu+g_m & -g_o-g_m & sC_\mu+g_o+g_L & -g_L \\ 0 & -g_E & -g_L & g_E+g_L \end{bmatrix}$$

can ignore i_4 when set $v_4=0$ $\Rightarrow$ delete 4th row & column

$$Y_{model} = \begin{bmatrix} g_\pi+s(C_\mu+C_\pi) & -g_\pi-sC_\pi & -sC_\mu \\ -g_\pi-sC_\pi-g_m & g_o+g_\pi+g_m+g_E+sC_\mu & -g_o \\ +g_m-sC_\mu & -g_o-g_m & g_o+g_L+sC_\mu \end{bmatrix} \Rightarrow \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = Y_{model} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}$$

Roughly



1) $v_o = R_E (g_m + g_\pi) v_{be}$

2) $v_i = v_{be} + v_o \Rightarrow v_{be} = v_i - v_o$

2) → 1) → $v_o = R_E (g_m + g_\pi)[v_i - v_o]$

$$\frac{v_o}{v_i} = \frac{(g_m + g_\pi) R_E}{1 + R_E (g_m + g_\pi)} < 1$$

$$i_3 = 0 = \begin{bmatrix} g_m - sC_\mu & -g_o - g_m \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} + (g_o + g_L + sC_\mu) v_3$$

$$v_3 = \frac{-1}{g_o + g_L + sC_\mu} \begin{bmatrix} g_m - sC_\mu & -g_o - g_m \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

$$Y_{2\text{-port}} = \begin{bmatrix} g_\pi + s(C_\mu + C_\pi) & -g_\pi - sC_\mu \\ -g_\pi - sC_\mu - g_m & g_o + g_m + g_\pi + g_E + sC_\mu \end{bmatrix} \frac{-1}{g_o + g_L + sC_\mu} \begin{bmatrix} -sC_\mu \\ -g_o \end{bmatrix} \begin{bmatrix} g_m - sC_\mu & -g_o - g_m \end{bmatrix}$$

$$= \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}$$

$$\left.\frac{v_2}{v_1}\right|_{i_2 = 0} \Rightarrow 0 = y_{21} v_1 + y_{22} v_2 \Rightarrow \frac{v_2}{v_1} = -\frac{y_{21}}{y_{22}}$$

(= no load)

note the sign

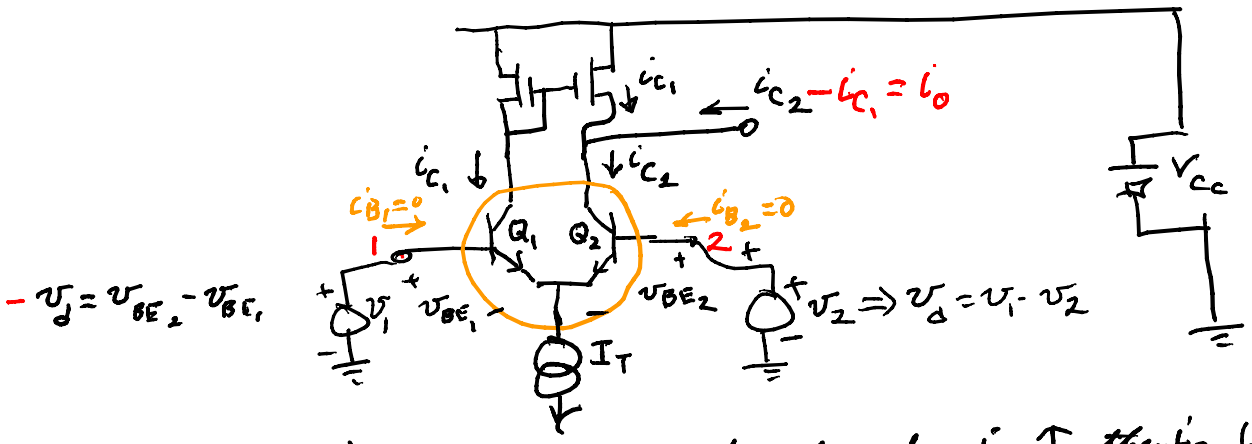
$$\frac{v_2}{v_1} = \frac{v_o}{v_i} = \frac{(-g_\pi - sC_\mu)(g_o + g_L + sC_\mu) + g_o (g_m - sC_\mu)}{(g_o + g_m + g_\pi + g_E + sC_\mu)(g_o + g_L + sC_\mu) - g_o (g_o + g_m)}$$

$$\left.\frac{v_o}{v_i}(s)\right|_{s=0} = \frac{(-g_\pi)(g_o + g_L) + g_o g_m}{(g_o + g_m + g_\pi + g_E)(g_o + g_L) - g_o (g_o + g_m)}$$

for $g_o \to 0$ $= \dfrac{-(g_\pi + g_m) g_L}{(g_m + g_\pi + g_E) g_L} =$

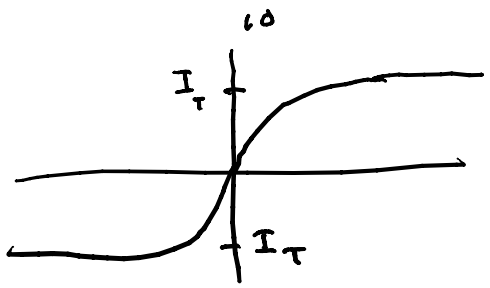
$g_L \to \infty$ $= \dfrac{-(g_\pi + g_m)}{g_m + g_\pi + g_E} \Rightarrow \dfrac{v_o}{v_i}(0) = \dfrac{(g_\pi + g_m)/g_E}{1 + (g_m + g_\pi)/g_E} < 1$

Differential pairs:



$I_T = i_{C_1} + i_{C_2}$ if I_T = fixed, when $i_{C_1} \uparrow$ then $i_{C_2} \downarrow$

"tail current"



with BJT

$i_o = I_T \tanh\left(\frac{v_d}{2V_T}\right)$

see p. 707 of text

after combine (7.73) – (7.72)