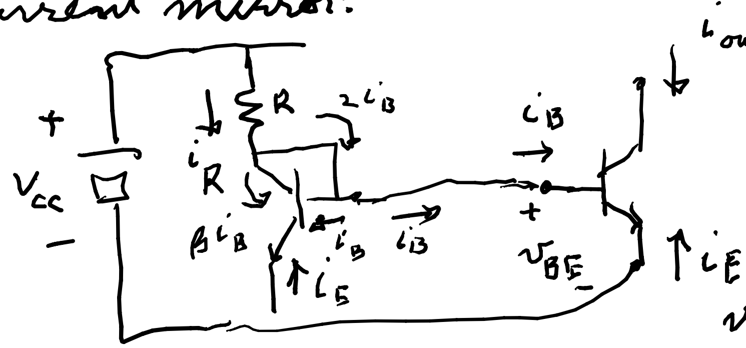
EE 303H
11/31/13

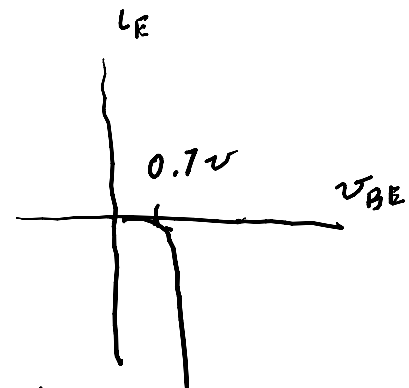
Note Title 10/31/2013

Exam on next Th, open book open notes

Questions on
1) current mirrors, BJT
2) Inverters, MOS (biasing)
3) Small signal gain of RLC MOS circuit

Current mirror:





$-i_E \approx I_{SE} e^{v_{BE}/V_T}$

↑ depend on base width

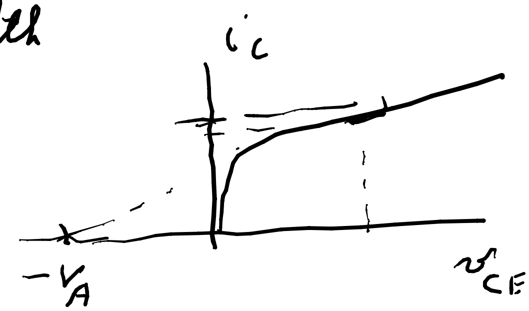
$G(V_{CC} - v_{BE}) = \beta i_B + 2 i_B$

($v_{BE} \approx 0.7$)

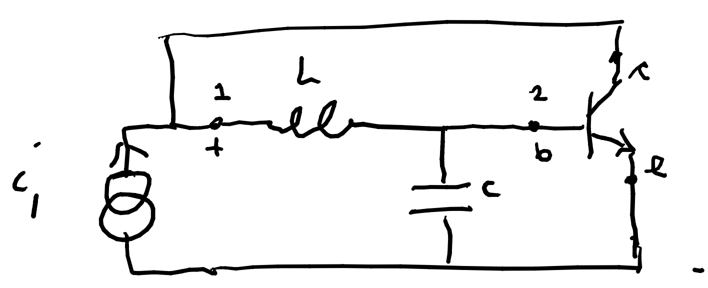
$= (\beta + 2) i_B$

$= (\beta+2) \frac{i_{out}}{\beta}$

$G = \frac{1}{R} = (1 + \frac{2}{\beta}) \frac{i_{out}}{V_{CC} - v_{BE}}$



Small signal:



BJT: $g_m = |I_C|/V_T$

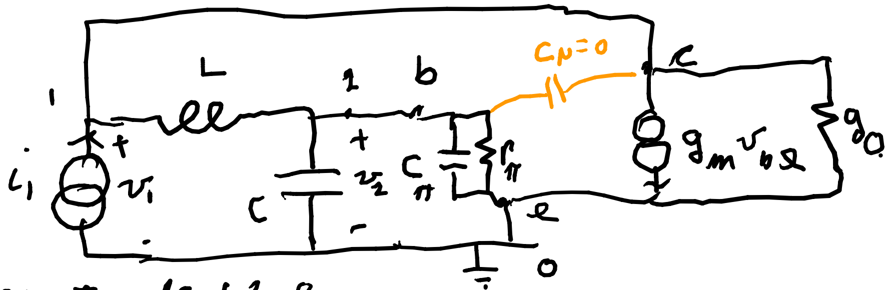
$g_o = |I_C|/V_A$

$\frac{1}{r_\pi} = g_\pi = \frac{1}{\beta} g_m$

C_π = given

C_μ = given $< C_\pi$

$\beta = h_{FE} = I_2/I_1 \Big|_{V_2 = 0}$



solve for v_1 & v_2

$C' = C + C_\pi$

KCL at nodes 1, 2, 0

node 1: $$0 = i_1 + \frac{1}{sL}(v_2 - v_1) + (-g_m v_2) + (-g_o v_1)$$

node 2: $$0 = \frac{1}{sL}(v_1 - v_2) + (-sC' v_2) + (-g_\pi v_2)$$

or

$$i_1 = \left(\frac{1}{sL} + g_o\right) v_1 + \left(-\frac{1}{sL} + g_m\right) v_2$$

$$0 = \left(-\frac{1}{sL}\right) v_1 + \left(\frac{1}{sL} + sC' + g_\pi\right) v_2$$

or

$$\begin{bmatrix} i_1 \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{1}{sL} + g_o & -\frac{1}{sL} + g_m \\ -\frac{1}{sL} & \frac{1}{sL} + sC' + g_\pi \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

node equations

$\underline{i} = Y \underline{v}$

$$\underline{v} = Y^{-1} \underline{i} = \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} z_{11} \\ \underline{z_{21}} \end{bmatrix} i_1$$

$$v_2 / i_1 = z_{21} = \frac{1/sL}{\underset{\Delta_y}{\overset{\shortparallel}{\det Y}}} \; ; \quad \Delta_y = \left(\frac{1}{sL} + g_o\right)\left(\frac{1}{sL} + sC' + g_\pi\right) - \left(-\frac{1}{sL}\right)\left(-\frac{1}{sL} + g_m\right)$$

$$= \frac{C'}{L} + \frac{g_\pi}{sL} + \frac{g_o}{sL} + sC' g_o + g_o g_\pi - \frac{g_m}{sL}$$

$$= \frac{1}{sL}\left[s^2 L C' g_o + \left(g_o g_\pi + \frac{C'}{L}\right) L s + (g_\pi + g_o - g_m) \right]$$

$$\Delta_y = \frac{C' g_o}{s}\left[s^2 + \left(\frac{g_\pi}{C'} + \frac{1}{L g_o}\right) s + \left(\frac{1}{LC}\right)\left(1 + \frac{g_\pi}{g_o} - \frac{g_m}{g_o}\right) \right]$$

$$\frac{v_2}{i_1} = \frac{1/LC' g_o}{s^2 + \left(\frac{g_\pi}{C'} + \frac{1}{L g_o}\right) s + \frac{1}{LC}\left(1 + \frac{g_\pi}{g_o} - \frac{g_m}{g_o}\right)}$$

if $g_m = g_o + g_\pi$

then get a pole at 0