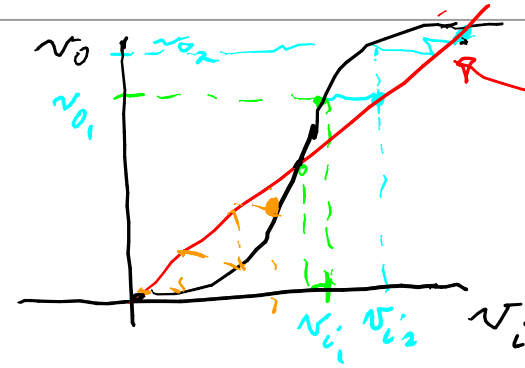
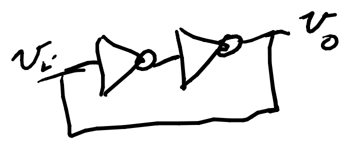
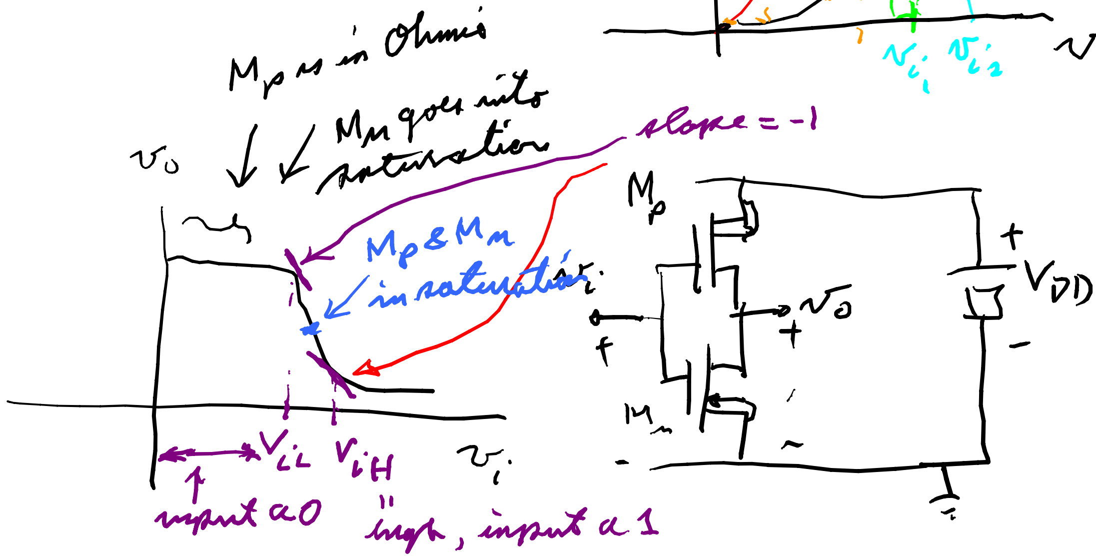
Note Title 10/4/2013

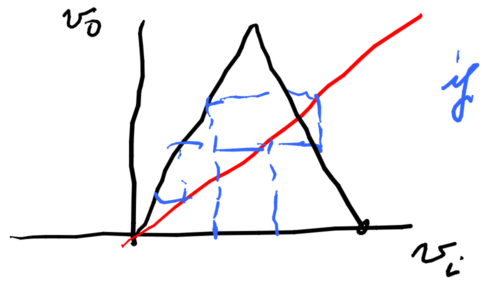
EE 303H
10/08/13





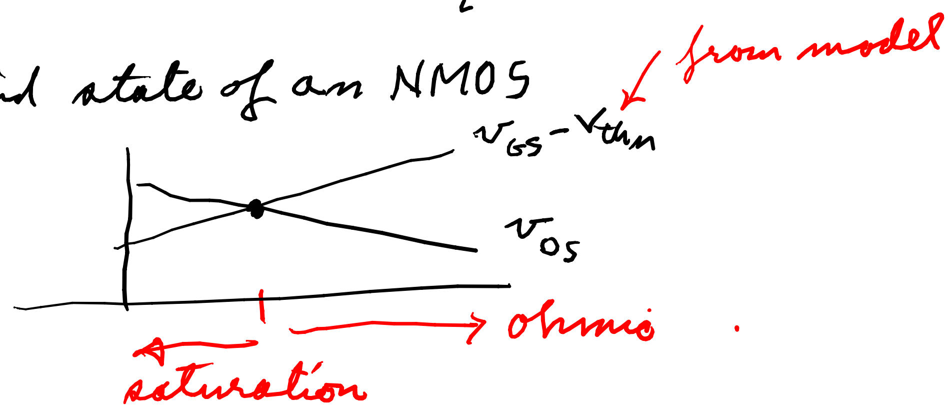


For chaos look at a return map



if an initial value returns to itself after 3 returns then this will give "chaos"

To find state of an NMOS



For V_{iH}, M_n is ohmic & M_p is saturated

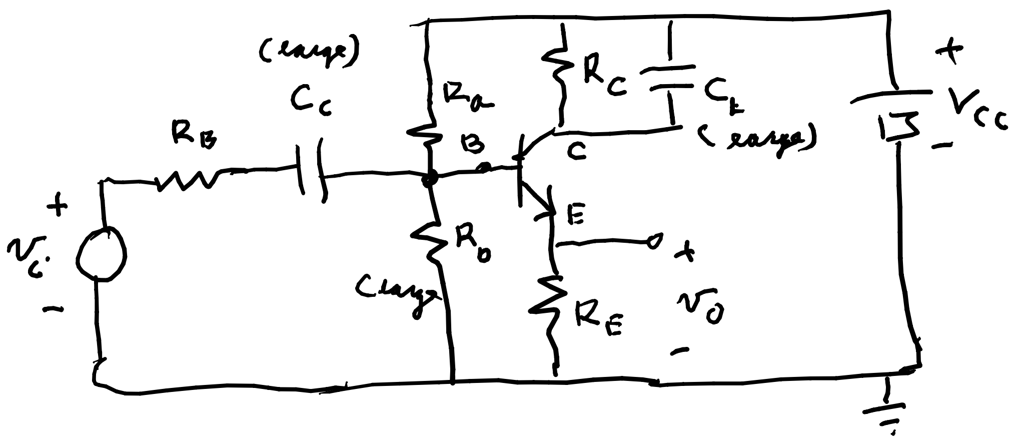
$$\left.\begin{aligned} i_{S_p} = i_{D_n} &= k_p\left(V_{DD} - v_i - |V_{TO_p}|\right)^2\left(1 + \lambda_p (V_{DD} - v_o)\right) \\ &= k_n\left(2(v_i - V_{TO_n})v_o - v_o^2\right)(1 + \lambda_n v_o) \end{aligned}\right\} \text{difference} = f(v_i, v_o)$$

for slope $= -1 = \dfrac{dv_o}{dv_i}$

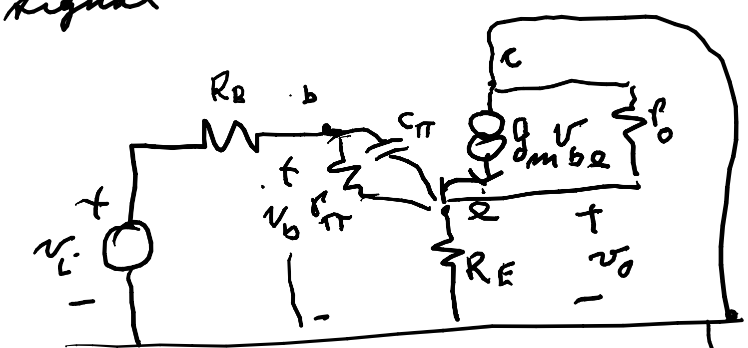
But note $F'(v_i, v_o(v_i)) + 1 = 0$

$$\Rightarrow \quad \frac{dv_o}{dv_i} = -\frac{\partial F(v_i, v_o(v_i))/\partial v_i}{\partial F(v_i, v_o(v_i))/\partial v_o} = -1$$

solve for $v_o(v_i)$, a quadratic eq. in v_o & substitute into $F(v_i, v_o(v_i))$ to find v_i



For small signal



$\dfrac{g_m}{\beta_F} = g_\pi = \dfrac{1}{r_\pi} \qquad g_m = \dfrac{I_C}{V_T}, \quad r_o = \dfrac{I_C}{V_{AF}} \qquad V_T \simeq 0.26\,mV$

derive v_o/v_i (A) use KCL, sum currents into a node to 0

@ b: $\quad G_B(v_i - v_b) - (g_\pi + sC)(v_b - v_e) = 0 = G_B(v_i - v_b) - y_\pi(v_b - v_e)$

@ e: $\quad -G_E v_o + g_m(v_b - v_e) - g_o v_o + y_\pi(v_b - v_e) = 0$

$$\begin{bmatrix} G_B + y_\pi & -y_\pi \\ -(g_m + y_\pi) & G_E + g_m + g_o + y_\pi \end{bmatrix} \begin{bmatrix} v_b \\ v_e \end{bmatrix} = \begin{bmatrix} G_B v_i \\ 0 \end{bmatrix}$$

here $v_e = v_o$

$$v_b = \frac{(G_E + g_m + g_o + y_\pi)}{g_m + y_\pi} \cdot v_o \Rightarrow \text{2nd eq.}$$

$$\Rightarrow \left[\frac{G_B + y_\pi}{g_m + y_\pi}\left(G_E + g_m + g_o + y_\pi\right) - y_\pi\right] v_o = G_B v_i$$

$$\frac{v_o}{v_i}(s) = \frac{G_B(g_m + g_\pi + sC_\pi)}{(G_B + g_m + sC_\pi)(G_E + g_m + g_o)} = \frac{\overset{G_B(g_m+g_\pi)}{\overset{\shortparallel}{a}} + s\overset{G_B C_\pi}{\overset{\shortparallel}{b}}}{c + s\underset{(G_E+g_m+g_o)C_\pi}{\underset{\shortparallel}{d}}}$$

for unit step response, use $v_i = \frac{1}{s}$

$$v_o(s)\Big|_{v_i = 1(t)} = \frac{a+bs}{c+ds} \times \frac{1}{s} = \frac{k_1}{s} + \frac{k_2}{s + c/d} = \frac{a/c}{s} + \frac{\frac{a - b(c/d)}{-c/d}}{s + c/d}$$

$$v_o(t)\Big|_{1} = \frac{a}{c} 1(t) + \left(\frac{a - b(c/d)}{-c/d}\right) e^{-(c/d)t} 1(t)$$

Impulse response. $d v_o(\,)\big|_{v_i = 1(t)} / dt$

$$v_o(t)\Big|_{\delta = v_i} = \frac{a}{c}\delta(t) + (a - bc/d)\, e^{-(c/d)t} 1(t) + \left(\frac{a - b(c/d)}{-c/d}\right)\delta(t)$$

Frequency response

$$\text{mag.}\left(\frac{v_o}{v_i}(s)\right)\Big|_{s = j\omega} = \left|\frac{a + j\omega b}{c + j\omega d}\right| = \frac{|a + jb\omega|}{|c + j\omega d|}$$