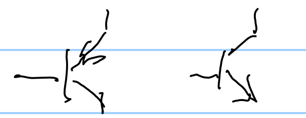
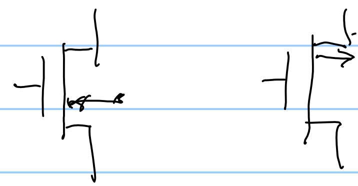
Note Title 12/8/2016

EE 303 #1

12/08/16



PNP NPN



NMOS PMOS

in saturation

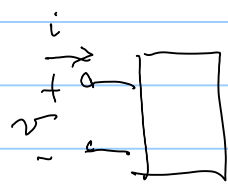
$i_{D_n} = k_n (v_{GS} - V_{TO_n})^2 (1 + \lambda v_{DS})$

in ohmic

$= k_n \left(2(v_{GS} - V_{TO_n})(v_{DS}) - v_{DS}^2\right)$

off $i_D = 0$

exponential square law



$v = z\, i \,, \quad i = y\, v$

$z = 1/y$

$= y^{-1}$

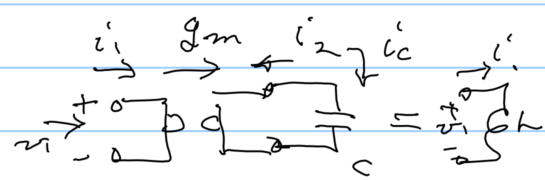
Y eq. circuit

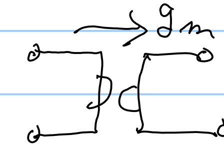
G component in Spice $\Leftarrow$ $Y = \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix}$ has no Z as $\det Y = 0$

for our circuits $Y = \begin{bmatrix} C_{11} s & -C_{12} s \\ -sC_{12} + g_m & sC_{22} + g_o \end{bmatrix}$

$$Y_1 = \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix}, \quad Y_2 = \begin{bmatrix} 0 & -g_m \\ 0 & 0 \end{bmatrix} \Rightarrow Y = \underbrace{\begin{bmatrix} 0 & -g_m \\ g_m & 0 \end{bmatrix}}_{\text{passive}} \Leftarrow \text{a gyrator}$$

active





$+v_1 \sim i_1$

$$-sCv_2 = -i_c = \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 0 & -g_m \\ g_m & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

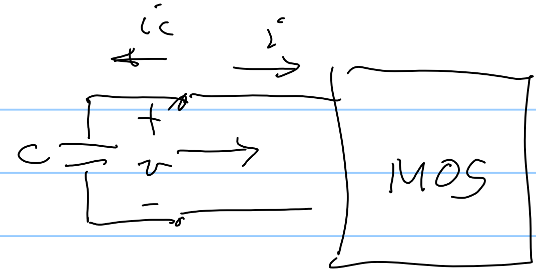
$$-sCv_2 = g_m v_1, \quad i_1 = -g_m v_2$$

$$v_2 = -\frac{1}{g_m} i_1 \Rightarrow -sC\left(\frac{-1}{g_m}\right) i_1 = g_m v_1 \Rightarrow v_1 = s\frac{C}{g_m^2} i_1$$

$$\frac{v_1}{i_1} = z_{in} = s\frac{C}{g_m^2} = sL \Rightarrow L = C/g_m^2$$

if $g_m = 10^{-3} \Rightarrow L = 10^6 C$

if $C = 1\mu Fd \Rightarrow L = 1$ Henry



$\Rightarrow$ square law

$$\dot{x} + ax^2 + bx + c = 0 \quad \text{Riccati equation}$$

$$\frac{dx}{dt} = -(ax^2+bx+c) = -a(x-\alpha_1)(x-\alpha_2)$$

$$-a\,dt = \frac{dx}{(x-\alpha_1)(x-\alpha_2)} \Rightarrow \int_0^t (-a\,d\tau) = \int_{x(0)}^{x(t)} \frac{dx}{(x-\alpha_1)(x-\alpha_2)}$$

$$-at = \int_{x(0)}^{x(t)} \left[\frac{k_1}{(x-\alpha_1)}dx + \frac{k_2}{(x-\alpha_2)}dx\right] ; \quad \frac{1}{(x-\alpha_1)(x-\alpha_2)} = \frac{k_1}{(x-\alpha_1)} + \frac{k_2}{(x-\alpha_2)}$$

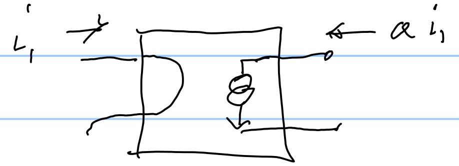
$$k_1 = \left.\frac{1}{x-\alpha_2}\right|_{x=\alpha_1} = 1/(\alpha_1-\alpha_2), \quad k_2 = 1/(\alpha_2-\alpha_1)$$

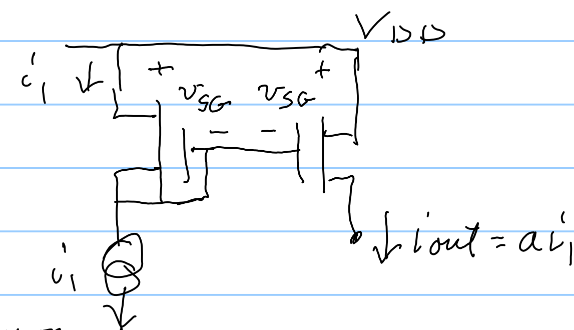
$$= \int_{x(0)}^{x(t)} \left[\frac{k_1}{x-\alpha_1}dx + \frac{k_2}{x-\alpha_2}dx\right] = \int_{x(0)-\alpha_1}^{x(t)-\alpha_1} \frac{k_1}{y}dy + \int_{x(0)-\alpha_2}^{x(t)-\alpha_2} \frac{k_2}{y}dy$$

$$-at = k_1 \ln\left(\frac{x(t)-\alpha_1}{x(0)-\alpha_1}\right) + k_2 \ln\left(\frac{x(t)-\alpha_2}{x(0)-\alpha_2}\right) = k_1\left(\ln\left(\frac{\frac{x-\alpha_1}{x(0)-\alpha_1}}{\frac{x-\alpha_2}{x(0)-\alpha_2}}\right)\right)$$

$$-\frac{a}{k_1}t = \ln\left(z(x)\right) \Rightarrow \frac{x-\alpha_1}{x-\alpha_2}\cdot\left(\frac{x(0)-\alpha_2}{x(0)-\alpha_1}\right) = e^{-at/k_1}$$

Current mirrors: F component in .Spice





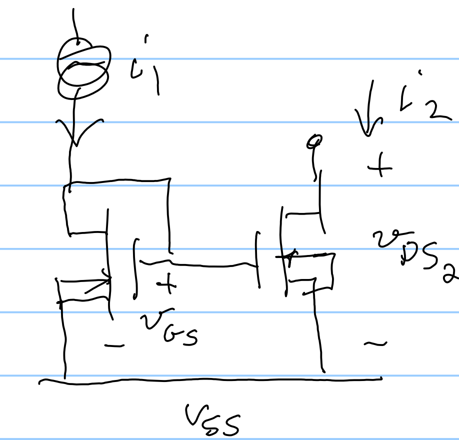
$$k_p = \frac{KP}{2}\cdot\frac{W}{L}$$

current only down
$\Rightarrow$ sourcing current

$$i_1 = k_{p}\left(v_{SG} - |V_{TOp}|\right)^2$$

$$i_2 = k_{p_2}\left(v_{SG} - |V_{TOp}|\right)^2$$

$$\frac{i_2}{i_1} = \frac{k_{p_2}}{k_{p_1}} = \frac{(W/L)_2}{(W/L)_1}$$

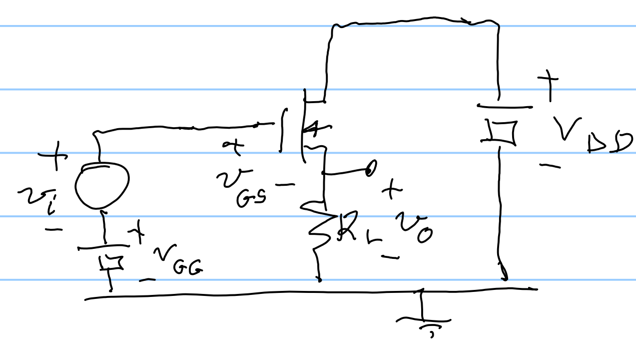


sinking current

$v_{DS_2} > v_{GS} - V_{TO}$

if bulk not at source then $V_{TO} \rightarrow$ $V_{th} = V_{TO} + \gamma\left(\sqrt{V_{SB} + \phi} - \sqrt{\phi}\right)$

grounded drain amplifier



v_o will be less than v_i due to drop of signal on GS.