EE303
10/11/12

Note Title 10/10/2012

$$i_1 = \frac{1}{2}\left\{I_T \pm \sqrt{2 k v_i^2 I_T - k^2 v_i^4}\right\} = \frac{I_T}{2}\left\{1 \pm \sqrt{\frac{2k}{I_T}}\, v_i \sqrt{1-\frac{1}{4}\left(\sqrt{\frac{2k}{I_T}}\, v_i\right)^2}\right\}$$

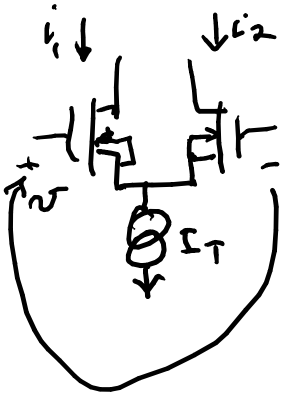
$i_2 = I_T - i_1$; $i_o = i_1 - i_2 = 2 i_1 - I_T$; as $i_1 \uparrow$ if $v_i \uparrow$ use + in i_1

$$= I_T \sqrt{\frac{2k}{I_T}}\, v_i \sqrt{1-\frac{1}{4}\left(\sqrt{\frac{2k}{I_T}}\, v_i\right)^2}$$

Body effect p. 324, Eq. (5.107)

$$v_{th} = VTO + GAMMA\left(\sqrt{PHI + v_{SB}} - \sqrt{PHI}\right)$$

$$PHI = 2\varphi_F \quad , \quad GAMMA = \gamma$$

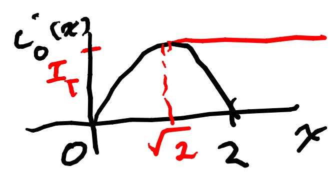


$$i_o = i_1 - i_2 = i_1 - (I_T - i_1) = 2 i_1 - I_T$$

$$i_1 + i_2 = I_T \qquad i_o = I_T \sqrt{\frac{2k}{I_T}}\, v \sqrt{1-\frac{1}{4}\left(\sqrt{\frac{2k}{I_T}}\, v\right)^2}$$

$$k = \frac{KP}{2}\cdot\frac{W}{L} \qquad i_o(x) = I_T\, x \sqrt{1-\frac{1}{4}x^2}$$

$$x = \sqrt{\frac{2k}{I_T}}\, v$$



$$\frac{di_o}{dx} = I_T\left\{\sqrt{1-\frac{1}{4}x^2} + x\frac{1}{\sqrt{1-\frac{1}{4}x^2}}\cdot\frac{1}{2}\left(-\frac{1}{4}2x\right)\right\}$$

$$= 0 = I_T\left\{\frac{1-\frac{1}{4}x^2 - \frac{1}{4}x^2}{\sqrt{1-\frac{1}{4}x^2}}\right\} \Rightarrow 0 = 1 - \frac{1}{2}x^2$$

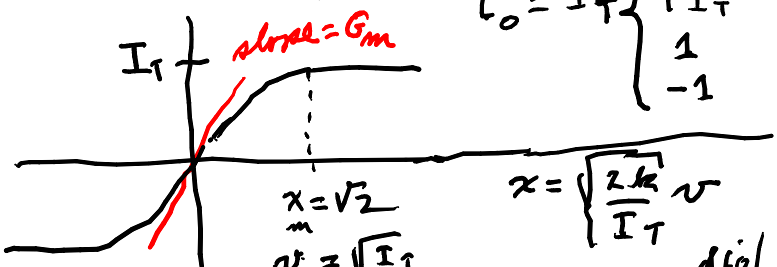
$i_{o_{max}}$ is at $x = \pm\sqrt{2}$, $x_m = x_{max} \Rightarrow i_o = I_T\sqrt{2}\cdot\sqrt{1-\frac{1}{4}(\sqrt{2})^2} = I_T\frac{\sqrt{2}}{\sqrt{2}} = I_T$

$$-\sqrt{\frac{I_T}{k}} < v < \sqrt{\frac{I_T}{k}}$$

$$i_o = i_1 - i_2$$

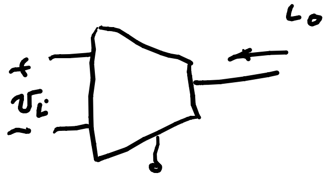
$$i_o = I_T\begin{cases}\sqrt{\frac{2k}{I_T}}\, v\sqrt{1-\frac{1}{4}\left(\sqrt{\frac{2k}{I_T}}\, v\right)^2} \\ 1 & \text{if } \sqrt{I_T/k} < v \\ -1 & -\sqrt{\frac{I_T}{k}} < v\end{cases}$$

$$@\ x = \sqrt{2},\quad v = \frac{\sqrt{2}}{\sqrt{\frac{2k}{I_T}}} = \sqrt{\frac{I_T}{k}}$$



$$x = \sqrt{\frac{2k}{I_T}}\, v$$

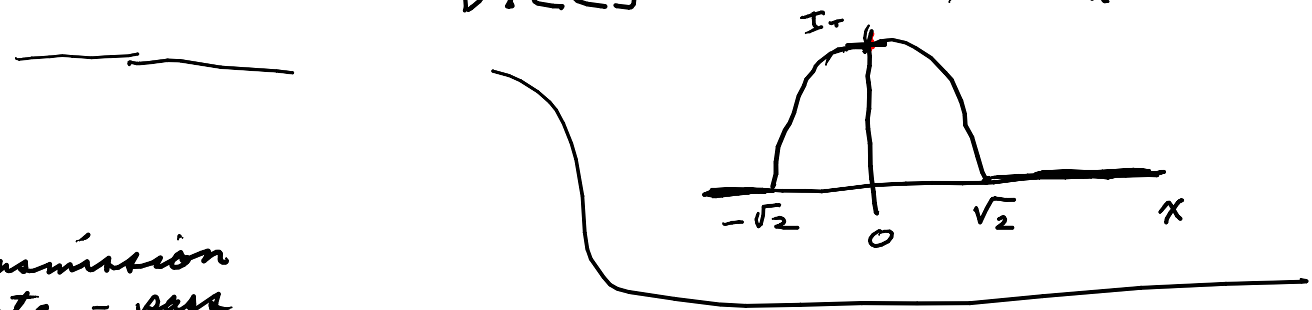
$$\left.\frac{di_o}{dv}\right|_{v=0} = \left. G_m\right|_{v=0} = \frac{I_T\left(1-\frac{x^2}{2}\right)}{\sqrt{1-\frac{1}{4}x^2}}\cdot\underbrace{\sqrt{\frac{2k}{I_T}}}_{=dx/dv}\Bigg|_{x=0} = \sqrt{2kI_T}$$



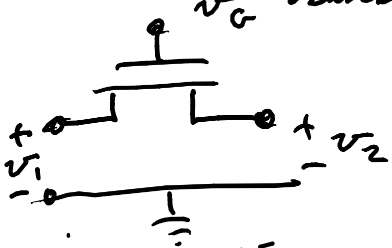
OTA = operational transconductance amplifier

DVCCS

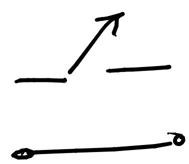
$\frac{di_o}{dx} \sim G_m$

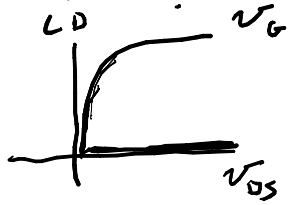


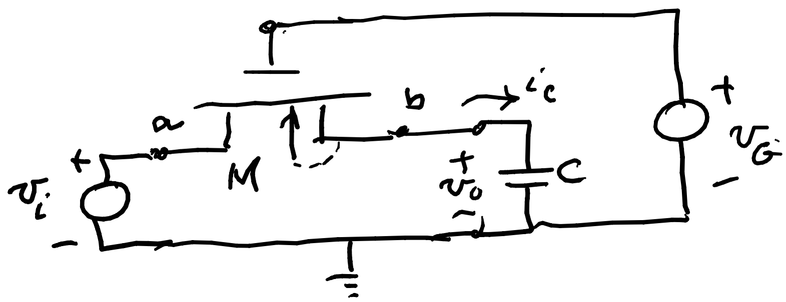
Transmission gate = pass transistor



$\approx$

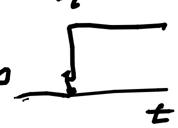






$a = S$ if $v_i < v_o$

$a = D$ if $v_i > v_o$



if $v_o = 0$ @ $t = 0$ & v_i is a step

and $v_G = \max > 0$; $v_G = V_i$

$\Rightarrow$ a = Drain & b = Source

$$i_c = C\frac{dv_o}{dt} = i_D = \frac{KP}{2}\frac{W}{L}(v_{GS} - V_{th})^2$$

as M is in saturation $v_{GS} = V_i - v_o$

$v_{DS} = V_i - v_o$

$$v_{DS} \geq v_{GS} - V_{th}$$

$$C\frac{dv_o}{dt} = k\left(V_i - v_o - V_{th}\right)^2 ; \quad k = \frac{KP}{2}\frac{W}{L}$$

(assume V_{th} = const. = VTO

$$= \frac{C\, d(V_i - V_{th} - v_o)}{dt} = -C\frac{dv_o}{dt} = C\frac{dx}{dt}$$

$$= -k x^2$$

$$\boxed{\frac{dx}{dt} = -\frac{k}{C} x^2}$$ Riccati eq.

$x = V_i - V_{th} - v_o$

$$\frac{dx}{dt} = -\frac{dv_o}{dt}$$

$x(0) = V_i - VTO$

$$\frac{dx}{x^2} = -\frac{k}{C}\,dt$$

$$\int_{x(0)}^{x(t)} \frac{dx}{x^2} = \int_0^t -\frac{k}{C}\,d\tau$$

$$= -\frac{1}{x}\Bigg|_{x(0)}^{x(t)} = -\frac{k}{C}\tau\Bigg|_0^t = -\frac{k}{C}t$$

$$= -\frac{1}{x(t)} + \frac{1}{x(0)} = -\frac{k}{C}t$$

$$\frac{1}{x} = \frac{kt}{C} + \frac{1}{x(0)} \Rightarrow x = \frac{1}{\frac{kt}{C} + \frac{1}{x(0)}}$$

$$x(t) = V_i - V_{th} - v_0 = \frac{1}{\frac{kt}{C} + \frac{1}{V_i - V_{TO}}}$$

$$v_0(t) = V_i - V_{th} - \frac{1}{\frac{kt}{C} + \frac{1}{V_i - V_{TO}}}$$

note $v_0(0) = 0$ as desired