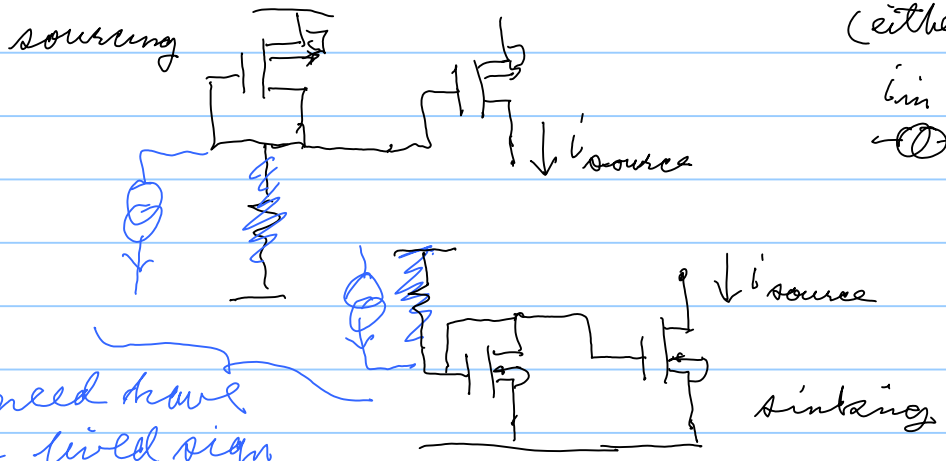
EE 303 H
10/27/15

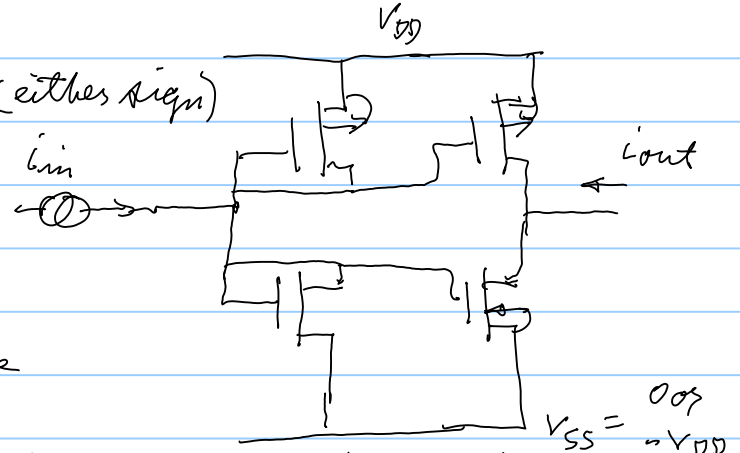
Note Title 10/27/2015

Exam on Th. open book open notes

1. calculating g_m, MOS, BJT
2. current sources & current mirrors
3. Transmission gates
4. Capacitors low & charging c's

Bidirectional current mirror

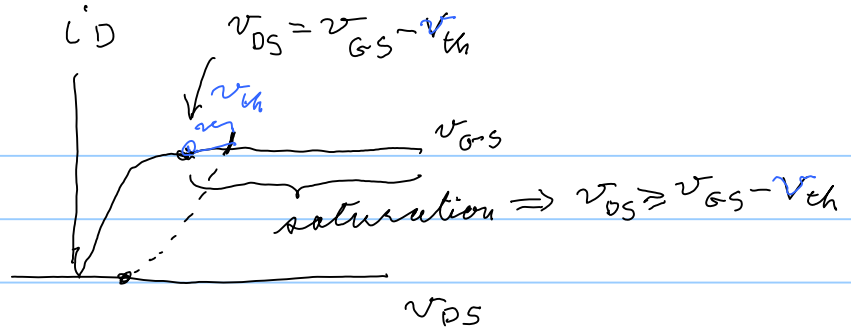


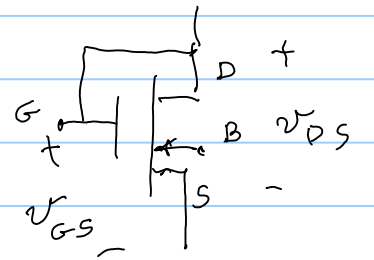


a bidirectional current mirror

saturation

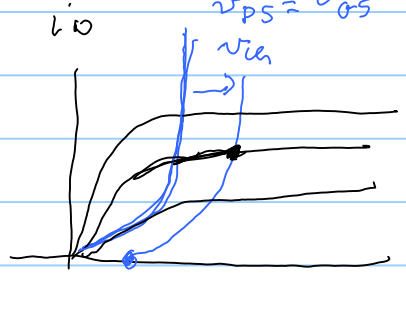
$i_D = k_n (v_{GS} - V_{th})^2$

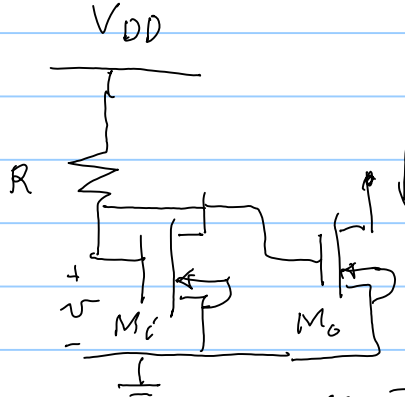




$\Rightarrow v_{GS} = v_{DS} = v$ $\quad v_{DS} = v$ $\quad v_{GS} - V_{th} = v - v_{th}$

> if $v_{th} > 0$





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

$\Downarrow$

$i_D = i_D = \frac{V_{DD} - v}{R} = k_n (v - v_{th})^2$ $\quad | \; v_{th} = V_{TO}$

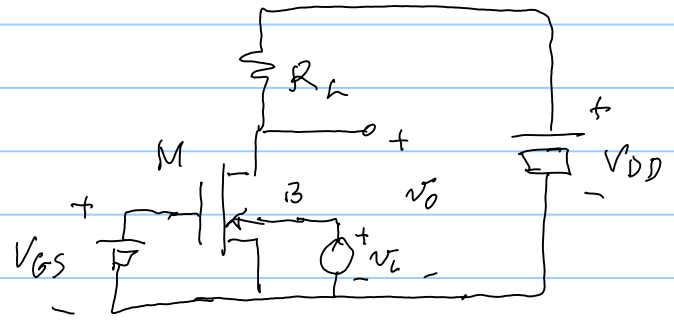
$v = \sqrt{\frac{i_D}{k_n}} + V_{TO} \Rightarrow R = \frac{V_{DD} - v}{i_D}$

needs v_D to put M_D also in saturation

GAMMA

We have $v_{th} = VTO + \gamma\left(\sqrt{v_{SB}+2\phi_f} - \sqrt{2\phi_f}\right)$ body effect

n-channel here $v_{SB}+2\phi_f \geq 0$ eq 5.107 6th ed



$\left|\frac{v_o}{v_i}\right| \approx g_m R_L$

low freq

$g_m = \frac{\partial i_D}{\partial v_i}\bigg|_Q = \frac{\partial i_D}{\partial v_{th}}\bigg|_Q \cdot \frac{\partial v_{th}}{\partial v_{SB}}\bigg|_Q \cdot \frac{\partial v_{SB}}{\partial v_i}\bigg|_Q =$

$v_{SB} = -v_i \Rightarrow \frac{\partial v_{SB}}{\partial v_i} = -1$

@ assume $V_{BS} = 0$

$\Rightarrow$ bulk @ source potential when $v_i = 0$

assume M is in saturation $i_D = k_n (v_{GS} - v_{th})^2$

ignore Early effect ($\times [1 + \lambda v_{DS}]$) $\Rightarrow \frac{\partial i_D}{\partial v_{th}} = 2k_n(v_{GS} - v_{th})(-1)$

$\frac{\partial v_{th}}{\partial v_{SB}} = \frac{\gamma \cdot 1/2}{\sqrt{v_{SB}+2\phi_f}} \times$

$\partial v_{SB}/\partial v_i$

$$g_m = -2k_n(v_{GS}-v_{th})\Big|_{@} \times \frac{\gamma \times 1/2}{\sqrt{v_{SB}+2\phi_f}}\Big|_{@} \times (-1) = \frac{\gamma k_n (V_{GS}-V_{TO})}{\sqrt{2\phi_f}} \quad \text{in } V$$

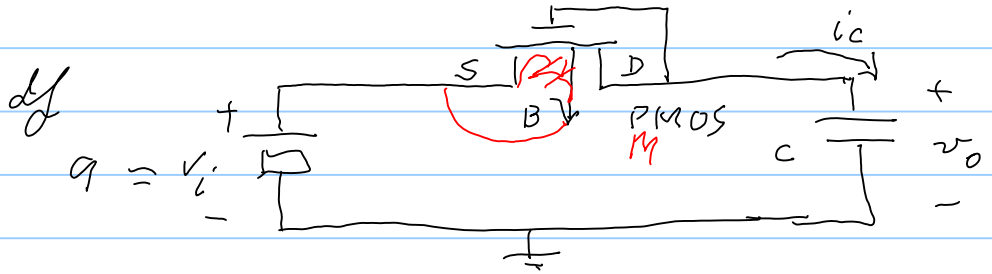
$2\phi_f \approx 0.6$

$k_n = \frac{K'_p}{2}\frac{W}{L}$ in A/V^2 $\quad (V_{GS}-V_{TO}) = V_{OV}$ = overdrive in V

ϕ_f is in V ; g_m is A/V $\quad \frac{A}{V} \sim \gamma \times \frac{A}{V^2} \times \frac{V}{\sqrt{V}}$ $\quad \gamma \approx \sqrt{V} \approx \text{Volts}^{1/2}$

if $\gamma \approx 0.4\ V^{1/2}$, $k_n = \left(10^{-5}/4\right)$

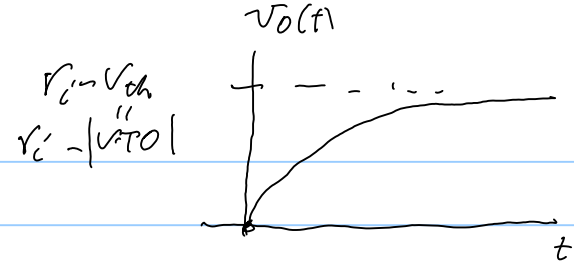
$$g_m = 0.4 \times \frac{10^{-5}}{4} \times \frac{(4-1)}{0.8} = \frac{3}{0.8} \times 10^{-5} \approx 40 \times 10^{-6} \text{ Mhos}$$



If $v_i = 0$

M is always in saturation (cutoff)

$v_0(t)\Big|_{t=0} = 0$



$$i_C = C\frac{dv}{dt} = C\frac{dv_O}{dt} = i_S = k_p\left(v_{SG} - |V_{TO}|\right)^2 = k_p\left(v_i - v_O - |V_{TO}|\right)^2$$

$$\frac{C\,d\left(-\left[\left(v_i - |V_{TO}|\right) - v_O\right]\right)}{dt} = k_p\left(v_i - v_O - |V_{TO}|\right)^2 \Rightarrow -C\frac{dx}{dt} = k_p x^2$$

$x = v_i - |V_{TO}| - v_O$

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

$x(0) = v_i - |V_{TO}|$

$$= -\frac{1}{x}\Big|_{x(0)}^{x(t)} = -\frac{k_p}{C}t \Rightarrow \text{find } v_O(t)$$