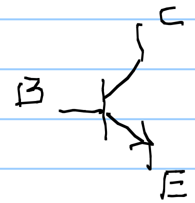
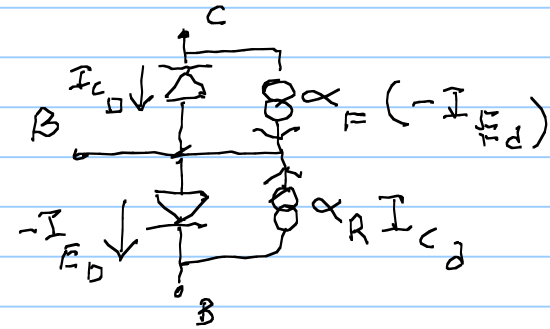
Note Title 9/20/2014

EE303H
09/25/14

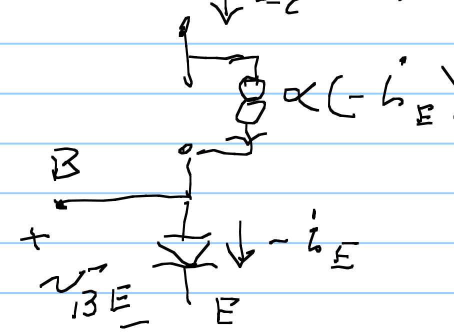
Ebers-Moll model of BJT



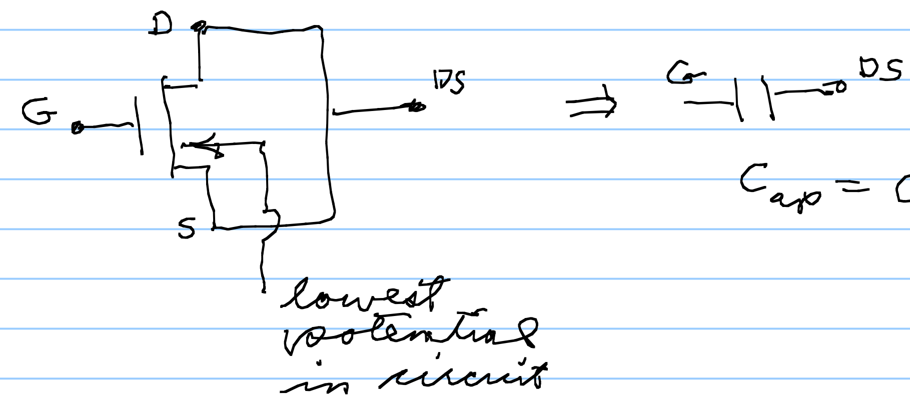


in forward active region
(large signal model)

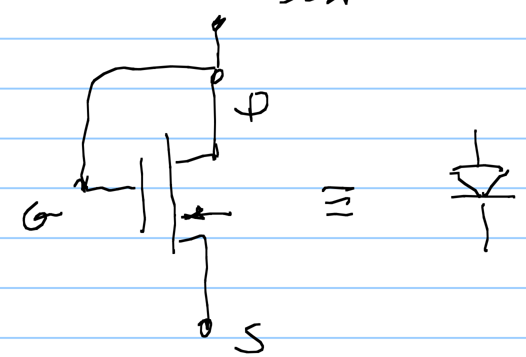
$i_C = \alpha e^{v_{BE}/V_T}$



How to make a capacitor



$$C_{ap} = C_{GS} + C_{GD}$$



$$v_{GS} = v_{DS}$$

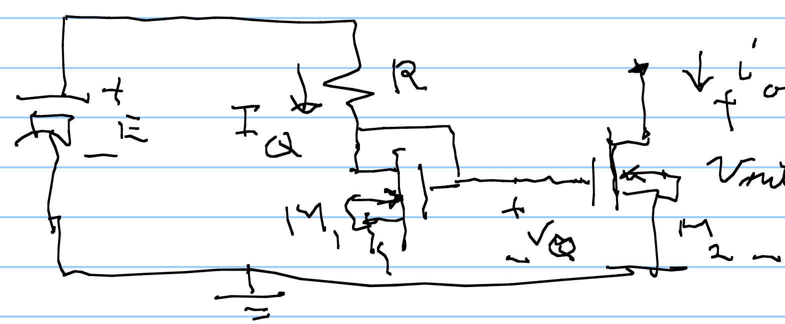
$v_{GS} - V_{TO} \leq v_{DS}$ are in saturation

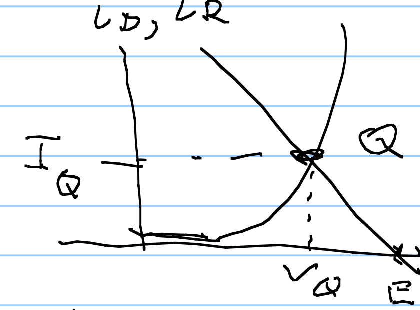
holds for this diode

$$i_D = \frac{KP}{2}\frac{W}{L}(v_{DS} - V_{TO})^2(1+\lambda v_{DS}) \quad \text{if } v_{DS} \geq V_{TO}$$

$$= 0 \quad \text{if } v_{DS} < V_{TO}$$

Current mirror MOS





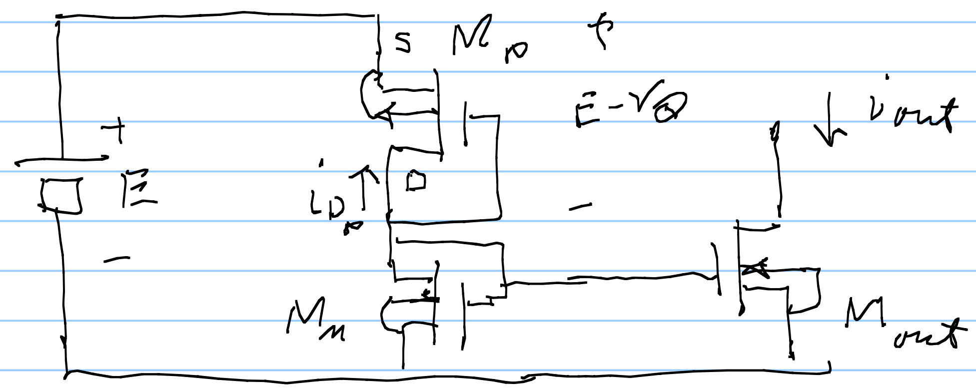
$i_{out} = I_Q$

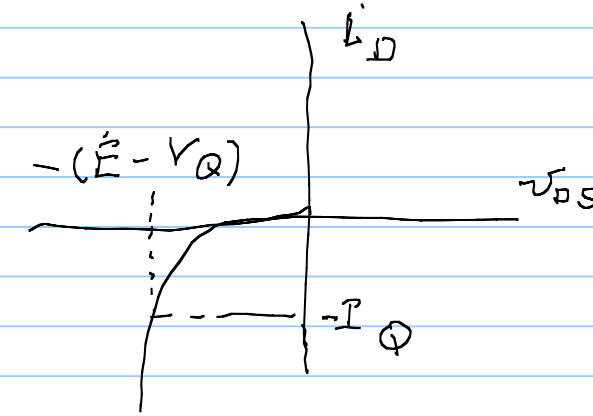
⇑

if M_2 is in saturation

$\Rightarrow v_{out} \geq V_Q - V_{TO}$

can make R with an MOS diode



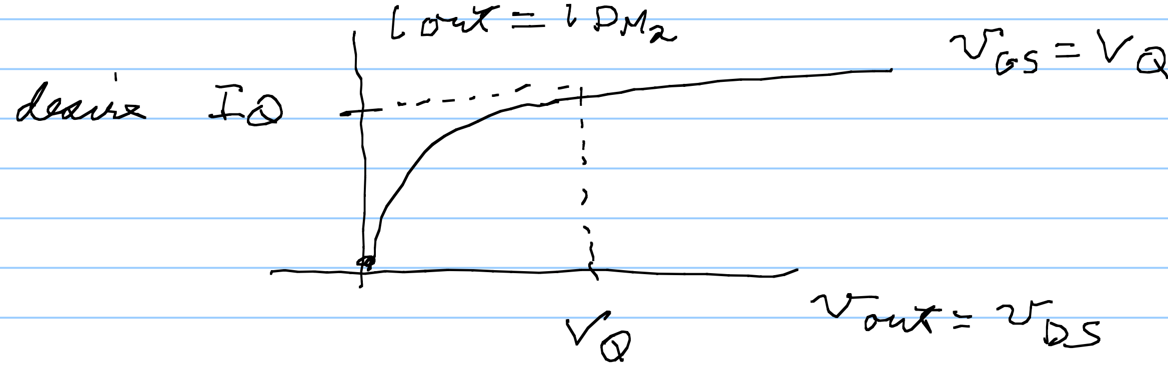


$$-i_{D_p} = \frac{KP}{2}\frac{W}{L}\left(-v_{DS} - |V_{TO_p}|\right)^2 = -I_Q$$

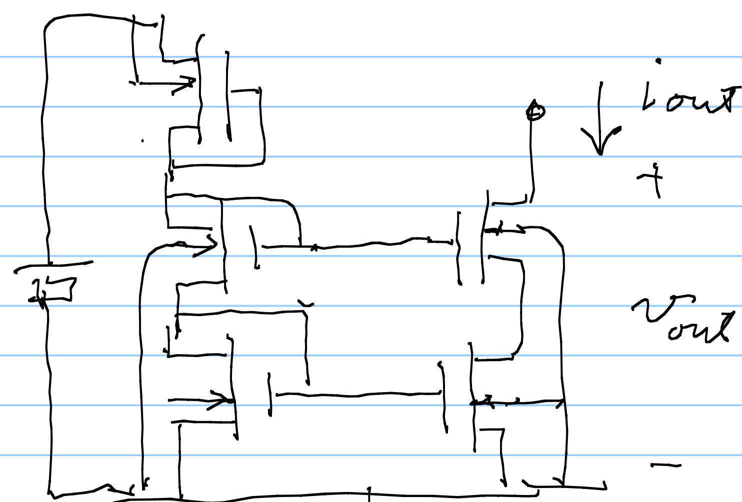
$$\Rightarrow \quad I_Q = \frac{KP}{2}\frac{W}{L}\left((E - V_Q) - |V_{TO_p}|\right)^2 \Rightarrow \text{gives } \frac{W}{L} \text{ for } M_p$$

$$\frac{W}{L} = \frac{2I_Q}{KP\left((E - V_Q) - |V_{TO_p}|\right)^2}$$

But things vary with output voltage

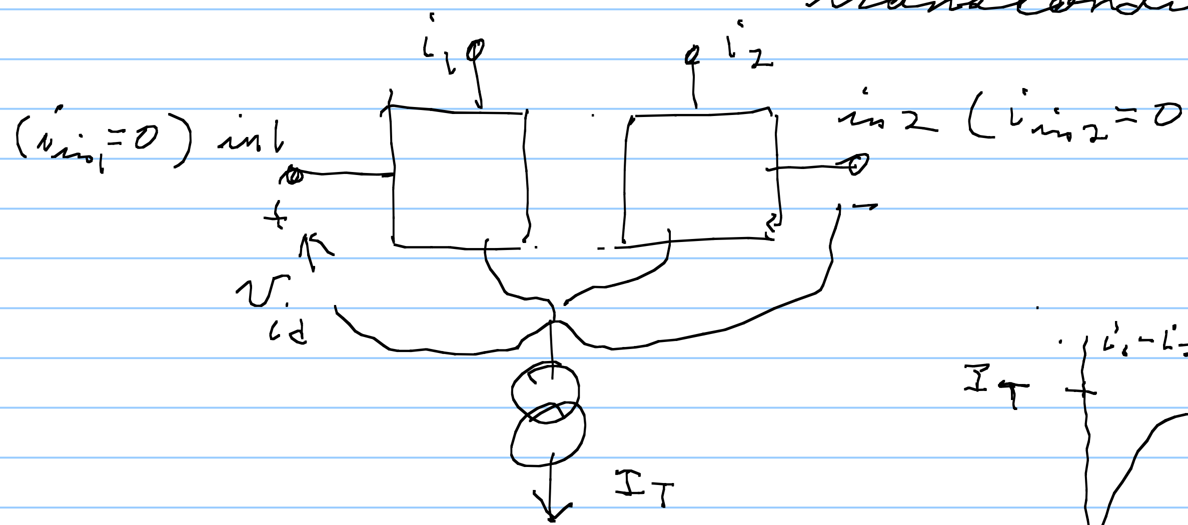


so i_{out} changes if the load v_{out} changes



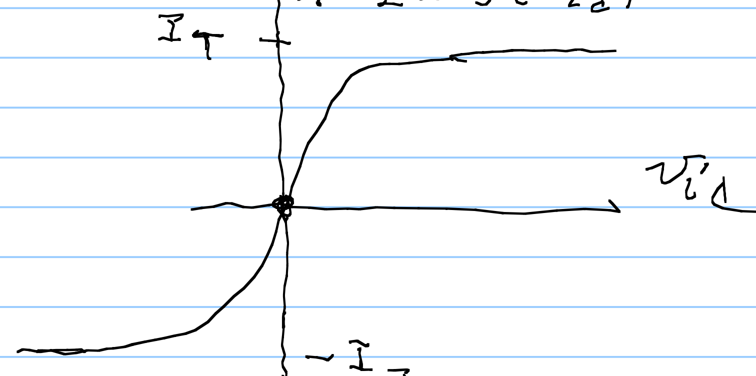
cascode

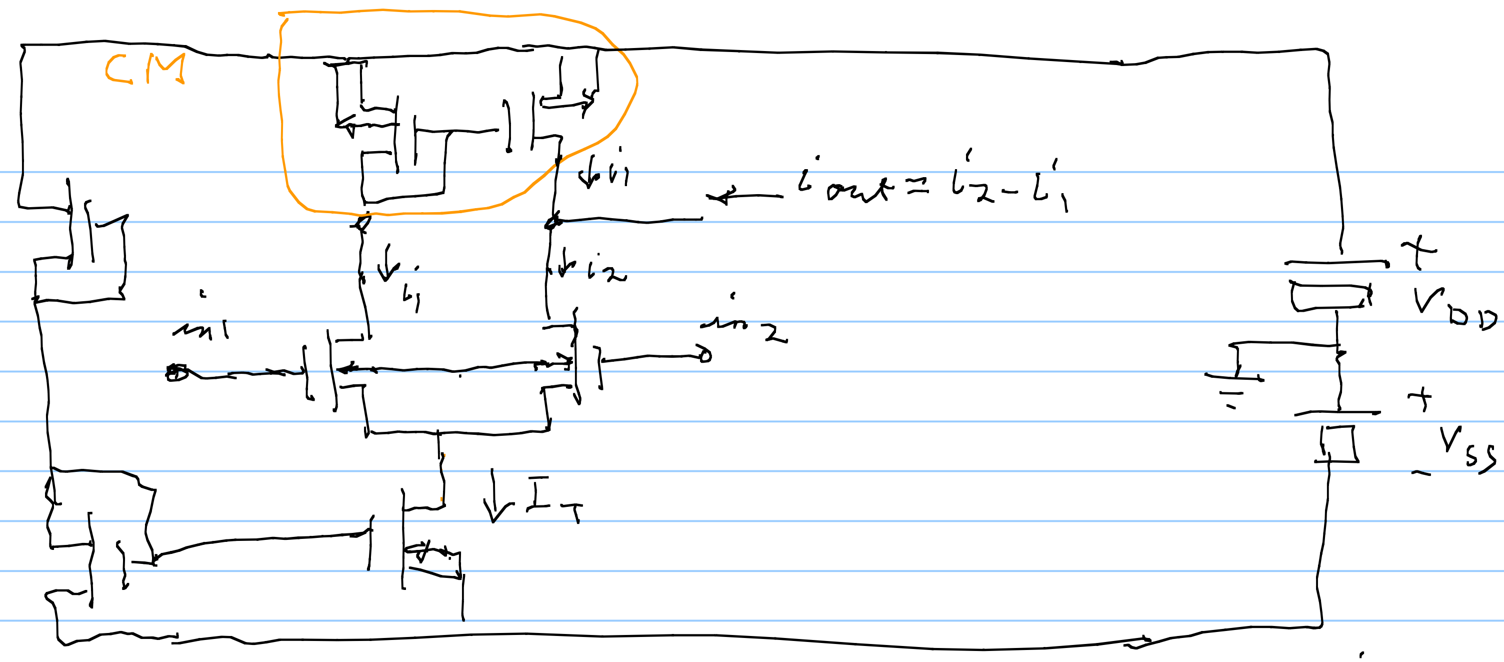
Differential pair (used for OTA = operational transconductance amplifier)



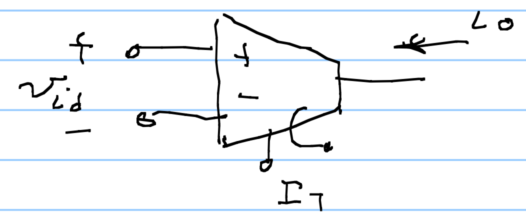
$i_1 + i_2 = I_T$

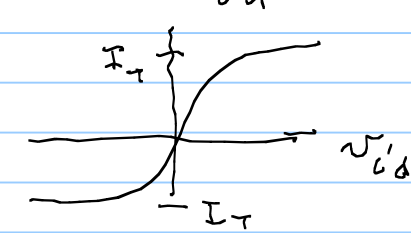
$i_1 - i_2 = f(v_{id})$





$\Rightarrow$ an OTA





small signal $i_o = g_m v_{id}$ slope $= g_m$

if made with BJT's $\quad i_O = I_T \tanh(v_{id}/2V_T)$

assume for MOS that all transistors are in saturation

$$v_{id} = v_{G_1} - v_{G_2} \quad ; \quad i_1 = i_{D_1} \,,\; i_2 = i_{D_2}$$

$$i_D = k(v_{GS} - V_{TO})^2 \qquad k = \frac{K_P}{2}\frac{W}{L}$$

$$v_{GS_1} = V_{TO} + \sqrt{\frac{k}{i_1}} \,, \quad v_{GS_2} = V_{TO} + \sqrt{k/i_2}$$

$$v_{id} = v_{GS_1} - v_{GS_2} = \sqrt{\frac{i_1}{k}} - \sqrt{\frac{i_2}{k}}$$