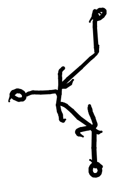
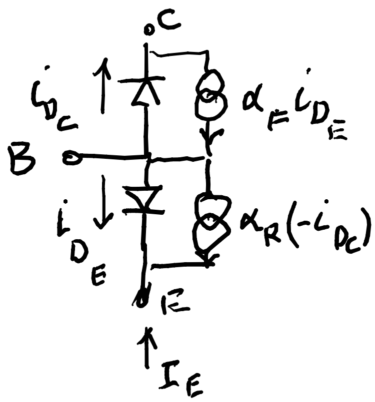
EE303
02/22/12

Note Title 2/22/2012



$\Rightarrow$

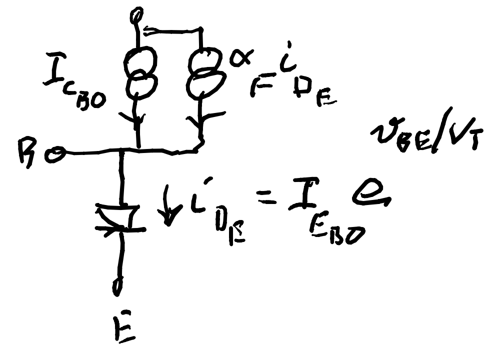


Ebers-Moll

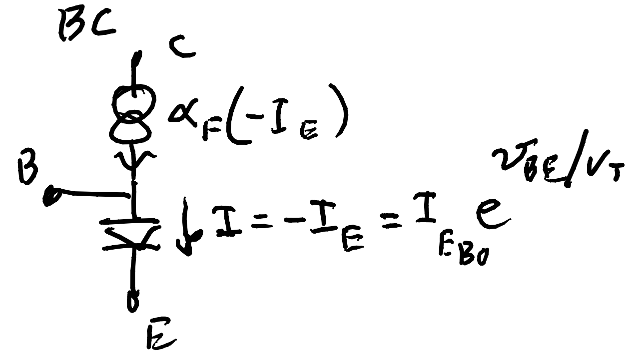
$\Rightarrow$

F bias BE

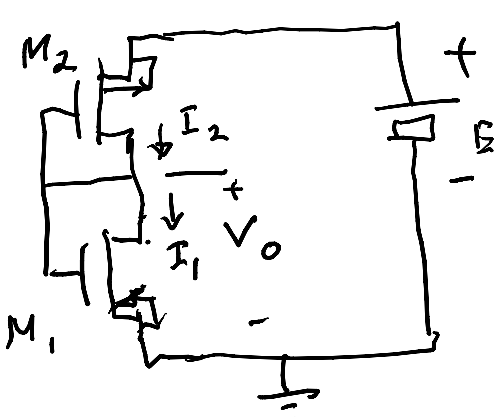
R bias BC



$\Rightarrow$



Use of CMOS for creating currents & voltages



to see transistors are in saturation (for enhancement mode devices)

$$V_{GS} - V_{TO} \le V_{DS}$$

M_1: $V_{DS} = V_0 = V_{GS}$

$$V_{GS} - V_{TO} = V_{DS} - V_{TO} < V_{DS}$$

for M_2: $E - V_0 = V_{SD} = V_{SG}$

$$V_{SG} - V_{TO_p} \geq V_{SD} \text{ but } V_{TO_p} < 0$$

$$I_1 = \frac{KP_n}{2}\left(\frac{W}{L}\right)_n (V_0 - V_{TO_n})^2$$

$\Rightarrow$ yields V_0 $\qquad \beta = \frac{KP}{2}\frac{W}{L}$

$$KCL = I_2 = \frac{KP_p}{2}\left(\frac{W}{L}\right)_p \left(E - V_0 - |V_{TO_p}|\right)^2$$

$$\sqrt{\beta_n} \cdot (V_0 - V_{TO_n}) = \sqrt{\beta_p}\left(E - V_0 - |V_{TO_p}|\right)$$

$$V_0 - V_{TO_n} = \sqrt{\frac{\beta_p}{\beta_n}}\left(E - |V_{TO_p}|\right) - \sqrt{\frac{\beta_p}{\beta_n}} \cdot V_0$$

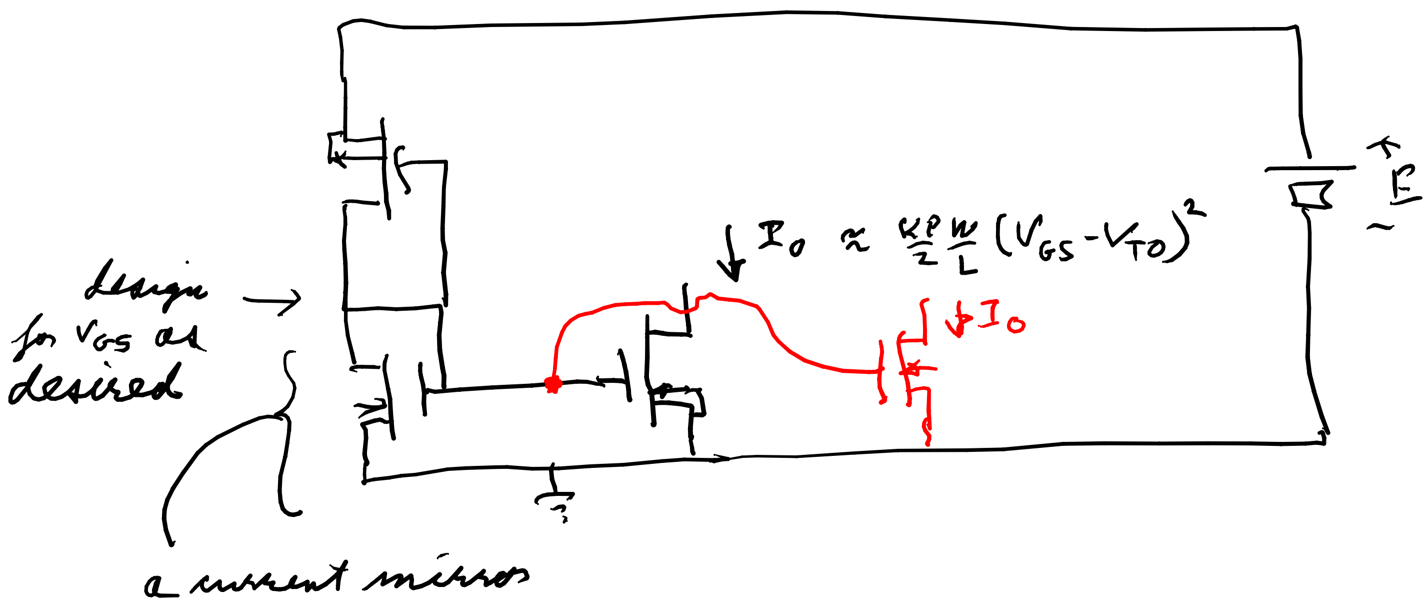
$$\left(1+\sqrt{\beta_p/\beta_n}\right)V_o = V_{TO_n} - \sqrt{\frac{\beta_p}{\beta_n}}|V_{TO_p}| + \sqrt{\frac{\beta_p}{\beta_n}}\,E$$

$$V_o = \frac{1}{1+\sqrt{\beta_n/\beta_p}}\cdot E + \left(\frac{V_{TO_n} - \sqrt{\frac{\beta_p}{\beta_n}}|V_{TO_p}|}{1+\sqrt{\beta_p/\beta_n}}\right)$$

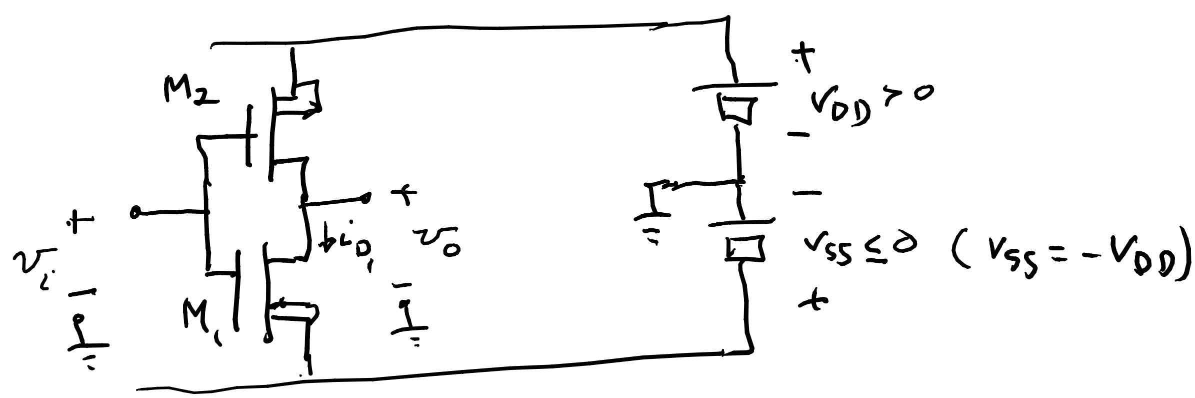
if given V_o can design the transistors by adjusting the W/L's

$$\frac{\beta_n}{\beta_p} = (E - V_o - |V_{TO_p}|)^2 / (V_o - V_{TO_n})^2$$

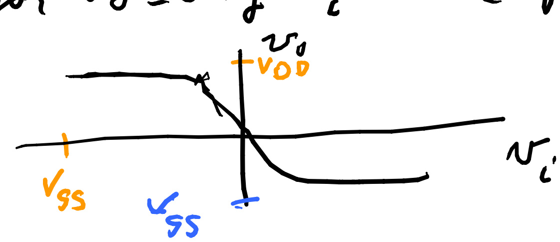
To make a current source

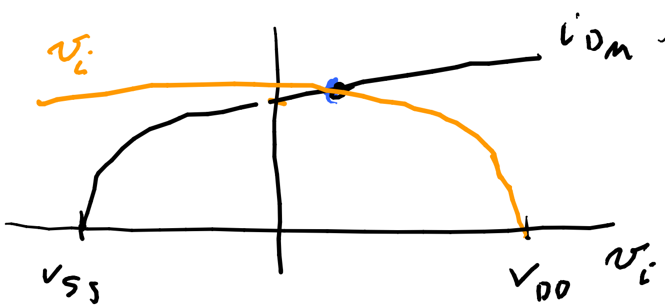


Look at the CMOS inverter



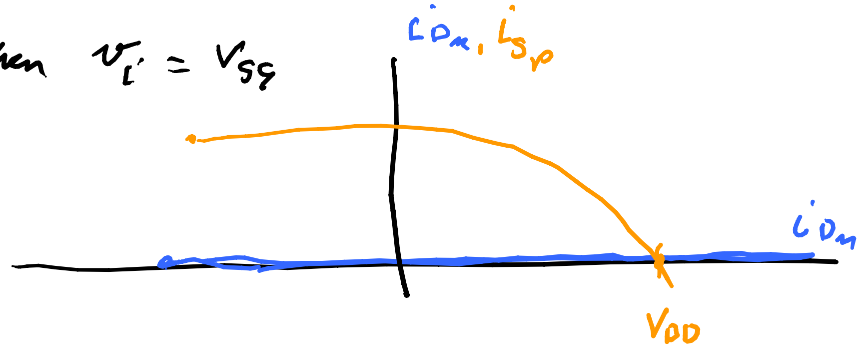
design for $v_o = 0$ if $v_i = 0$ (by choice of W/L's)



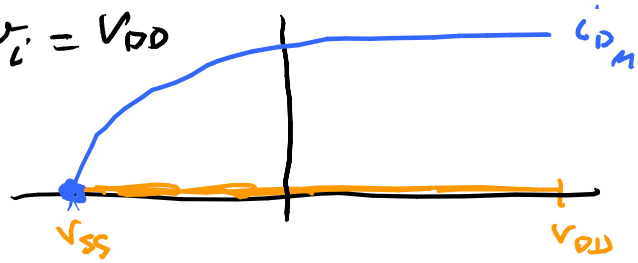


here $V_{SS} < v_i < V_{DD}$

When $v_i = V_{SS}$

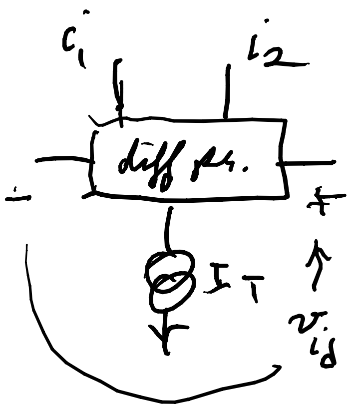


When $v_i = V_{DD}$



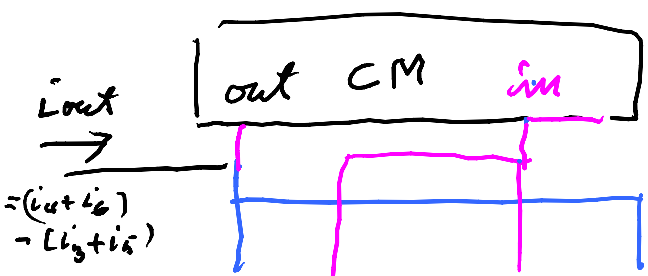
In the two rest points of V_{SS} & V_{DD} no current flows as one of M_1 or M_2 is turned off.

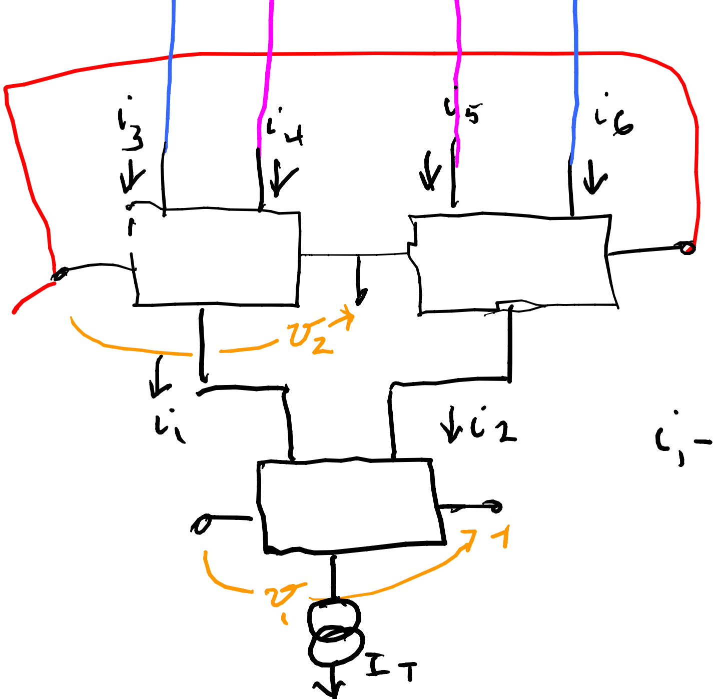
Multiplier from the differential pair



BJT; $i_2 - i_1 = I_T \tanh(v_{id}/2V_T)$

(gives a 2 quadrant multiplier if vary I_T)





$$i_4 - i_3 = i_1 \tanh(v_2/2V_T)$$

$$i_5 - i_6 = i_2 \tanh(v_2/2V_T)$$

dif

$$i_1 - i_2 = I_T \tanh(v_1/2V_T)$$

$$\underbrace{(i_4 - i_3) - (i_5 - i_6)}_{\text{via KCL}} = (i_1 - i_2)\tanh(v_2/2V_T) = I_T \tanh(v_1/2V_T)(\tanh v_2/2V_T)$$

$$= i_{out}$$

for small $i_o \approx I_T \cdot \frac{v_1}{2V_T} \cdot \frac{v_2}{2V_T}$