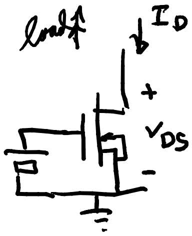
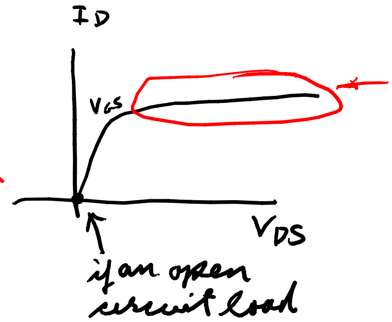
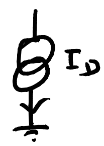
EE 303H
09/17/09

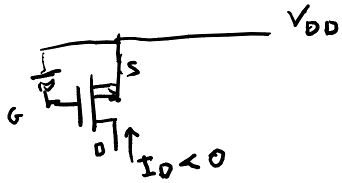
Current sources – mirrors

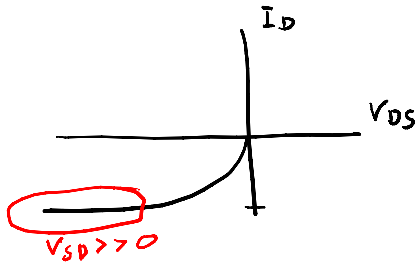


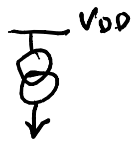




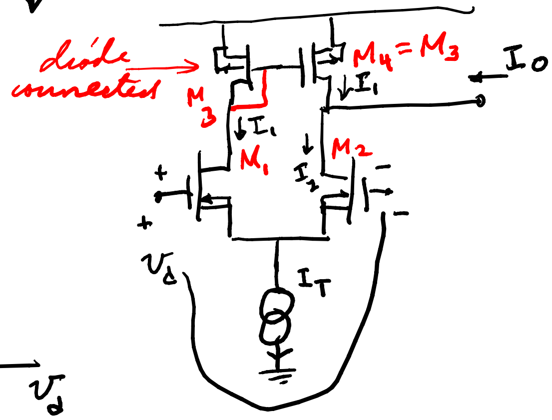
this is a current "sink"





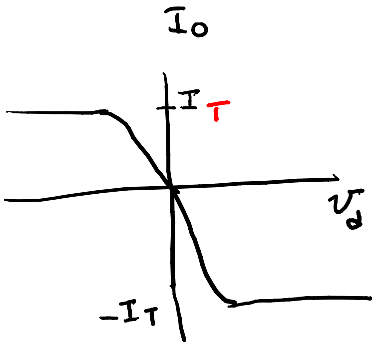


this is a current "source"



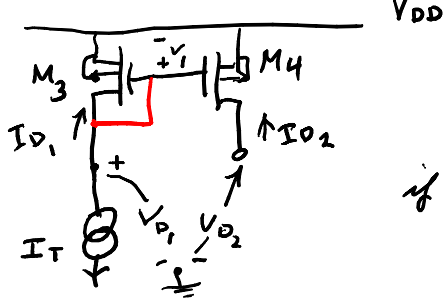
OTA = operational transconductance amplifier

I_T = tail current source

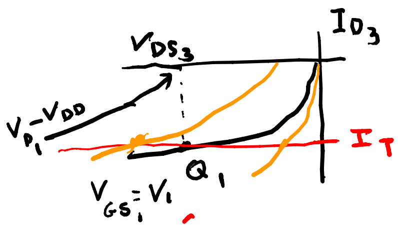


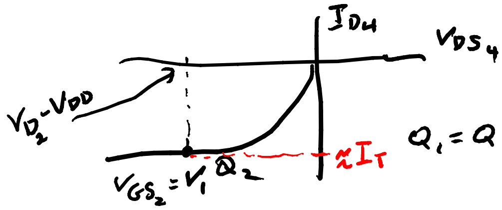
when $v_d >> 0$, I_T goes all through M_1

$v_d << 0$ I_T goes all through M_2
$(I_1 = 0, I_2 = I_T)$



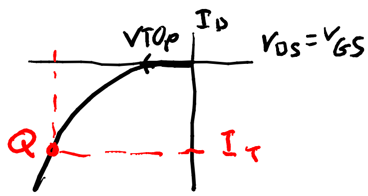
if $V_{D_1} = V_{D_2}$ then $I_{D_1} = I_{D_2}$ if $M_3 = M_4$
as both would have the same operating point

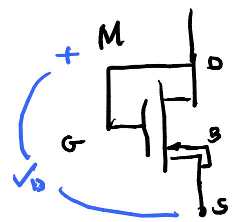




$Q_1 = Q_2$ if $V_{D_1} - V_{DD} = V_{D_2} - V_{DD}$

short G to D on M_3





$V_{GS} - VTO_n$ compare V_{DS}

here $V_{DS} = V_{GS}$

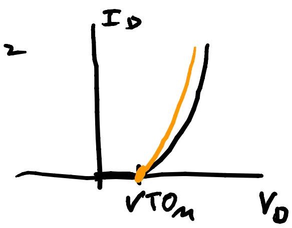
$V_{GS} - VTO_n = V_{DS} - VTO_n < V_{DS}$

if $VTO_n > 0$ then M is in saturation

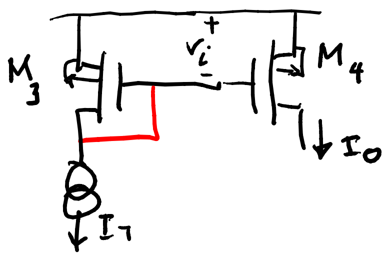
$$I_D = \frac{KP}{2}\frac{W}{L}(V_{GS} - VTO_n)^2 = \frac{KP}{2}\frac{W}{L}(V_D - VTO_n)^2$$

(for $V_{GS} = V_D > VTO_n$)

$$= \frac{KP}{2}\frac{W}{L}(V_D - VTO_n)^2 (1 + \lambda V_D)$$



$$V_D \approx VTO_n + \sqrt{I_T / \left(\frac{KP}{2}\frac{W}{L}\right)}$$ for $I_T > 0$

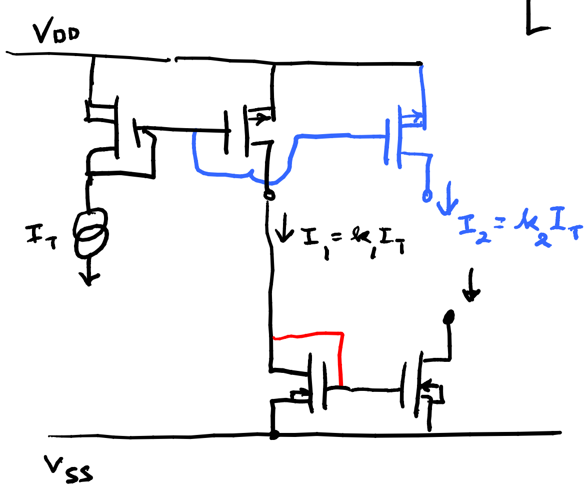


$$I_O = -I_{D_{M_4}} = \frac{KP}{2}\left(\frac{W}{L}\right)_4 (V_i - |VTO_p|)^2$$ if M_4 is in saturation

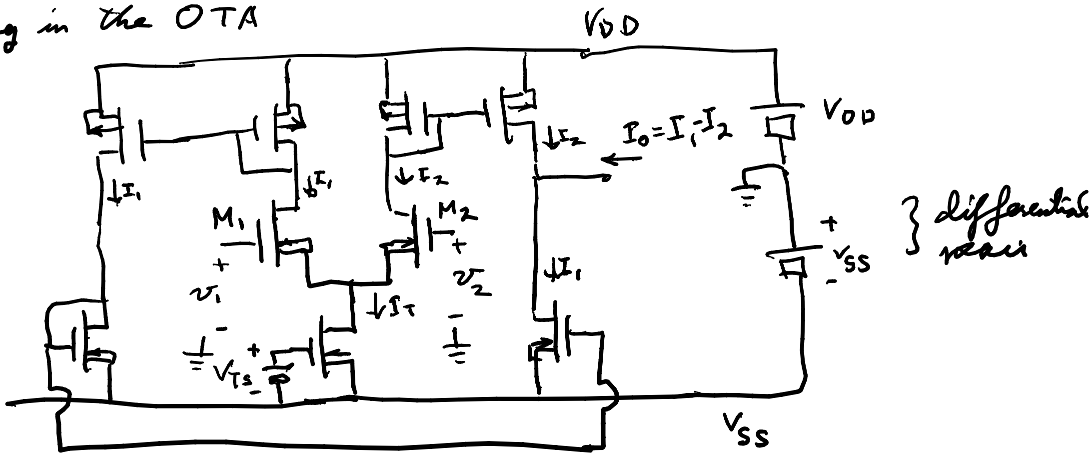
where $V_i = |VTO_p| + \sqrt{I_T / \left(\frac{KP}{2}\right)\left(\frac{W}{L}\right)_3}$

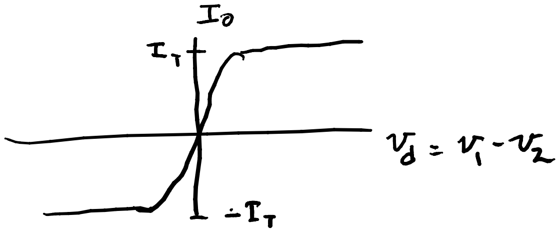
$$I_O = \left(\frac{KP}{2}\right)\left(\frac{W}{L}\right)_4 \left(\sqrt{\frac{I_T}{\frac{KP}{2}(W/L)_3}}\right)^2$$

$$= \left[\frac{(W/L)_4}{(W/L)_3}\right] I_T$$

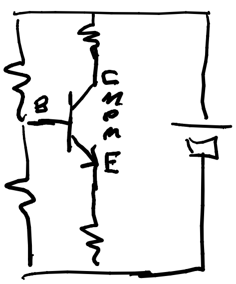


Using in the OTA





BJT equivalent circuit (we use 2-port Y matrices appendix B, B-2)



back biased C-B diode (n-p)

forward biased B-E diode (p-n)

$i_C \approx \beta i_B$

$-i_E = I_S e^{v_{BE}/V_T}$ $\qquad V_T = kT/Q$

For small signal behaviours desire the Q point & make a Taylor series expansion of i_C