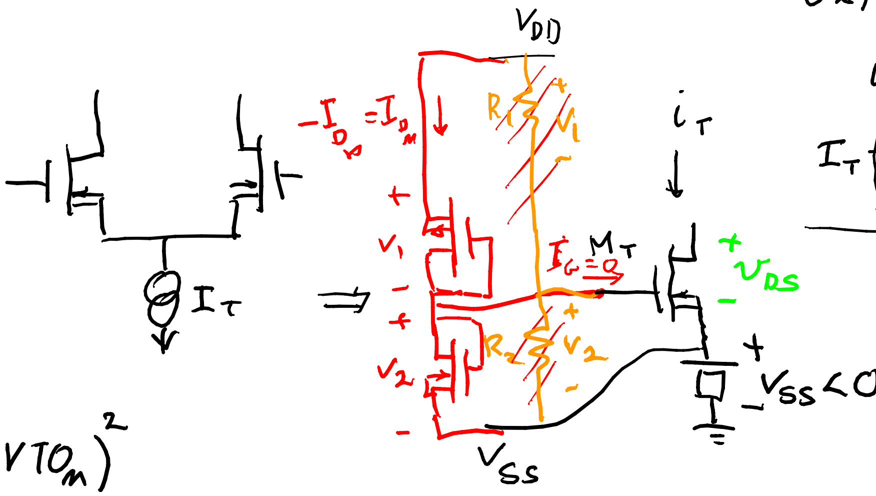
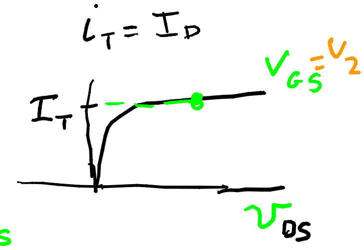
Homework due 1 period later

EE 303
02/26/07





$$I_{D_m} = \frac{KP_m}{2}\left(\frac{W}{L}\right)_m (V_2 - VTO_m)^2$$

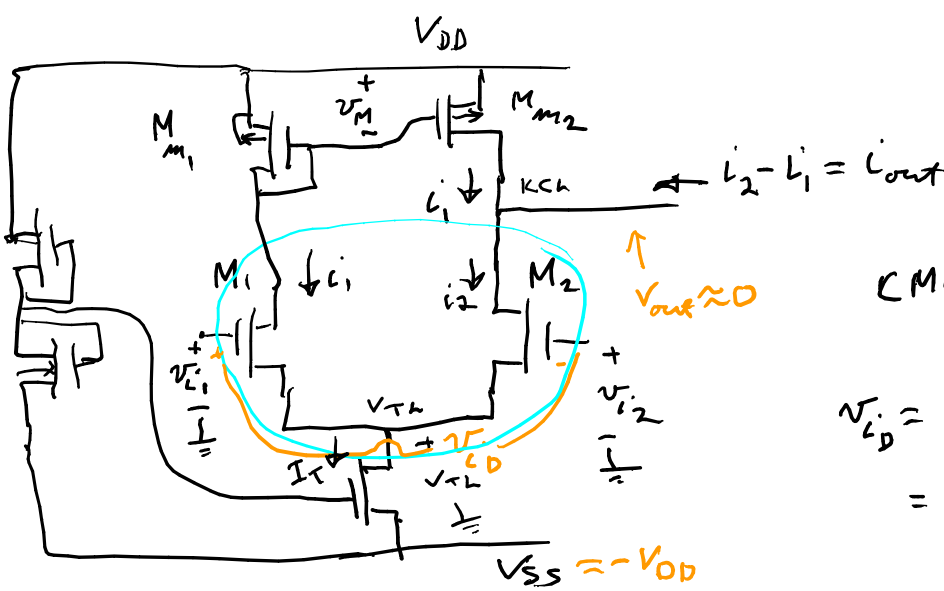
$$= -I_{D_p} = \frac{KP_p}{2}\left(\frac{W}{L}\right)_p (V_{DD} - V_2 - |VTO_p|)^2$$

$$V_2 = \frac{R_2}{R_1 + R_2} \cdot (V_{DD} - V_{SS})$$

$$\left(\frac{W}{L}\right)_p = \left(\frac{KP_n}{KP_p}\right)\left(\frac{V_2 - VTO_m}{V_{DD} - V_2 - |VTO_p|}\right)^2 \cdot \left(\frac{W}{L}\right)_m$$

requires V_{DS} to give saturation (can guarantee by "large" enough V_{DD} & $|V_{SS}|$

use large L/W to get small current



CMOS differential pair

$$v_{iD} = v_{i_1} - v_{i_2}$$

$$= v_{GS_1} - v_{GS_2}$$

KCL: $I_T = i_1 + i_2 = \frac{KP_m}{2}(v_{i_1} - V_{TL} - VTO_m)^2 \left(\frac{W}{L}\right)_m$ if in saturation for M_1 & M_2

$$+ \frac{KP_m}{2}(v_{i_2} - V_{TL} - VTO_m)^2 \left(\frac{W}{L}\right)_m$$

$$i_{out} = i_2 - i_1 = \frac{KP_n}{2}\left(v_{i_2} - V_{TL} - VTO_n\right)^2\left(\frac{W}{L}\right)_n - \frac{KP_n}{2}\left(v_{i_1} - V_{TL} - VTO_n\right)^2\left(\frac{W}{L}\right)$$

$$2i_2 = I_T + i_{out} = \frac{KP_n}{2}\left(v_{i_1} - v_{iD} - V_{TL} - VTO_n\right)^2\left(\frac{W}{L}\right)_n \times 2$$

$$2i_1 = I_T - i_{out} = \frac{KP_n}{2}\left(v_{i_1} - V_{TL} - VTO_n\right)^2\left(\frac{W}{L}\right)_n \times 2$$

$$\sqrt{\frac{I_T + i_{out}}{KP_n (W/L)_n}} = v_{i_1} - v_{iD} - V_{TL} - VTO_n$$

$$\sqrt{\frac{I_T - i_{out}}{KP_n (W/L)_n}} = v_{i_1} - V_{TL} - VTO_n$$

take difference $\Rightarrow$ $$v_{iD} = \sqrt{\frac{I_T - i_{out}}{KP_n \left(\frac{W}{L}\right)_n}} - \sqrt{\frac{I_T + i_{out}}{KP_n (W/L)_n}}$$

square $$v_{iD}^2 = \frac{I_T - \cancel{i_{out}}}{KP_n (W/L)_n} + \frac{I_T + \cancel{i_{out}}}{KP_n \left(\frac{W}{L}\right)_n} - 2\frac{1}{KP_n\left(\frac{W}{L}\right)}\sqrt{I_T^2 - i_{out}^2}$$

$$I_T^2 - i_{out}^2 = \left(I_T - \left(\frac{W}{L}\right)KP\,\frac{v_{iD}^2}{2}\right)^2$$

$$i_{out}^2 = \cancel{I_T^2} - \left(\cancel{I_T^2} - 2\left(\frac{W}{L}KP\right)\frac{v_{iD}^2 I_T}{\cancel{4}\,2} + \left(\frac{W}{L}KP\right)^2\frac{v_{iD}^4}{4}\right)$$

$$i_{out} = \pm\sqrt{\cancel{\tfrac{1}{2}}\left(\frac{W}{L}\cdot KP\right) I_T v_{iD}^2 - \frac{1}{4}\left(\frac{W}{L}KP\right) v_{iD}^4}$$

$$= \pm v_{iD}\cdot\sqrt{I_T\frac{\left(\frac{W}{L}\right)KP}{\cancel{2}} - \frac{1}{4}\left(\frac{W}{L}KP\right)v_{iD}^2}$$

if M_1 & M_2 are in sat