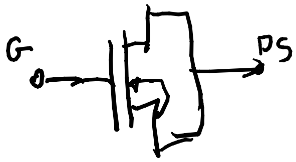
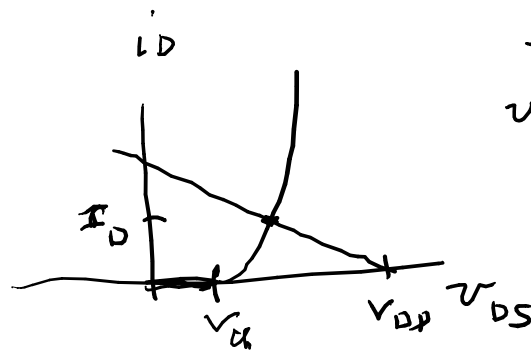
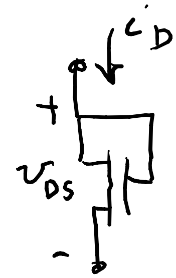
Note Title 9/25/2013

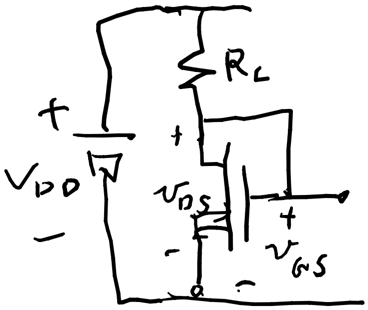
EE303H
09/26/13
+09/27/13

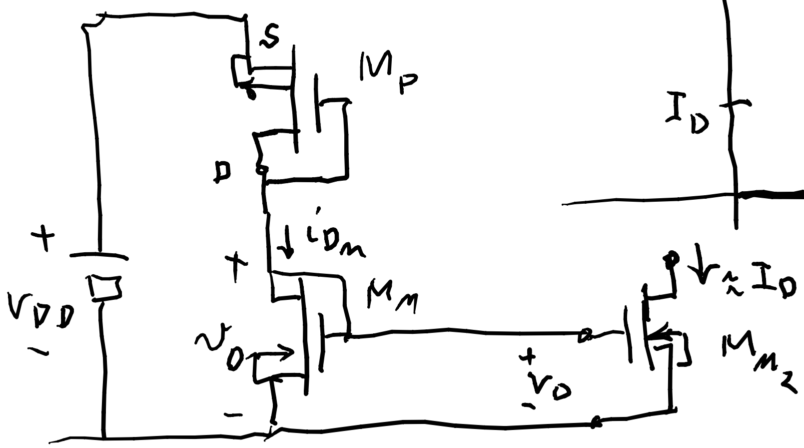
How to make a MOS capacitor

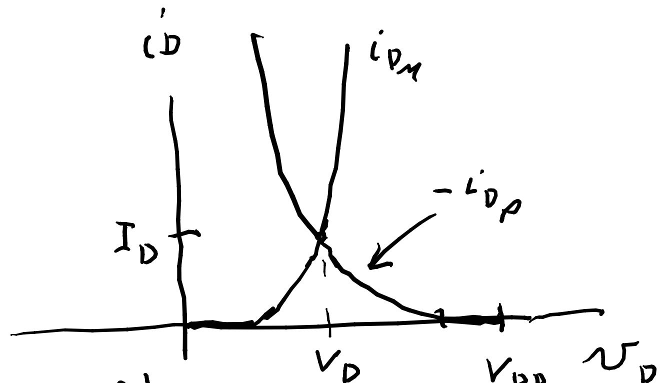












How to design for a given I_D (ignore λ, $\lambda = 0$

$$I_{D_n} = \frac{KP_n}{2}\frac{W_n}{L_n}(V_{GS}-V_{TO_n})^2 \qquad V_{GS}=V_D$$

$$-I_{D_p} = I_{S_p} = \frac{KP_p}{2}\frac{W_p}{L_p}(V_{DD}-V_D-|V_{TO_p}|)^2 \qquad \text{assume } V_{TO_n} = -V_{TO_p}$$

$$\therefore \quad \underbrace{(V_D - V_{TO_n})^2}_{=V_{GS_n}} = \frac{I_D}{\frac{KP_n}{2}\frac{W_n}{L_n}} \Rightarrow V_D = V_{TO} + \sqrt{\frac{I_D}{\frac{KP_n}{2}\frac{W_n}{L_n}}}$$

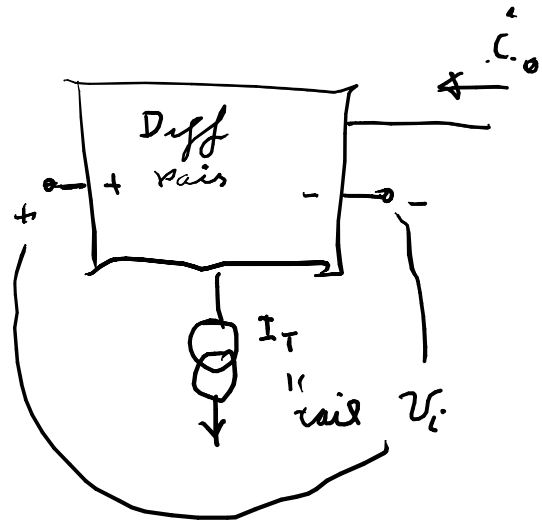
drop as turn on M_n

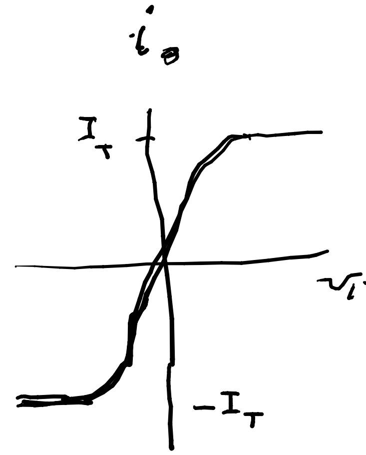
$$M_p \Rightarrow V_{DD} - V_D - V_{TO} = \sqrt{\frac{I_D}{\frac{KP_p}{2}\frac{W_p}{L_p}}} \Rightarrow$$

$$\Downarrow$$

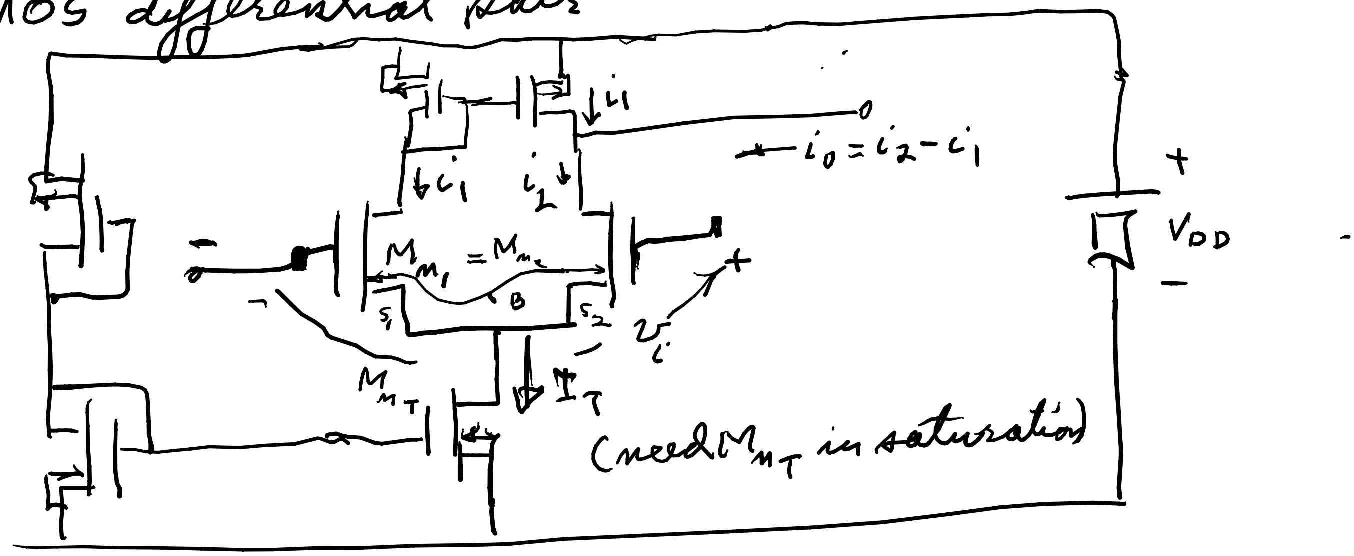
$$V_{DD} - V_{TO_n} - \sqrt{\frac{I_D}{\frac{KP_n}{2}\frac{W_n}{L_n}}} - |V_{TO_p}| = \sqrt{\frac{I_D}{\frac{KP_p}{2}\frac{W_p}{L_p}}}$$

can solve for $\left(\frac{W}{L}\right)_p$ or $\left(\frac{W}{L}\right)_n$ to give I_D





MOS differential pair



$$i_1 + i_2 = I_T \qquad 2i_2 = I_T + i_o$$

$$i_2 - i_1 = i_o \qquad 2i_1 = I_T - i_o$$

$$i_1 = I_{D_{M_{n_1}}} = \frac{KP}{2}\frac{W}{L}\left(v_{GS_{M_{n_1}}} - V_{th_{M_{n_1}}}\right)^2, \quad i_2 = I_{D_{M_2}} = \frac{KP}{2}\frac{W}{L}\left(v_{GS_{M_2}} - V_{th_{M_{n_2}}}\right)^2$$

$$v_i = v_{GS_2} - v_{GS_1} = V_{th_{M_n}} + \sqrt{\frac{i_2}{\frac{KP}{2}\frac{W}{L}}} - \left(V_{th_{M_{n_1}}} + \sqrt{\frac{i_1}{\frac{KP}{2}\frac{W}{L}}}\right)$$

$$v_i = \sqrt{\frac{i_2}{\frac{KP}{2}\frac{W}{L}}} - \sqrt{\frac{i_1}{\frac{KP}{2}\frac{W}{L}}} \Rightarrow v_i^2 = \frac{i_2}{\frac{KP}{2}\frac{W}{L}} + \frac{i_1}{\frac{KP}{2}\frac{W}{L}} - 2\frac{\sqrt{i_1 i_2}}{\frac{KP}{2}\frac{W}{L}}$$

$$\frac{K'}{2}\frac{W}{L}\cdot v_i^2 = i_1 + i_2 - 2\sqrt{i_1 i_2} = I_T - 2\sqrt{i_1(i_0+i_1)} = I_T - 2\sqrt{i_1 i_2}$$

$$a v_i^2, \quad a = \frac{K'}{2}\frac{W}{L} \qquad \left(\frac{a v_i^2 - I_T}{2}\right)^2 = \frac{(I_T - i_0)}{2}\cdot\frac{(I_T + i_0)}{2}$$

$$= \frac{1}{4}\left(I_T^2 - i_0^2\right)$$

$$\Rightarrow \quad i_0^2 = I_T^2 - \left(a^2 v_i^4 - 2 I_T a v_i^2 + I_T^2\right)$$

$$\Rightarrow \quad i_0 = \pm\sqrt{2 I_T a}\; v_i \sqrt{1 - \frac{a v_i^2}{2 I_T}}$$

(use + for given polarity)

max at $\frac{a v_i^2}{I_T} = 1$

$$\Rightarrow \quad v_i = \pm\sqrt{I_T/a}$$

$$\Rightarrow \quad i_{0_{max}} = +\sqrt{2 I_T a}\cdot\sqrt{\frac{I_T}{2a}} = I_T$$