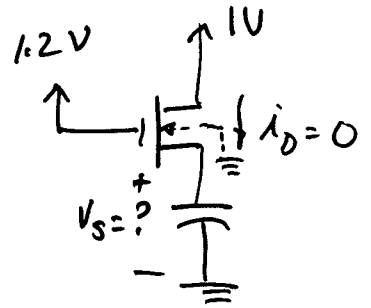
Problem Set #2 on Wednesday (1/26)

Prob. 2.5



Assume there is a bulk

$$V_T = V_{TO} + \gamma\left(\sqrt{V_{SB} + 2|\phi_F|} - \sqrt{2|\phi_F|}\right)$$

($V_{SB} = V_S$)

Take an iterative approach, start with $V_S = 1.2 - V_{TO}$

$$i = C\frac{dv}{dt}$$

$V_S \cong 0.734V$

SUMMARY OF DSM MODEL (LARGE SIGNAL)

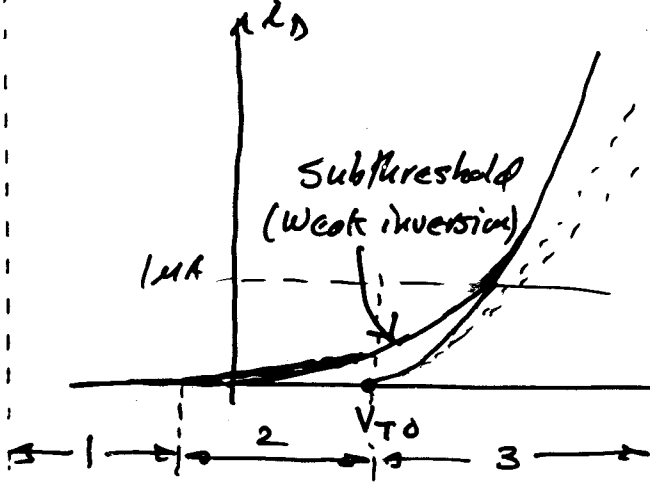
	Long Channel DSM	Short Channel ($V_{DS(sat)}$) DSM
Linear	$i_{DS} = \frac{k'W}{L}\left[V_{GS} - V_T - \frac{V_{DS}}{2}\right]V_{DS}$	$i_{DS} = \frac{W}{L}\left(\frac{\mu C_{ox}}{1 + \frac{V_{DS}}{E_c L}}\right)\left(V_{GS} - V_T - \frac{V_{DS}}{2}\right)V_{DS}$
$V_{DS(sat)}$	$V_{DS(sat)} = V_{GS} - V_T$	$V_{DS(sat)} = \frac{(V_{GS} - V_T)E_c L}{(V_{GS} - V_T) + E_c L}$
Saturation $V_{DS} \geq V_{DS(sat)}$	$i_{DS} = \frac{k'}{2}\frac{W}{L}(V_{GS} - V_T)^2$	$i_{DS} = \frac{W v_{sat} C_{ox} E_c}{2}\left[\frac{(V_{GS} - V_T)^2}{(V_{GS} - V_T) + E_c L}\right]$

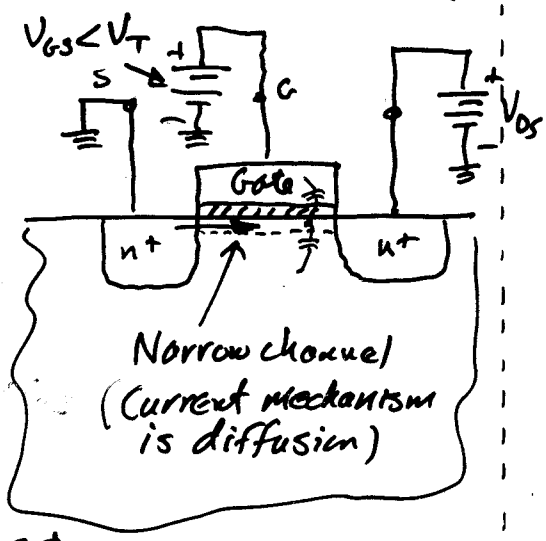
Please download Lectures 7 & 8

Subthreshold Conduction and Model

Strong inversion we found that the MOSFET works in 1.) saturation, 2.) active or 3.) cutoff regions.

There is a region for $V_{GS} < V_T$ where the current is very small and becomes a exponential function of V_{GS}.





1.) Substrate is not inverted if $\phi_s < \phi_F$

2.) Channel is weakly inverted if $\phi_F < \phi_s < 2\phi_F$

3.) Strong inversion if $\phi_s > 2\phi_F$

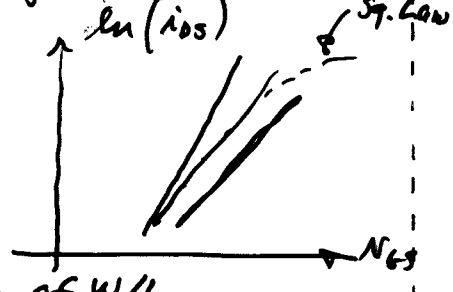
Large Signal Model — $J_D \propto \frac{dn_e}{dy} \propto n_{no} e^{-V_D/V_t}$

$$i_{sub} = I_s \exp\left[\frac{q(V_{GS} - V_T - V_{offset})}{n kT}\right]\left[1 - \exp\left(-\frac{q V_{DS}}{kT}\right)\right]$$

$$= \underbrace{I_s \exp\left[-\frac{q V_{OFFSET}}{n kT}\right]} \exp\left[\frac{q(V_{GS} - V_t)}{n kT}\right] 1 \quad \text{if } V_{DS} >> 0$$

$$\frac{W}{L} I_x \exp\left[\frac{q(V_{GS} - V_T)}{n kT}\right]$$

$1.5 < n < 3$

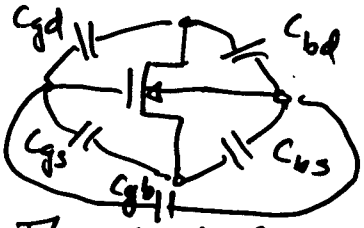


If $i_{DS} < 1\mu A$, then the MOSFET is in subthreshold for modest values of W/L.

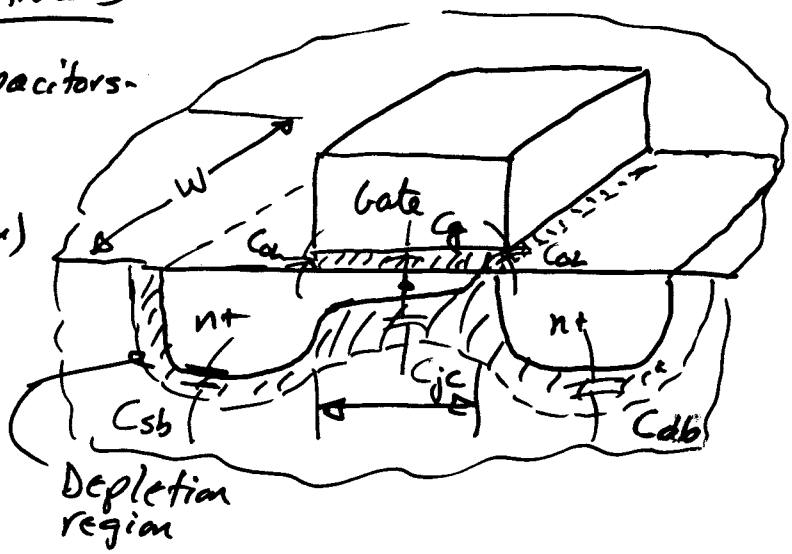
MOSFET CAPACITANCES

Types of MOSFET Capacitors-

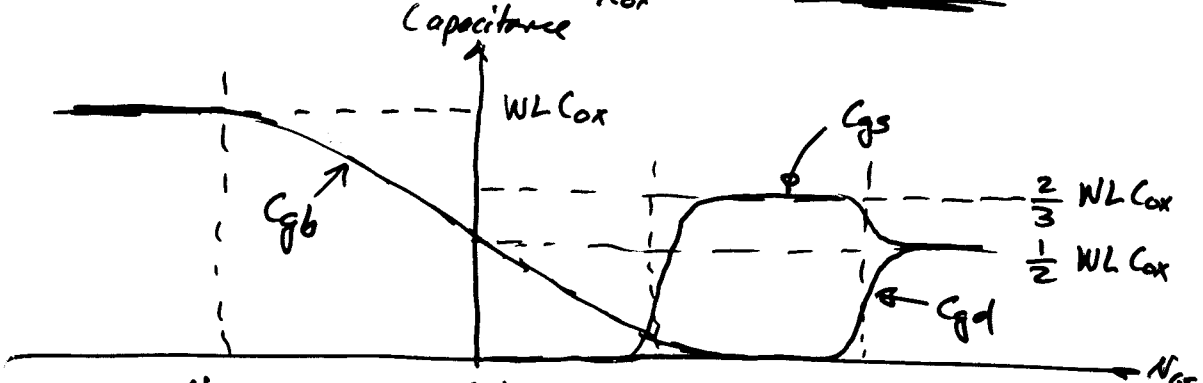
1.) Thin oxide
2.) pn junction (depletion)
3.) Overlap (C_{OL})

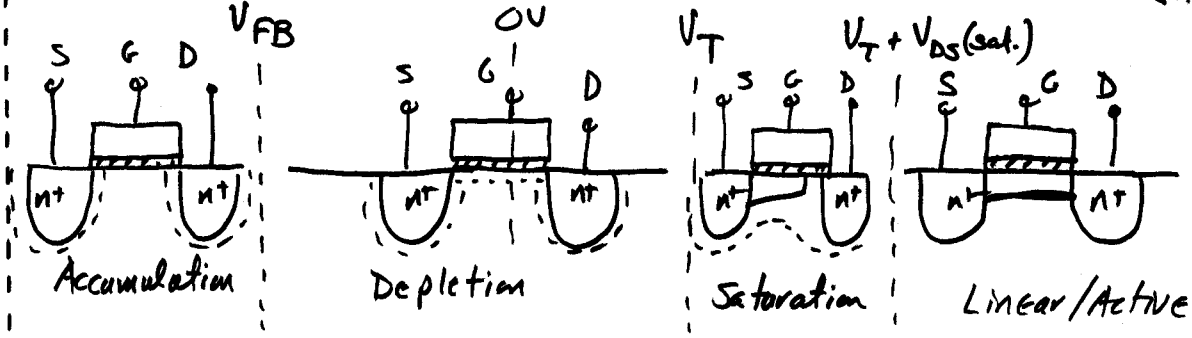


Thin Oxide Caps



$$C_g = C_G = WL\,C_{ox} = WL\,\frac{\epsilon_{ox}}{t_{ox}}$$





Depletion Capacitors next