EE5311

$$I_{DS} = \begin{cases} \mu_n C_{ox} \dfrac{W}{L} V_{DS} \left[(V_{GS} - V_T) - V_{DS}/2 \right] & V_{DS} \leq V_{GS} - V_T \\[2mm] \dfrac{1}{2} \mu_n C_{ox} \dfrac{W}{L} (V_{GS} - V_T)^2 & V_{DS} > V_{GS} - V_T \\[2mm] \sim 0 & V_{GS} < V_T \end{cases}$$
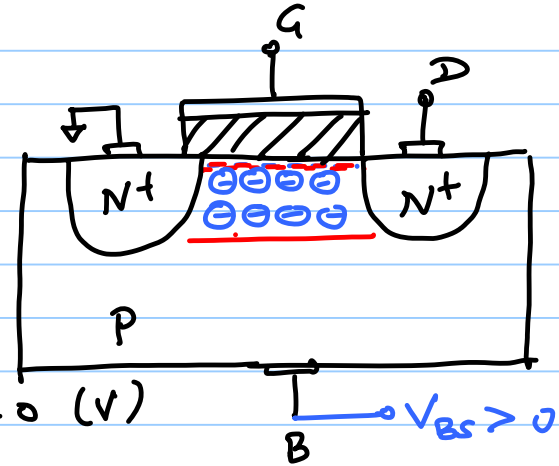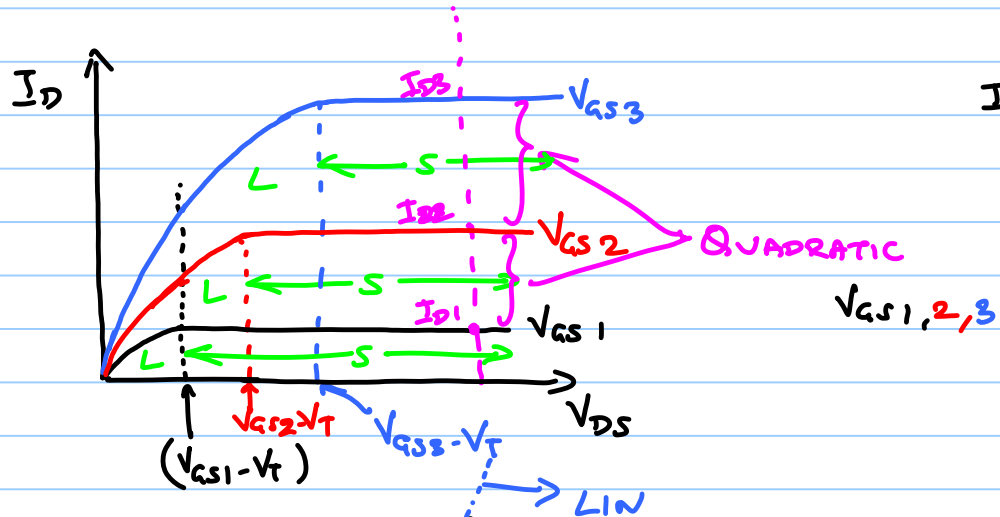
BODY EFFECT

$$V_{TH} = \psi_s + \frac{1}{C_{ox}} \sqrt{2\varepsilon_{si} q N_A |\psi_s|} \quad \leftarrow$$

$$\underline{V_{TH}} = V_{THO} + \gamma \left(\sqrt{|\psi_s + V_{SB}|} - \sqrt{|\psi_s|} \right)$$
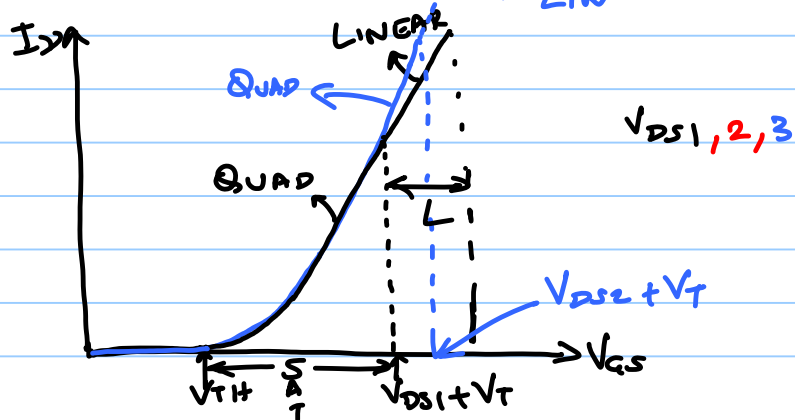
$V_{THO} \rightarrow$ THRESHOLD VOLTAGE @ $V_{SB} = 0$ (V)

$\gamma \rightarrow$ BODY EFFECT COEFF > 0 (for NMOS)
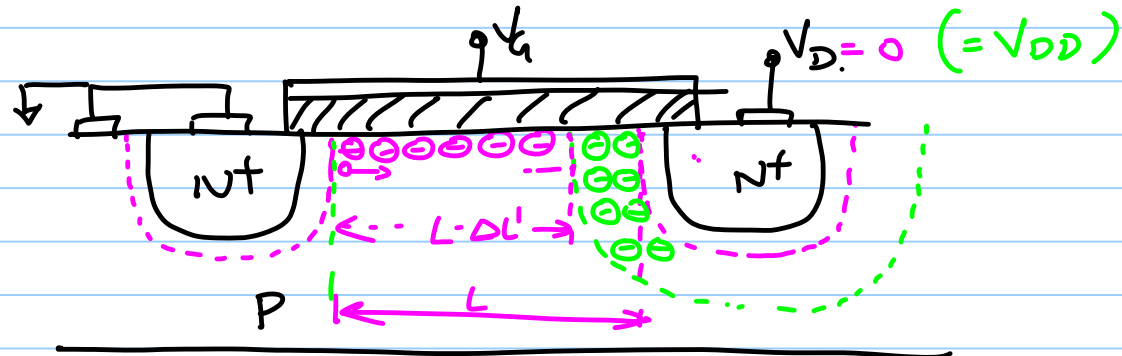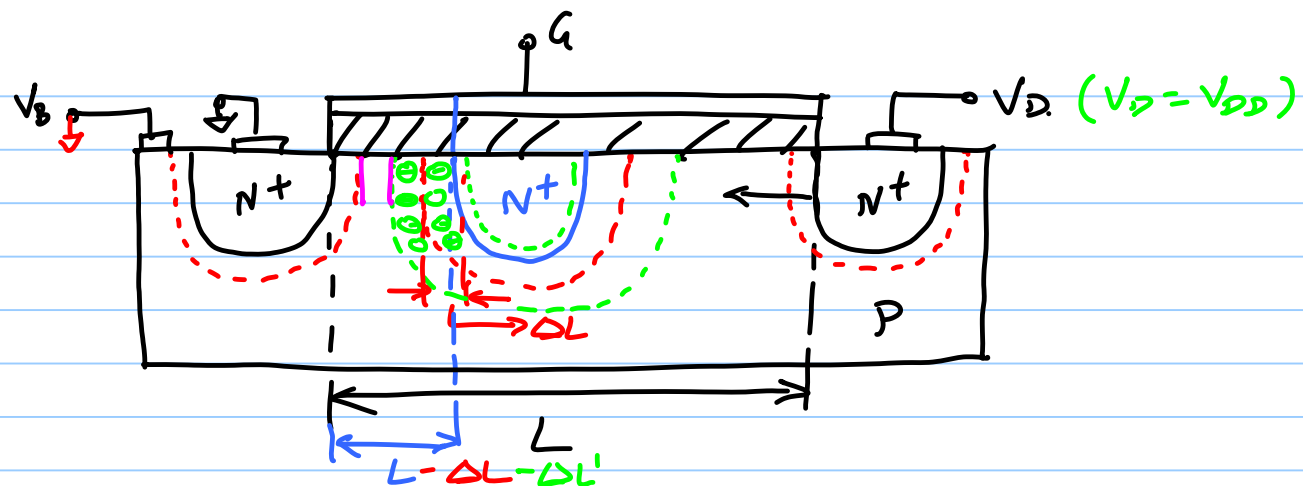$(\sqrt{V})$

$\Rightarrow V_{TH} \downarrow$

$V_{BS} > 0$

$$I_D = \begin{cases} \mu_n C_{ox} \dfrac{W}{L} V_{DS}\left[\underline{(V_{GS}-V_T)} - \dfrac{V_{DS}}{2}\right] & V_{DS} \le V_{GS}-V_T \\[2em] \mu_n C_{ox} \dfrac{W}{2L}(V_{GS}-V_T)^2 & V_{DS} > V_{GS}-V_T \end{cases}$$

I_D

I_{D3} V_{GS3}

L $\longleftarrow S \longrightarrow$

I_{D2}

L $\longleftarrow S \longrightarrow$ V_{GS2} $\longrightarrow$ QUADRATIC

I_{D1} V_{GS1}

L $\longleftarrow S \longrightarrow$

V_{DS}

$V_{GS2}-V_T$

$V_{GS3}-V_T$ $\longrightarrow$ LIN

$(V_{GS1}-V_T)$

$V_{GS\,1,2,3}$

I_D

LINEAR

QUAD $\longleftarrow$

QUAD

L

$V_{DS2}+V_T$

V_{GS}

V_{TH} SAT $V_{DS1}+V_T$

$V_{DS\,1,2,3}$

$V_{DS} > V_{GS}-V_T$

SHORT CHANNEL EFFECT:

CHANNEL LENGTH MODULATION: (CLM)

$$I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{TH})^2 \qquad (\text{LONG CHANNEL EQN} \neq f_n(V_{DS}))$$

$$L \rightarrow (L - \Delta L)$$

$$I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{(L - \Delta L)} (V_{GS} - V_{TH})^2 = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{TH})^2 (1 + \frac{\Delta L}{L})$$

$$\Rightarrow \quad I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{TH})^2 (1 + \lambda V_{DS})$$

$\downarrow$

λV_{DS}

$\downarrow$

CLM PARAM

I_D

V_{DS}

← LONG.