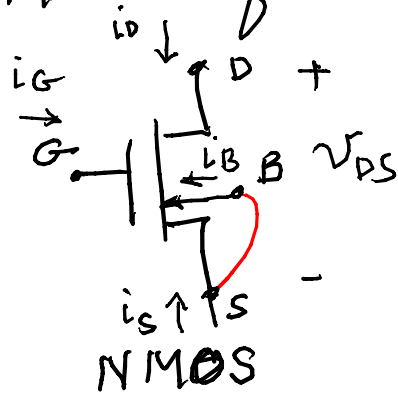


EE 312
02/27/06

MOS equivalent circuit

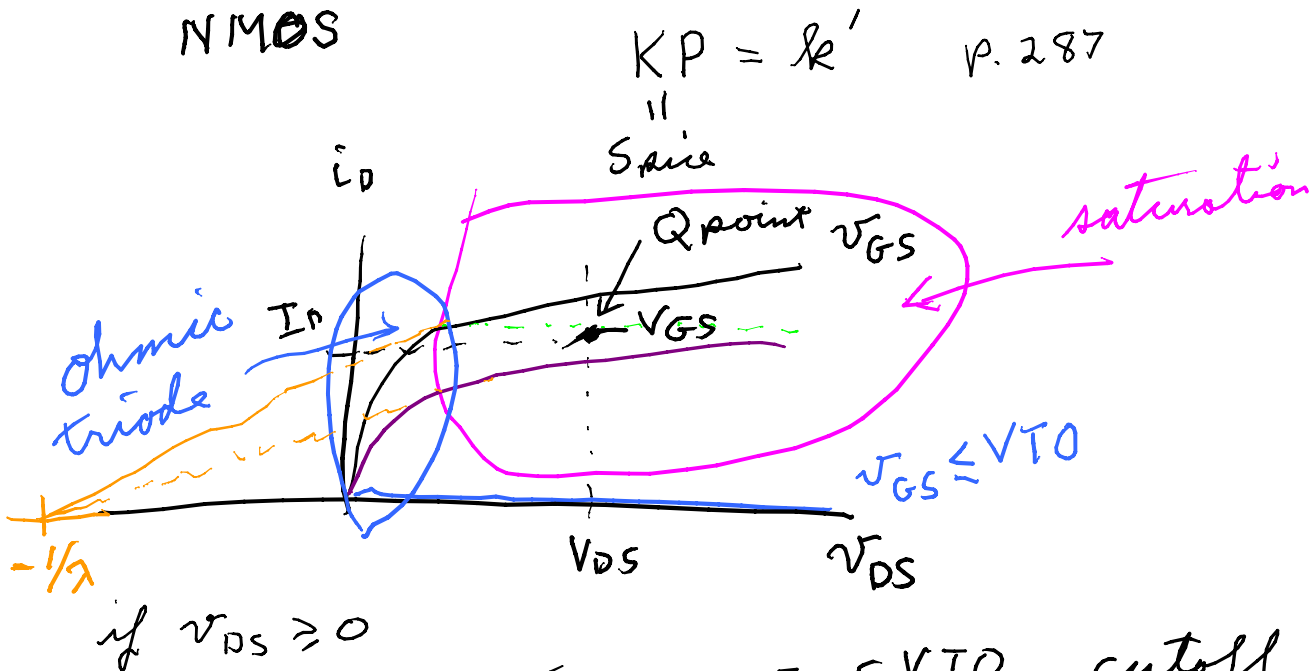


$V_{\text{threshold}} = V_{TO}$ if $v_{BS} = 0$

Spice parameters

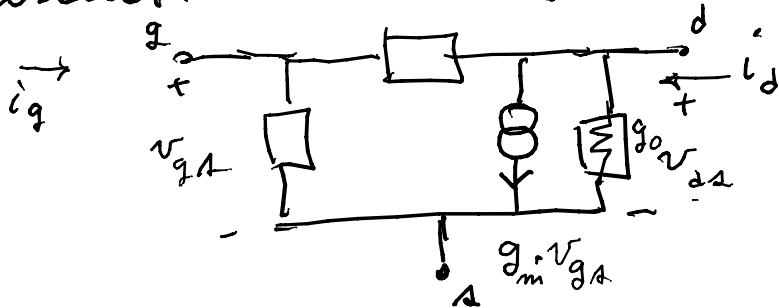
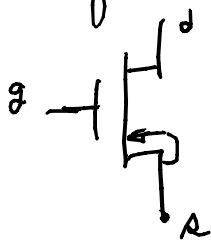
V_{th} on p. 287

$KP = k'$ p. 287



$$i_D = \frac{KP \cdot W}{2 \cdot L} \begin{cases} 0 & v_{GS} \leq V_{TO} \text{ cutoff} \\ [2(v_{GS} - V_{TO})v_{DS} - v_{DS}^2](1 + \lambda v_{DS}) & \text{ohmic} \\ & 0 \leq v_{DS} \leq v_{GS} - V_{TO} \\ (v_{GS} - V_{TO})^2(1 + \lambda v_{DS}) & \text{saturation} \\ & 0 \leq v_{GS} - V_{TO} \leq v_{DS} \end{cases}$$

→ equivalent circuit: (small signal)



$i_D = f(v_{GS}, v_{DS})$ use a Taylor expansion

$$= f(V_{GS}, V_{DS}) + \left. \frac{\partial i_D}{\partial v_{GS}} \right|_{V_{GS}, V_{DS}} (v_{GS} - V_{GS}) + \left. \frac{\partial i_D}{\partial v_{DS}} \right|_{V_{GS}, V_{DS}} (v_{DS} - V_{DS}) + \dots$$

$$i_D - I_D = i_d = \text{signal}$$

$$v_{GS} - V_{GS} = v_{gs} = "$$

$$v_{DS} - V_{DS} = v_{ds} = "$$

$$i_d = \left. \frac{\partial i_D}{\partial v_{GS}} \right|_{V_{GS}, V_{DS}} v_{gs} + \left. \frac{\partial i_D}{\partial v_{DS}} \right|_{V_{GS}, V_{DS}} v_{ds}$$

$$= g_m \cdot v_{gs} + g_o \cdot v_{ds}$$



in saturation

$$i_D = \frac{K_P W}{2 L} (v_{GS} - V_{TO})^2 (1 + \lambda v_{DS})$$

$$g_m = \left. \frac{\partial i_D}{\partial v_{GS}} \right|_{V_{GS}, V_{DS}} = \frac{2 \left(\frac{K_P W}{2 L} (v_{GS} - V_{TO})^2 (1 + \lambda v_{DS}) \right)}{(v_{GS} - V_{TO})} = 2 \frac{I_D}{v_{GS} - V_{TO}}$$

$$g_o = \left. \frac{\partial i_D}{\partial v_{GS}} \right|_Q = \lambda \left(\frac{k_p}{2} \frac{W}{L} (v_{GS} - v_{TO})^2 \right) \approx \lambda \cdot I_D$$