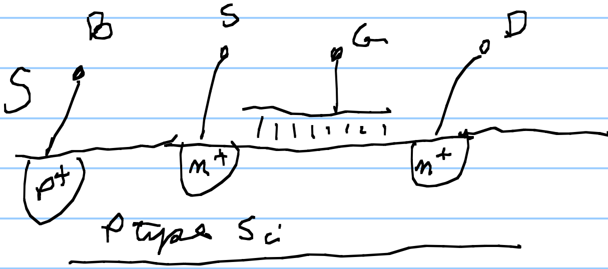
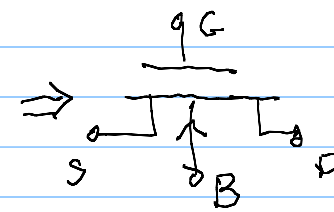
Note Title 9/6/2014

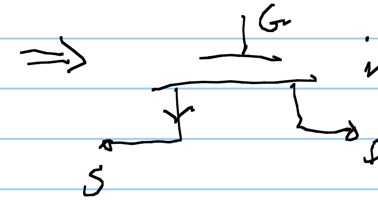
EE303H
09/09/14

side view of NMOS



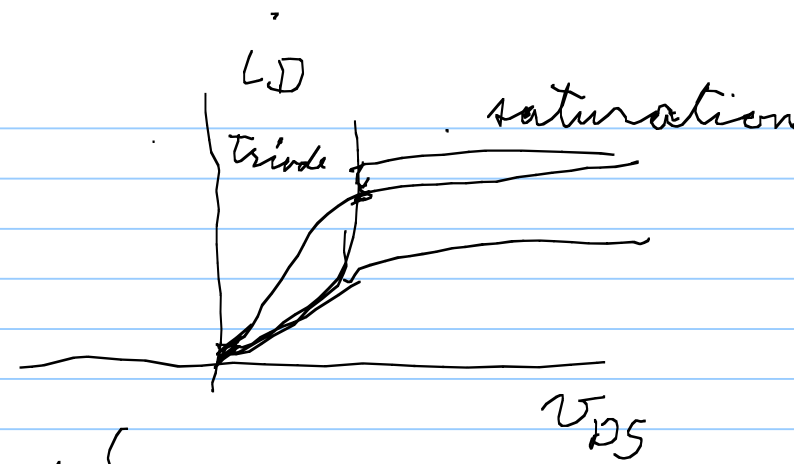
p. 233





if B=S

for eqs. see
Table 5.1, p. 249



Eq. in saturation

$$v_{DS} \geq v_{GS} - VTO$$

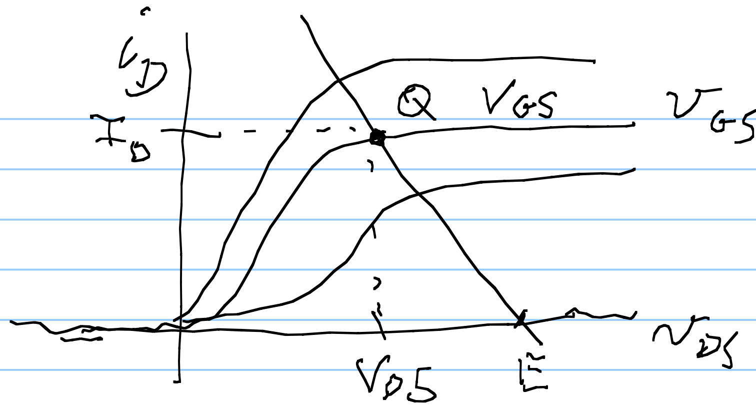
$$i_D = \frac{KP}{2}\frac{W}{L}(v_{GS} - VTO)^2(1 + \lambda v_{DS})$$

$v_{GS} \geq VTO$

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

if $v_{DS} \leq v_{GS} - VTO$

if $v_{GS} \leq VTO$ then $i_D = 0$ Turned off



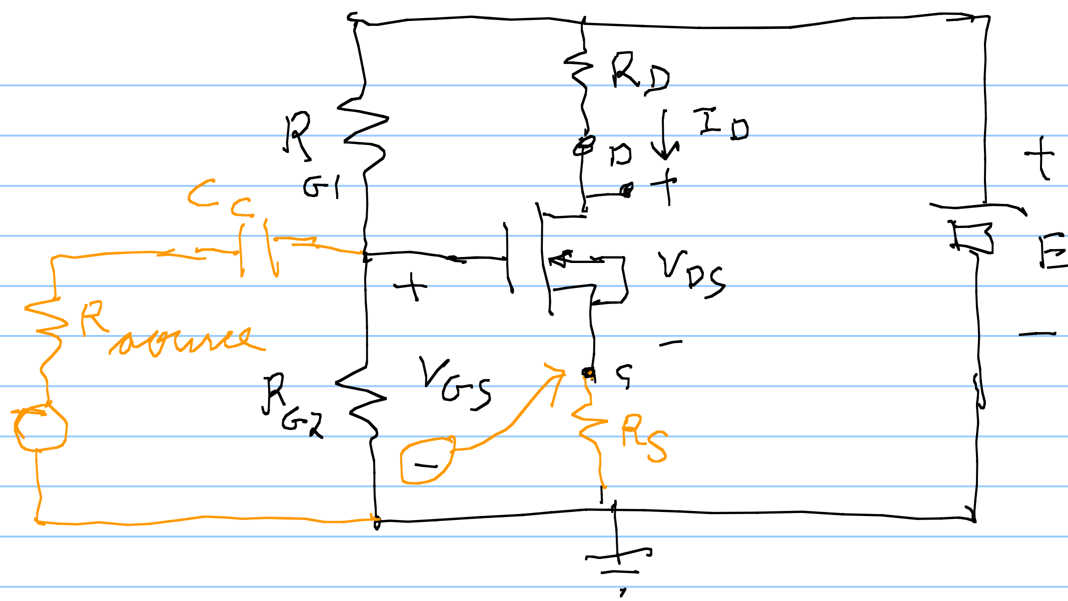
$$x_y = X_y + v_y$$

total — bias (DC) — signal

$$i_D = I_D + i_d, \quad v_{DS} = V_{DS} + v_{ds}$$

bias circuit, ex 5.6, p.263

fig.. Fig 5.31, p.274



$$V_{GS} = \frac{R_{G2}}{R_{G1}+R_{G2}} E$$

$$V_{DS} = E - R_D I_D$$

Given Q pt $\Rightarrow I_D, V_{DS}$

$$R_D \Rightarrow \frac{E - V_{DS}}{I_D} = R_D$$

design for a given Q pt.

choose large R_G's
so don't load source

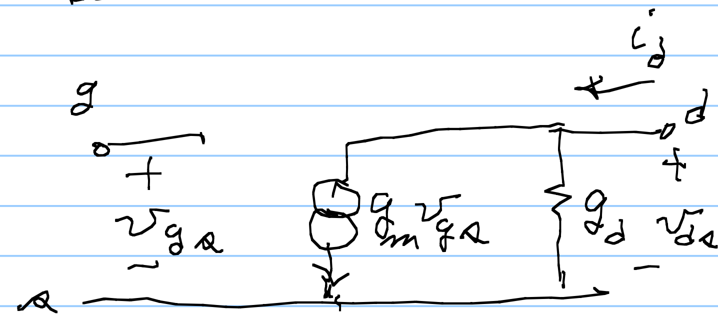
$$\frac{R_{G2}/R_{G1}}{1 + R_{G2}/R_{G1}} = E/V_{GS}$$

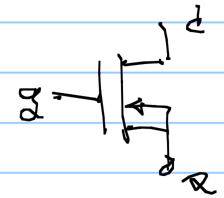
For transistor behavior use Taylor series for i_D vs. v_{GS}, v_{DS}

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

drop for small signal
$$\left\{ + \left.\frac{\partial^2 i_D}{\partial v_{GS}\,\partial v_{DS}}\right|_Q (v_{GS} - V_{GS})(v_{DS} - V_{DS}) + \cdots \right.$$

$$\Rightarrow \quad i_d = g_m v_{gs} + g_d\, v_{ds} \quad \Rightarrow$$





low frequency NMOS small signal equivalent & depends on Q point

$$g_d = \left.\frac{\partial i_D}{\partial v_{DS}}\right|_Q \quad \text{in saturation}$$

$$= \frac{\partial\left[\frac{KP}{2}\frac{W}{L}(v_{GS}-V_{TO})^2(1+\lambda v_{DS})\right]}{\partial v_{DS}} = \lambda \frac{KP}{2}\frac{W}{L}(v_{GS}-V_{TO})^2\Big|_Q$$

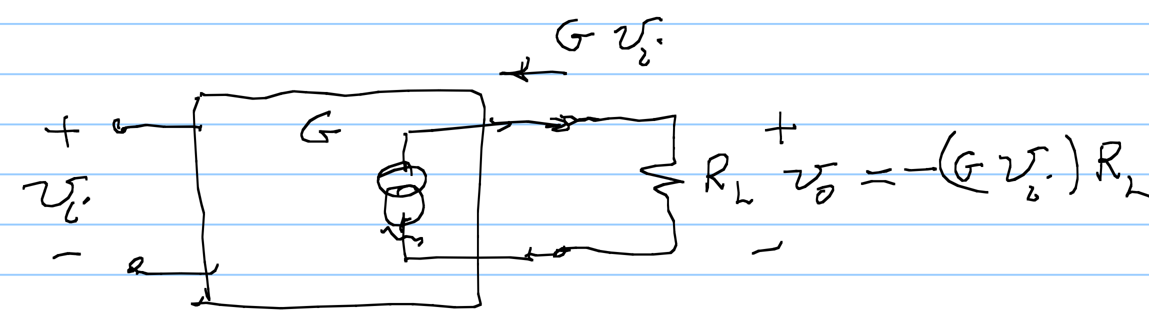
$$\approx \lambda \cdot i_D\Big|_Q = \lambda I_D$$

$$g_m = \left.\frac{\partial i_D}{\partial v_{GS}}\right|_Q \quad \text{in saturation}$$

$$= \frac{\partial\left[\frac{KP}{2}\frac{W}{L}(v_{GS}-V_{TO})^2(1+\lambda v_{DS})\right]}{\partial v_{GS}} = 2\cdot\frac{KP}{2}\frac{W}{L}(v_{GS}-V_{TO})(1+\lambda v_{DS})\Big|_Q$$

$$= 2\frac{I_D}{V_{GS} - V_{TO}}$$

as a theoretical case:



gain $\frac{v_o}{v_i} = -G R_L \Longrightarrow -g_m R_L$ for transistors

$\therefore$ if $g_m \approx 2\times 10^{-3} = 2\,m\mho$ then $R_L = 10\,K\Omega$ gives $\frac{v_o}{v_i} = -20$ as gain