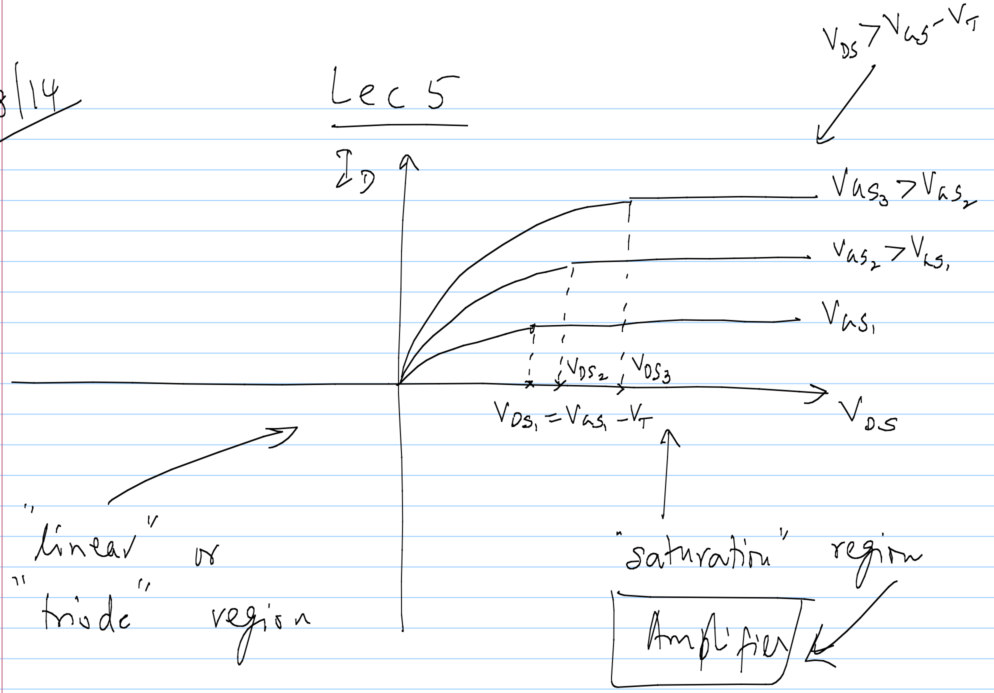
6/8/14

# Lec 5




In linear region:

$$I_D = \mu_n C_{ox} \frac{W}{L} \left[ (V_{GS} - V_T) V_{DS} - \frac{V_{DS}^2}{2} \right]$$

$$y_{21} = \frac{\partial f_2}{\partial V_1} = \frac{\partial I_D}{\partial V_{GS}}$$

$$= \mu_n C_{ox} \frac{W}{L} \cdot V_{DS}$$

$$y_{22} = \frac{\partial f_2}{\partial V_2} = \mu_n C_{ox} \frac{W}{L} \left[ V_{GS} - V_T - V_{DS} \right]$$

If $V_{DS} << (V_{GS} - V_T)$

$$y_{22} = \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_T)$$

$\Rightarrow$ Voltage-controlled resistance

In sat. region:

$$I_D = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L}\right) \left[ V_{GS} - V_T \right]^2$$

$$y_{21} = \frac{\partial f_2}{\partial V_1} = \frac{\partial I_D}{\partial V_{GS}} = g_m \quad \text{"transconductance"}$$

1) $$g_m = \left. \frac{\partial I_D}{\partial V_{GS}} \right|_{V_{GS_Q}} = \mu_n C_{ox} \left(\frac{W}{L}\right) (V_{GS_Q} - V_T)$$

2) $$g_m = \mu_n C_{ox} \left(\frac{W}{L}\right) \cdot \underbrace{\sqrt{\frac{2 I_D}{\mu_n C_{ox} \left(\frac{W}{L}\right)}}}_{V_{GS} - V_T}$$

$$= \sqrt{2 \mu_n C_{ox} \left(\frac{W}{L}\right) I_D}$$

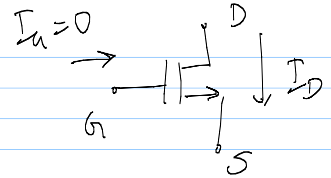
3) $g_m =$

$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS}-V_T)^2$$

$$\mu_n C_{ox}\left(\frac{W}{L}\right) = \frac{2I_D}{(V_{GS}-V_T)^2}$$

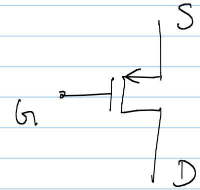
$$g_m = \frac{2I_D}{(V_{GS}-V_T)^2}\cdot(V_{GS}-V_T)$$

$$= \frac{2I_D}{(V_{GS}-V_T)}$$



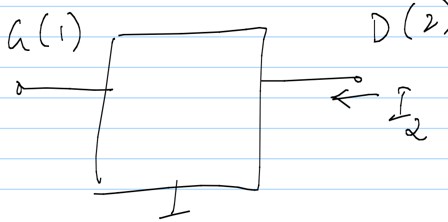

n- channel MOSFET

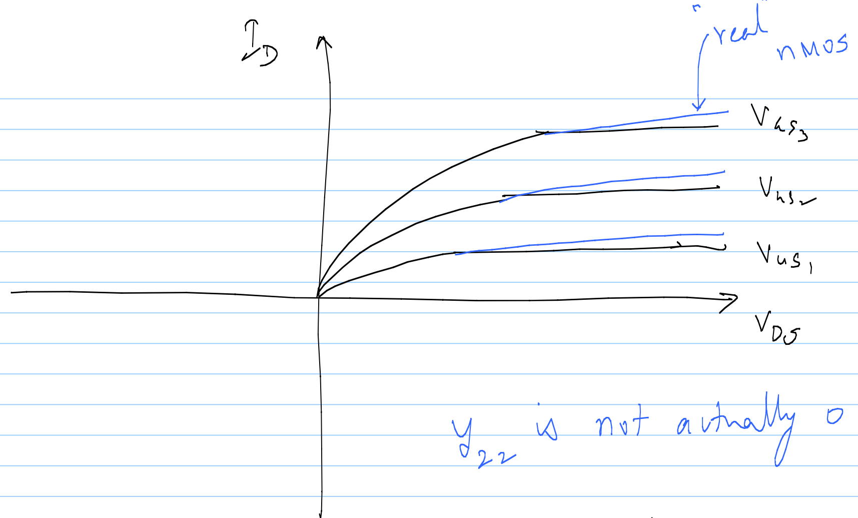
nMOS




p- channel MOSFET

pMOS




$y_{22}$ is not actually 0

$$\frac{v_L}{v_s} = \frac{-y_{21}}{y_{22}+G_L}$$

as long as $y_{22} \ll G_L$

"good" amplifier

$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS}-V_T)^2(1+\lambda V_{DS})$$

$\lambda$ is very small