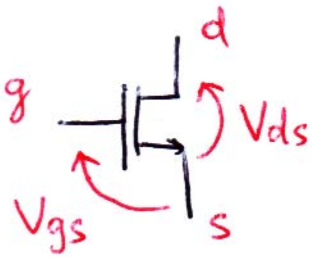
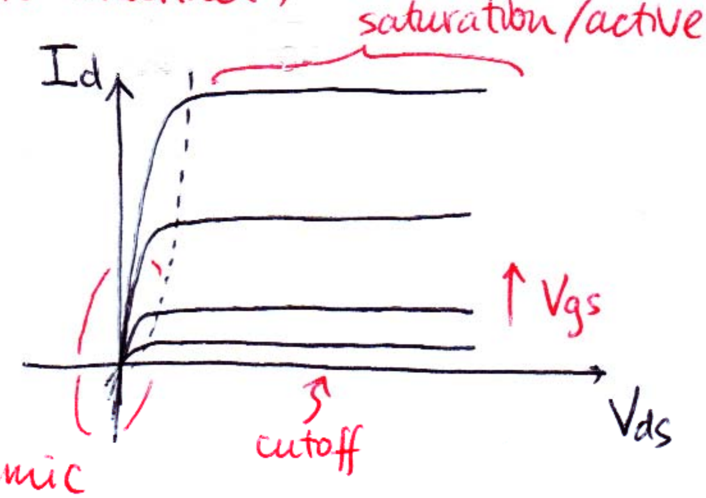
P3360/AEP 3630

Lecture 21

MOSFET modes (n-channel)



$I_d = I_s$



mathematical model

If $V_{gs} < V_T$, ⇒ cut off ($I_d = 0$)

Else if $V_{ds} < V_{gs} - V_T$, ⇒ ohmic

$$I_d = K(2(V_{gs}-V_T)V_{ds} - V_{ds}^2)$$

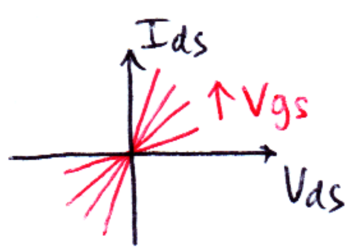
else, saturation

$$I_d = K(V_{gs}-V_T)^2 \neq f(V_{ds})$$

$[K] \sim \frac{mA}{V^2}$ $[V_T] \sim V$

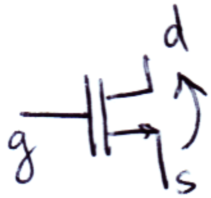
e.g. $100\ \frac{mA}{V^2}$ and $2V$ → const's specific to a MOSFET

Ohmic region

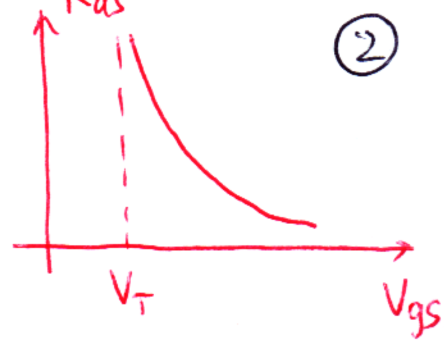


- volt. controlled R
- use for automatic gain controll

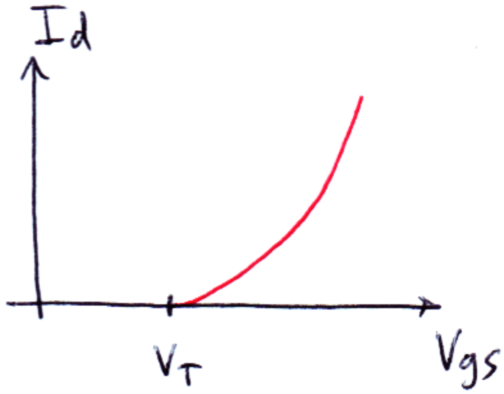
②



$$R_{ds} = \frac{V_{ds}}{I_d} \sim \underbrace{\frac{1}{2K(V_{gs}-V_T)}}_{\text{for small } V_{ds}}$$

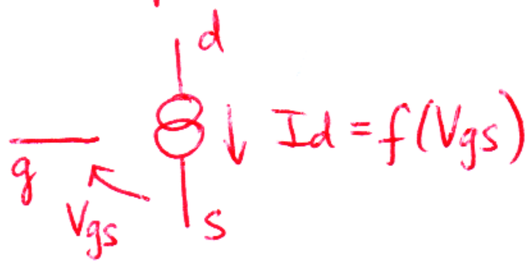


saturation (= active) region



$I_d = K(V_{gs}-V_T)^2 \quad V_{ds} > V_{gs}-V_T$

I_d is indep from V_{ds}

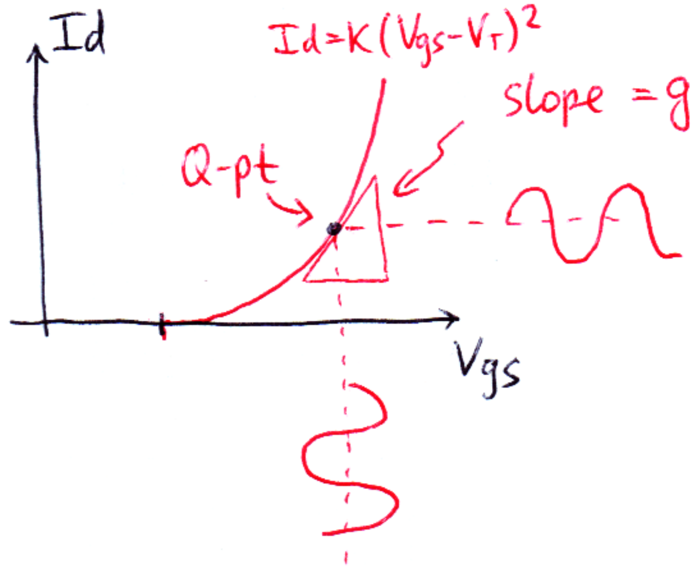


– volt. controlled current source

MOSFET circuit analysis

① large signal or Q-pt determination

② small-signal analysis (if amplification)



slope $= g_m \left(\frac{1}{\Omega}\right)$ = "transconductance"

$$g_m = \left(\frac{\partial I_d}{\partial V_{gs}}\right)_{Q\text{-}pt} = 2K\left(V_{gs}\big|_{Q\text{-}pt} - V_T\right)$$

$$g_m = 2\sqrt{K I_d\big|_{Q\text{-}pt}}$$