OPERATION OF MOSFET

2012142227 이 승 남

Derivation of I-V characteristic

- Channel Charge Density

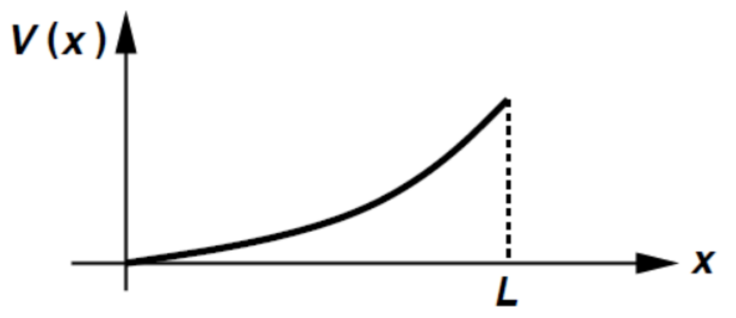
case1. $V_{GS} > V_{TH}, V_D = 0$

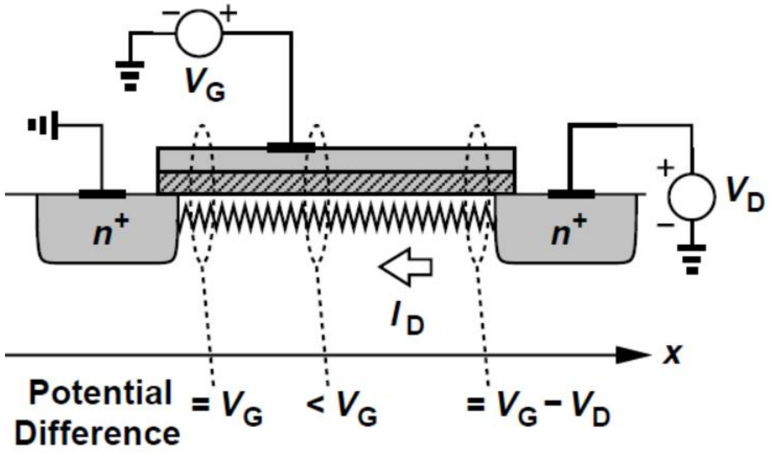
$$Q = WC_{ox}(V_{GS} - V_{TH})$$

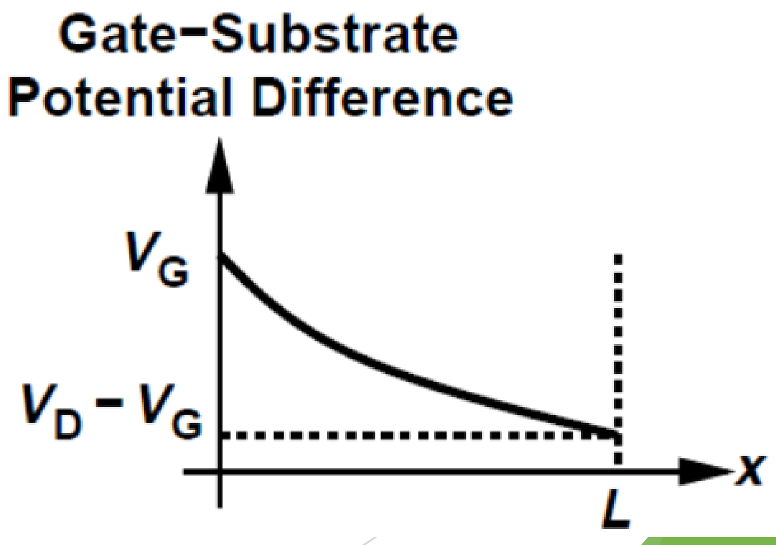
capacitance per unit area   overdrive voltage

case2. $V_{GS} > V_{TH}, V_D > 0$

$$Q(x) = WC_{ox}[V_{GS} - V(x) - V_{TH}]$$

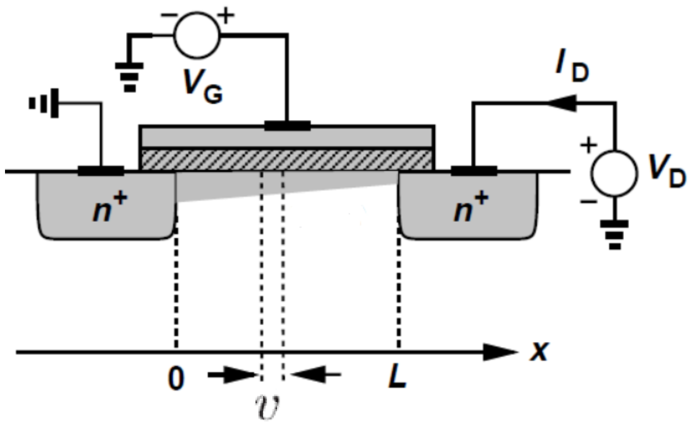






Derivation of I-V characteristics

- Drain Current



$$v = -\mu_n E,$$
$$= +\mu_n \frac{dV}{dx}$$

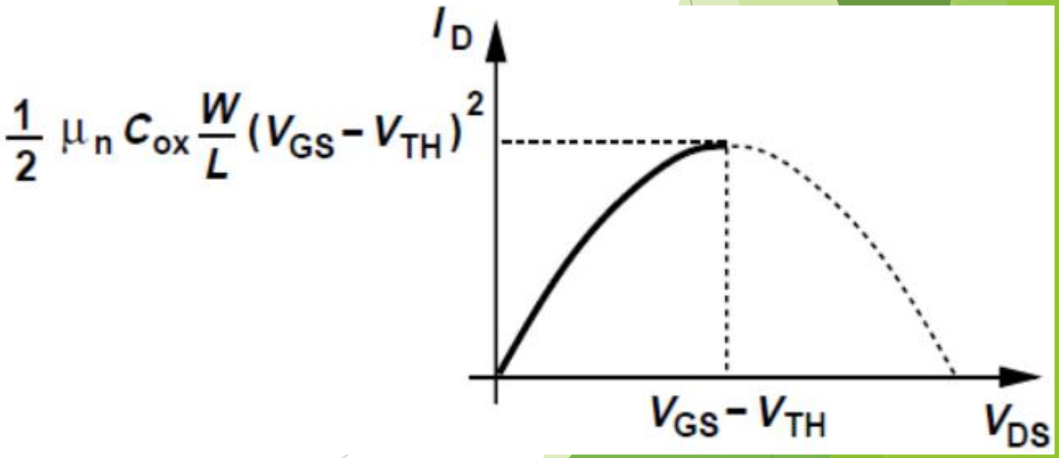
total charge in this length

$$v\, w\, C_{OX} \left(V_{GS} - V_{TH} - V_{(X)}\right)$$

$$I_D = W C_{ox}[V_{GS} - V(x) - V_{TH}]\mu_n \frac{dV(x)}{dx}$$

$$\int_{x=0}^{x=L} I_D dx = \int_{V(x)=0}^{V(x)=V_{DS}} \mu_n C_{ox} W[V_{GS} - V(x) - V_{TH}]dV.$$

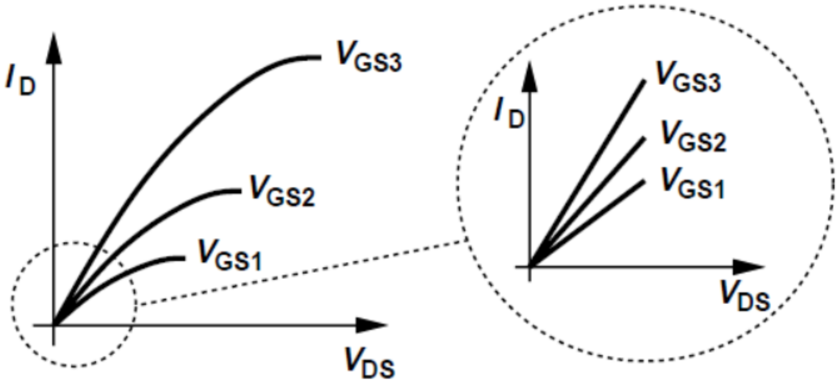
$$I_D = \frac{1}{2}\mu_n C_{ox} \frac{W}{L}[2(V_{GS} - V_{TH})V_{DS} - V_{DS}^2]$$



I_D-V_{DS} Characteristics

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

- How about V_{DS} has very small value?



$$I_D \approx \mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})V_{DS}$$

$$R_{on} = \frac{1}{\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})}$$

- A MOSFET can act as a voltage-dependent resistor.

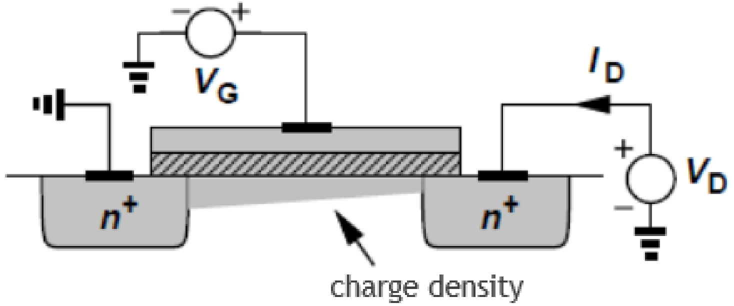
- MOSFET can be a switch.(ON : $V_{GS} >> V_{TH}$, OFF : $V_{GS} = V_{TH}$)

Only in situation that $V_{DS} << 2(V_{GS} - V_{TH})$!!

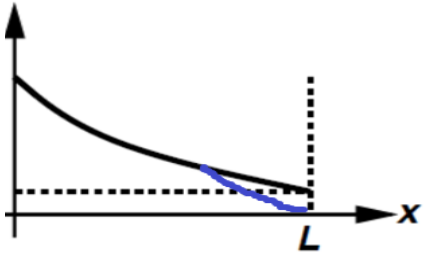
I_D-V_{DS} Characteristics

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

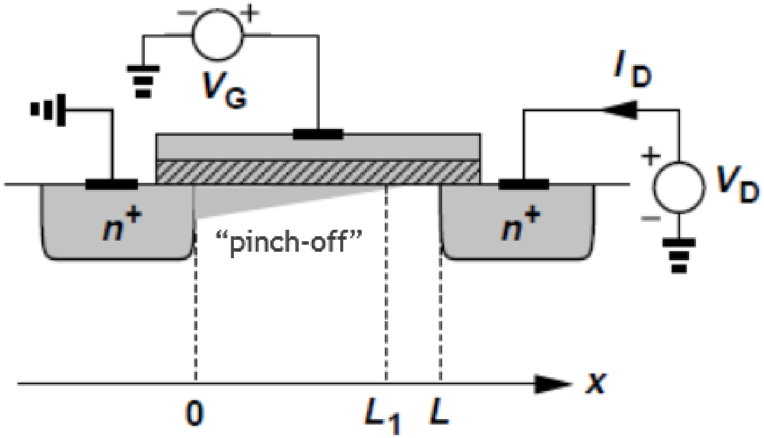
- How about V_{DS} is bigger than V_{GS} – V_{TH}



if V_{GS} – V_{DS} = V_{TH}, the charge drops to zero!!

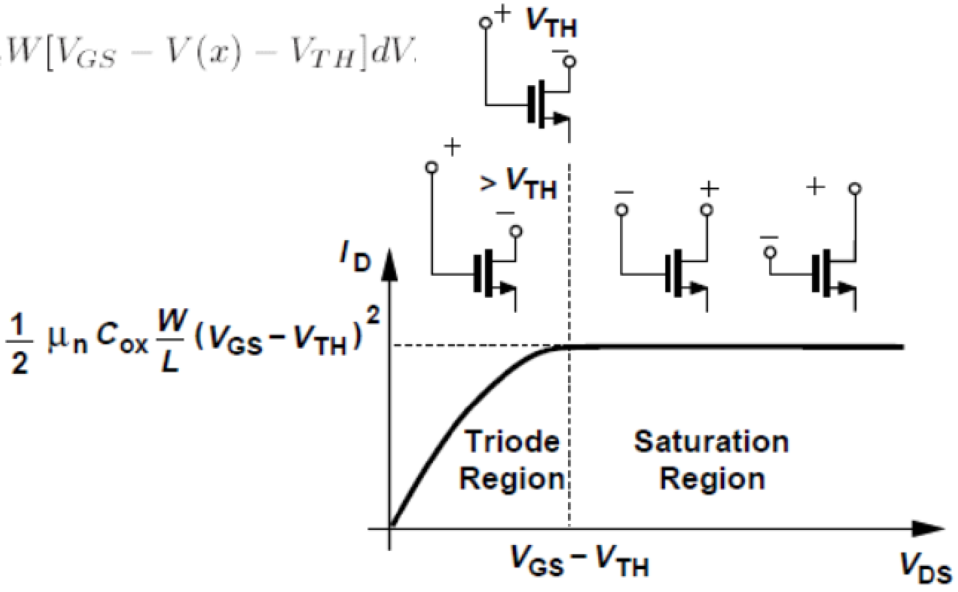


If V_{DS} is beyond V_{GS} – V_{TH}, the point that the charge density go to zero goes left.



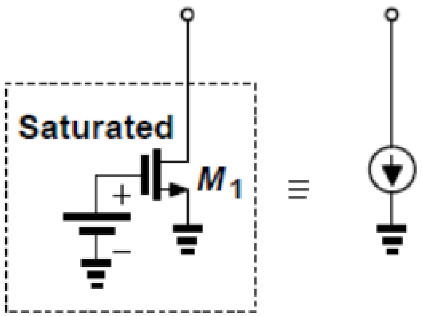
$$\int_{x=0}^{x=L_1} I_D dx = \int_{V(x)=0}^{V(x)=V_{GS}-V_{TH}} \mu_n C_{ox} W[V_{GS} - V(x) - V_{TH}]dV$$

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L_1}(V_{GS} - V_{TH})^2$$



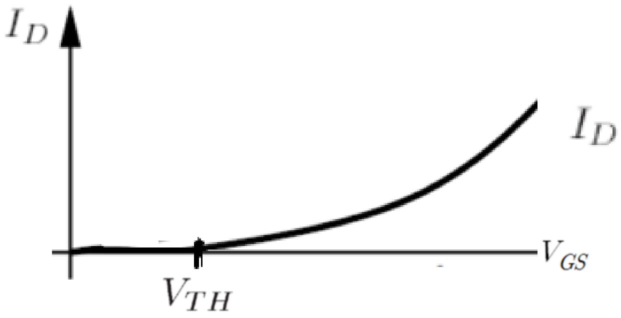
About Saturation

- Work as Current source



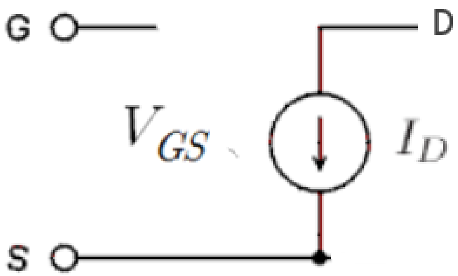
$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L_1}(V_{GS} - V_{TH})^2$$

- I_D-V_{GS} characteristic in saturated situation



$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L_1}(V_{GS} - V_{TH})^2$$

- Simple model in saturation (using this device, we can build an amplifier.)



$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L_1}(V_{GS} - V_{TH})^2$$

Thank you for your attention!!