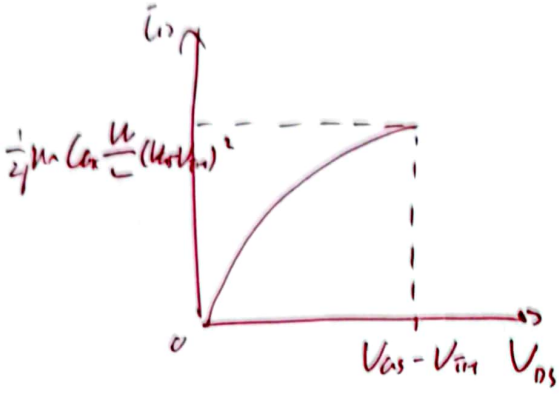
MOS I/V Characteristics



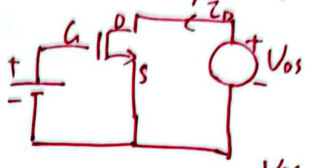
$$i_D = \mu_n \frac{W}{L} C_{ox}\left((V_{GS}-V_{TH})V_{DS} - \frac{1}{2}V_{DS}^2\right)$$

if $V_{DS}(V_{GS}-V_{TH}) >> \frac{1}{2}V_{DS}^2$

(即 V_{DS} 非常小)

即 $V_{DS} << 2(V_{GS}-V_{TH})$ 时

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

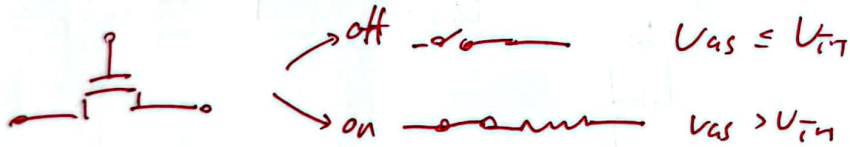


$$R_{on} = \frac{V_{DS}}{i_D} = \frac{1}{\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})}$$

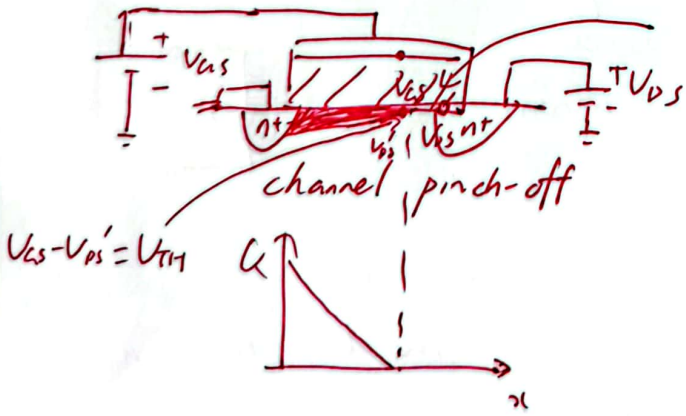
A MOSFET can act as a voltage-dependent resistor (if $V_{DS} << 2(V_{GS}-V_{TH})$)

MOS is on

MOS Device as a Switch

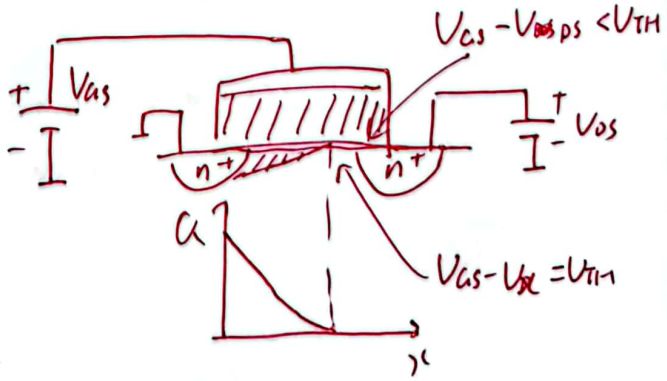


什么 i_D for $V_{DS} > V_{GS} - V_{TH}$?



if $V_{GS} - V_{DS} < V_{TH}$

No Q_n



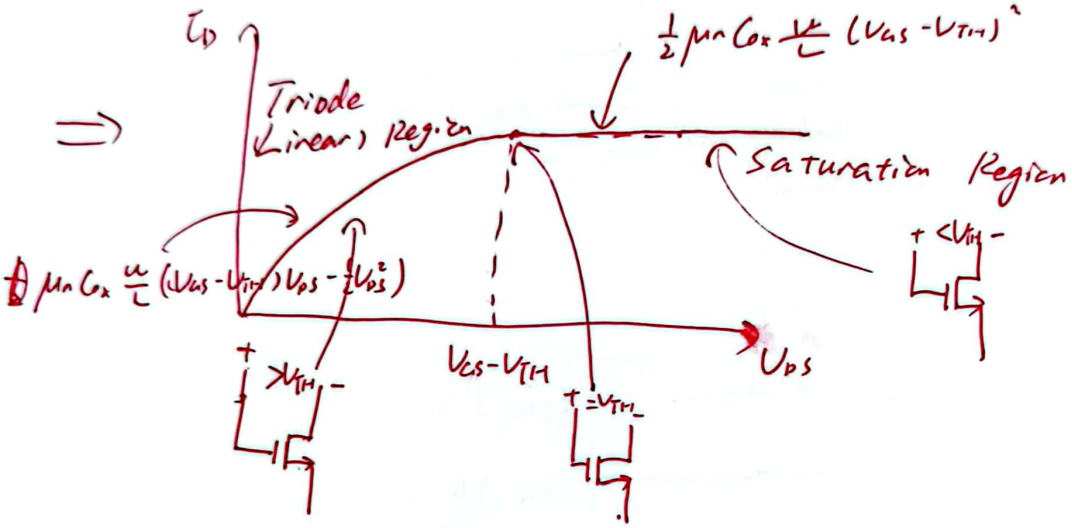
Redrive I/V equation

$$\int_0^L I_D \, dx = \int_0^{V_{DS}} \mu_n \frac{W}{L} C_{ox} (V_{GS} - V_{TH} - V(x)) \, dV$$

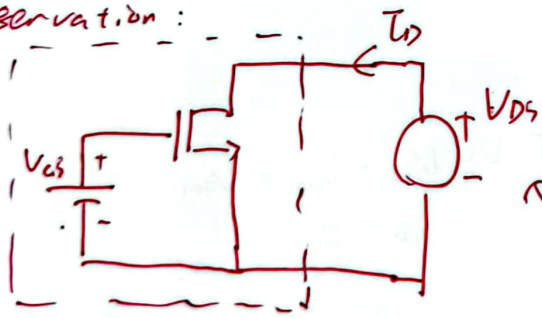
$$I_D L = \mu_n C_{ox} \frac{W}{L} \left((V_{GS} - V_{TH}) V(x) - \frac{1}{2} V(x)^2 \right) \Big|_0^{V_{GS}-V_{TH}}$$

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

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



Observation:



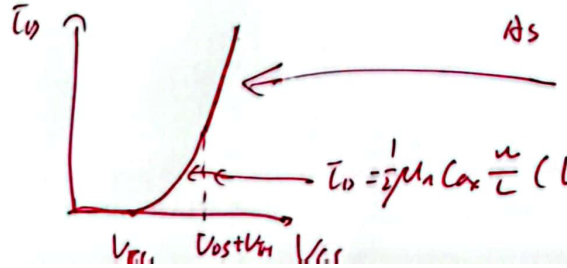
As $V_{DS} > V_{GS} - V_{TH}$, I_D current source I_D

- If $V_{DS} > 0$ and V_{DS} = constant

when $V_{GS} - V_{TH} > 0$, the MOS turn on.

now $V_{GS} - V_{TH} \le V_{DS}$, sat.

As $V_{DS}\uparrow$, $V_{GS} - V_{TH} > V_{DS}$, Triode.

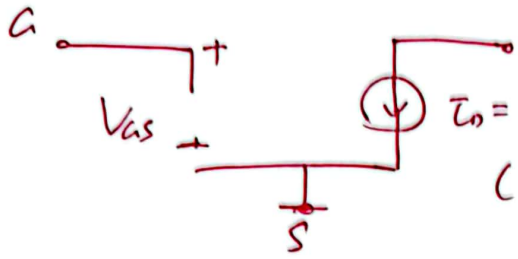


$I_D = \mu_n C_{ox} \frac{W}{L} \left((V_{GS} - V_{TH}) V_{DS} - \frac{1}{2} V_{DS}^2 \right) \rightarrow k = \mu_n C_{ox} \frac{W}{L} V_{DS}$

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

~~Example~~

Simple model sat.



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

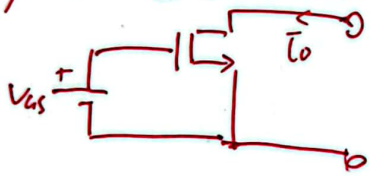
$(V_{DS} > V_{GS}-V_{TH})$

Example (use the model to design a current source)

$\mu_n C_{ox} = 100\mu A/V^2$. $V_{TH}=0.5V$ $\frac{W}{L}=\frac{5\mu m}{0.5\mu m}$

Design a 1 mA current source.

$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2 \Rightarrow$ ① $V_{GS}=1.91V$.



∴ $V_{DS} \geq 1.41V$ 时

$I_D = 1mA$. a current source