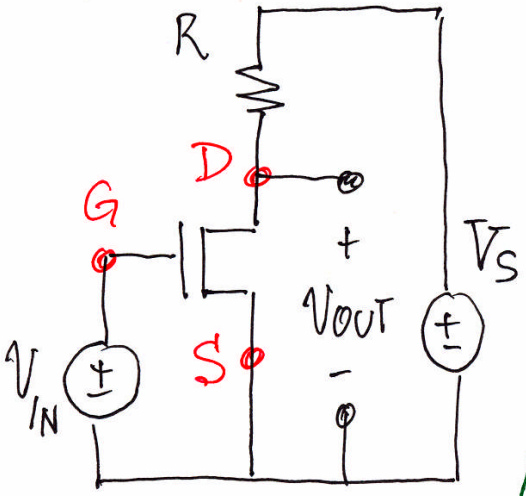
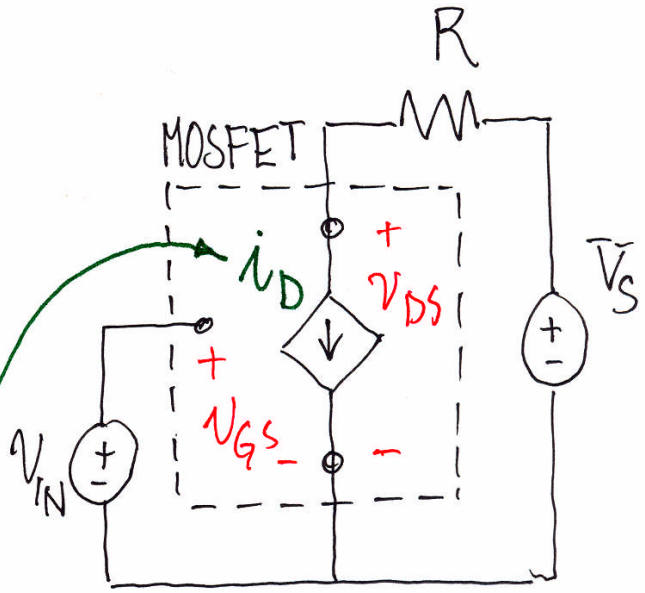
6.002 - Lecture 7

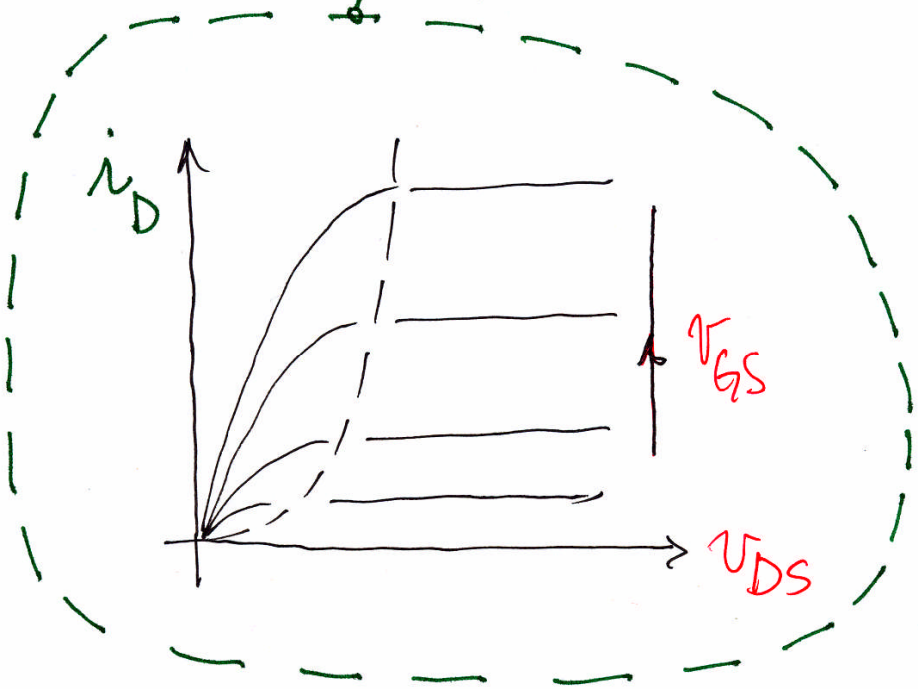
MOSFET Amplifiers

- Graphical Analysis
- MOSFET Details
- Closed-Form Analysis

MOSFET Amplifier







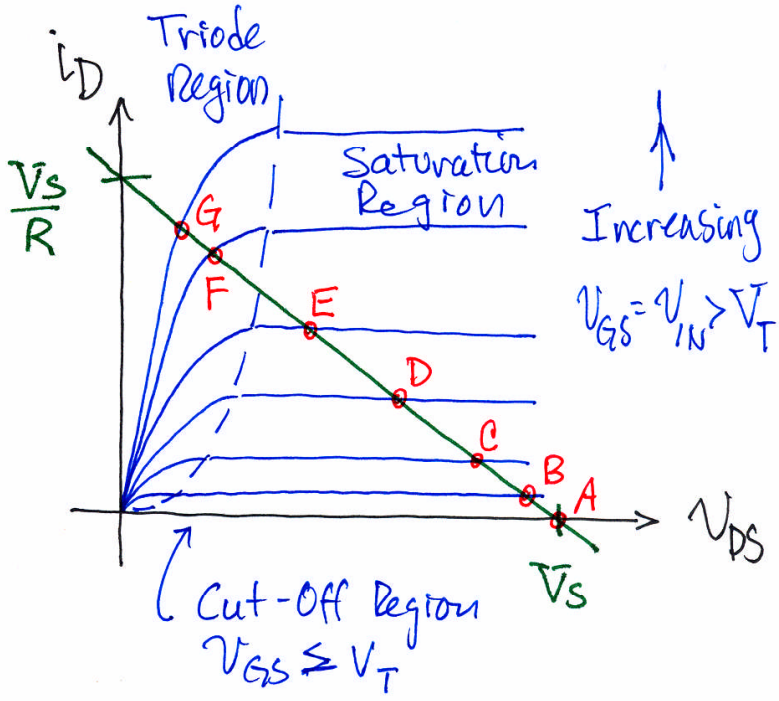
Graphical Analysis I

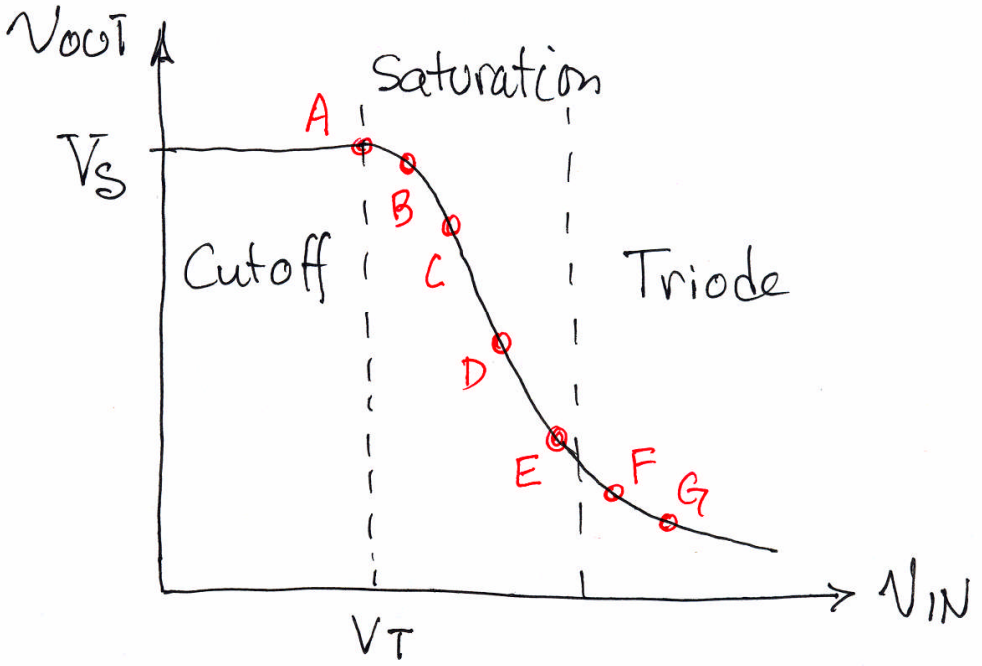
Thevenin:

$V_S = V_{DS} + R i_D$

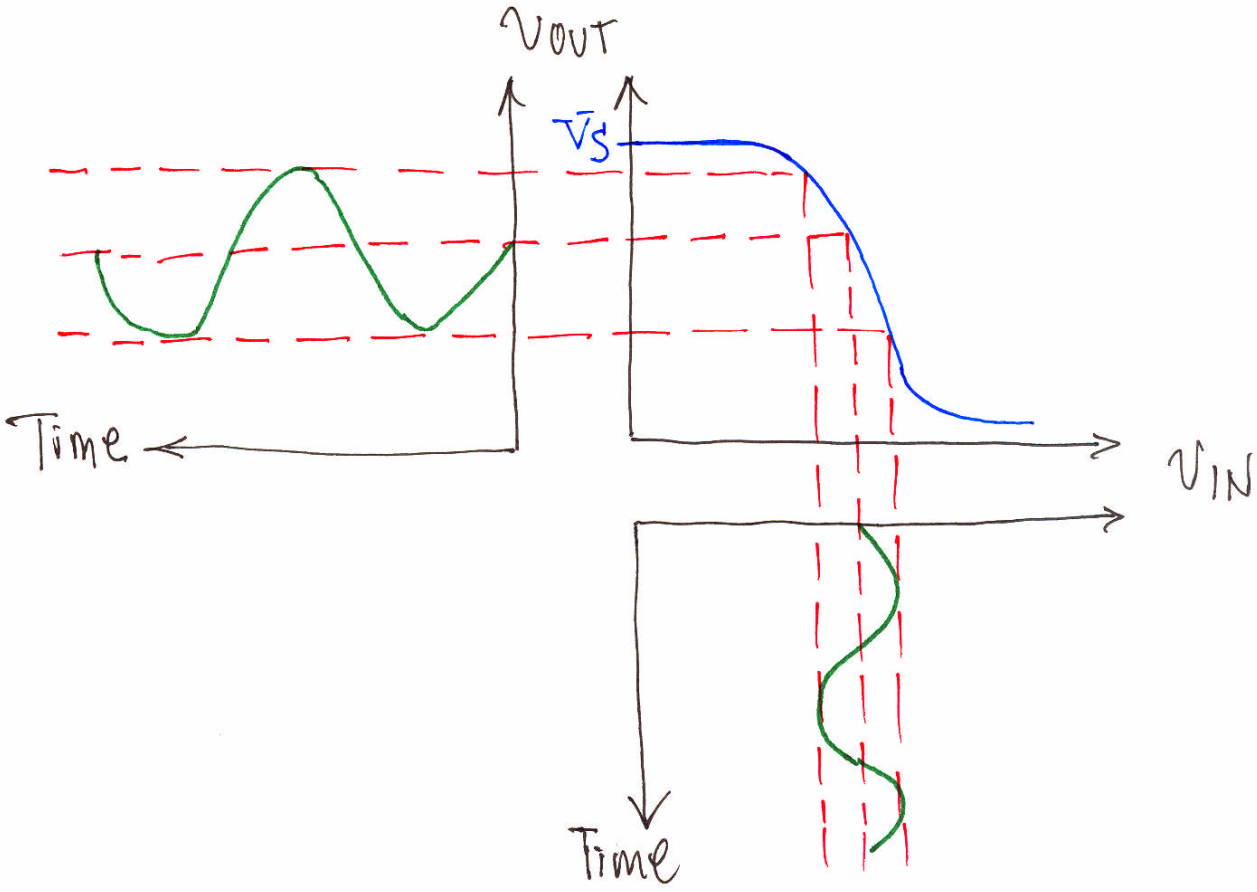
MOSFET:

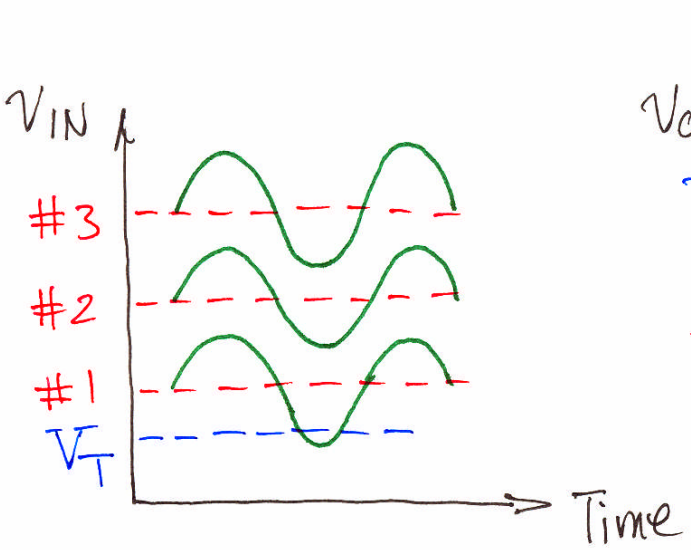
$i_D(V_{DS}, V_{GS} = V_{IN})$

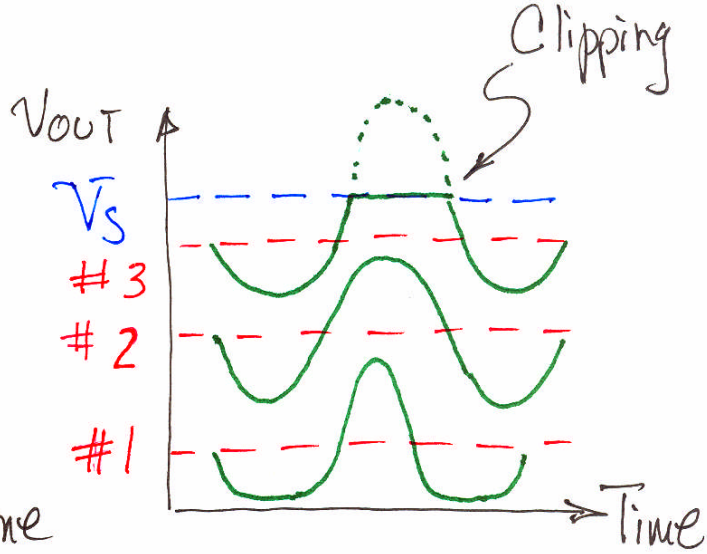




Graphical Analysis II





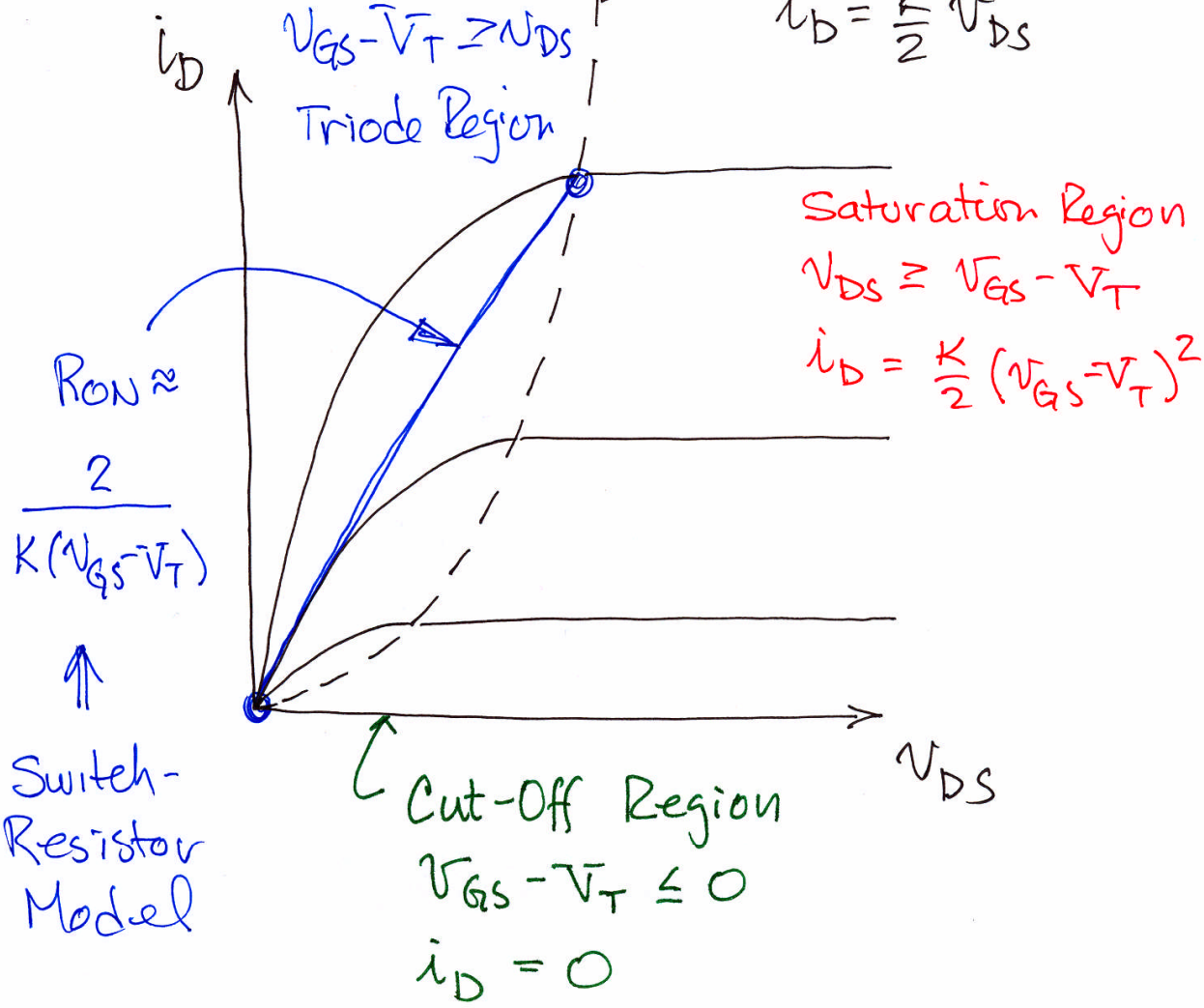


MOSFET Details

$i_D = K\left(v_{GS} - V_T - \frac{v_{DS}}{2}\right)v_{DS}$

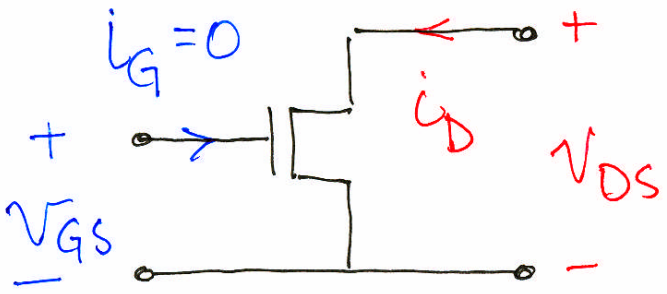
$v_{DS} = v_{GS} - V_T$

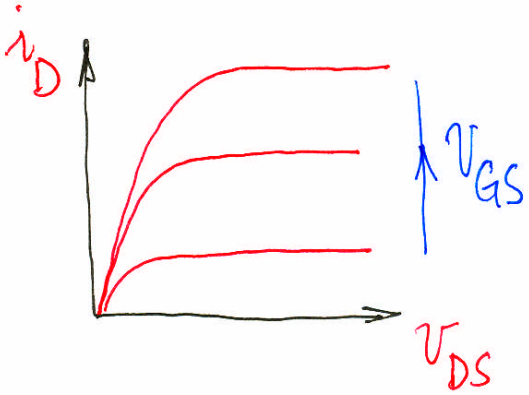
$i_D = \frac{K}{2} v_{DS}^2$



Also, $i_G \equiv 0$!

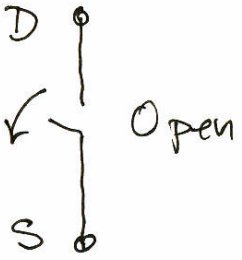
MOSFET Summary





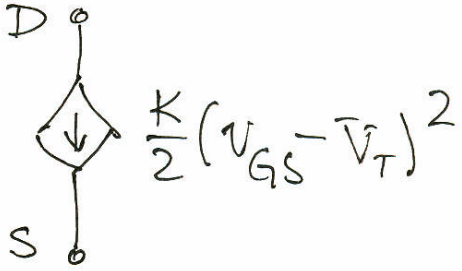
Cut-off

$v_{GS} - V_T \leq 0$



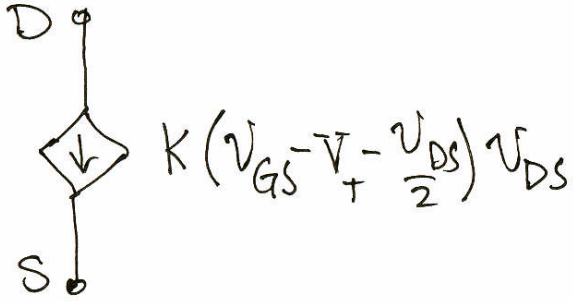
Saturation

$0 \leq v_{GS} - V_T \leq v_{DS}$



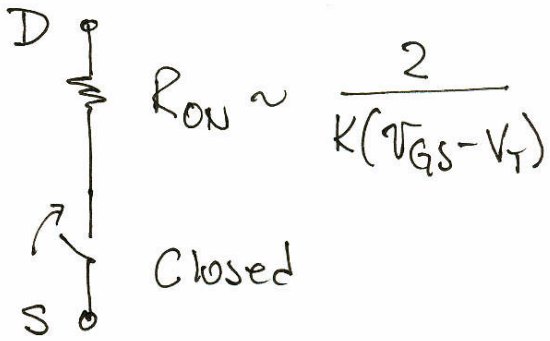
Triode (Amp)

$v_{DS} \leq v_{GS} - V_T$

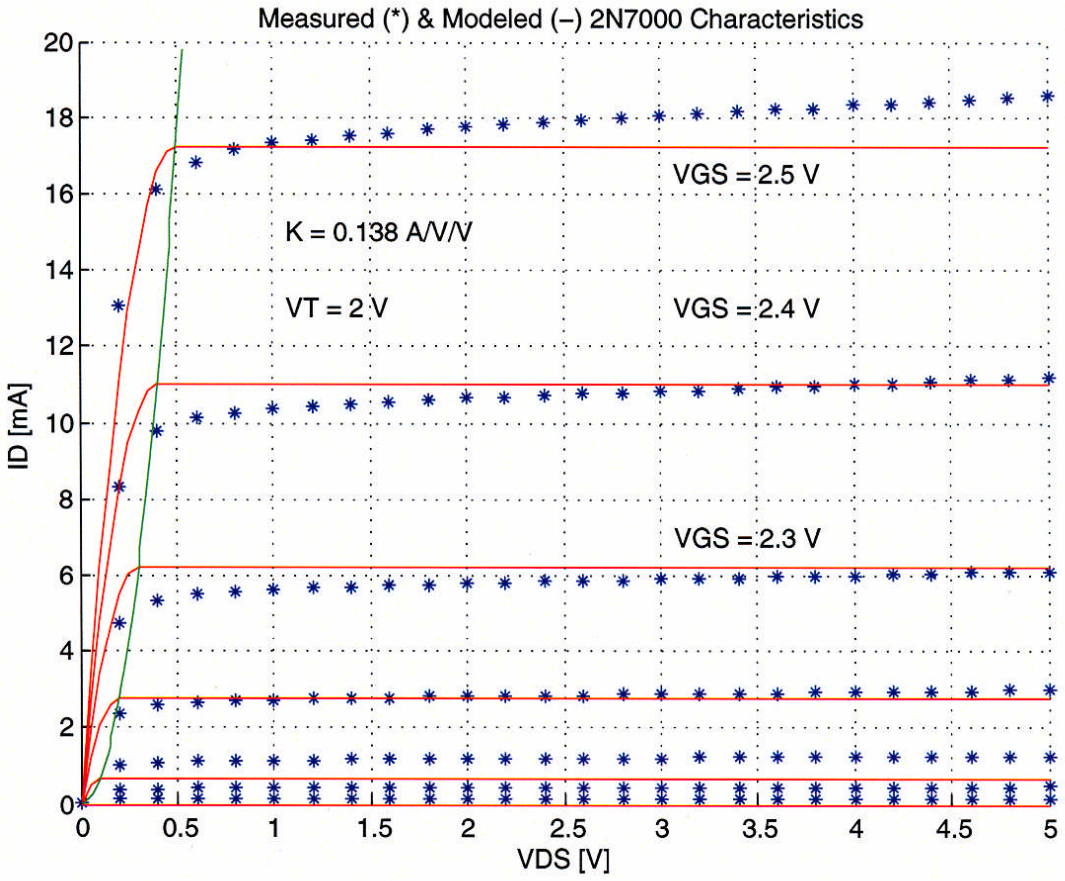


Triode (Logic)

$v_{DS} \leq v_{GS} - V_T$



iLab MOSFET Data



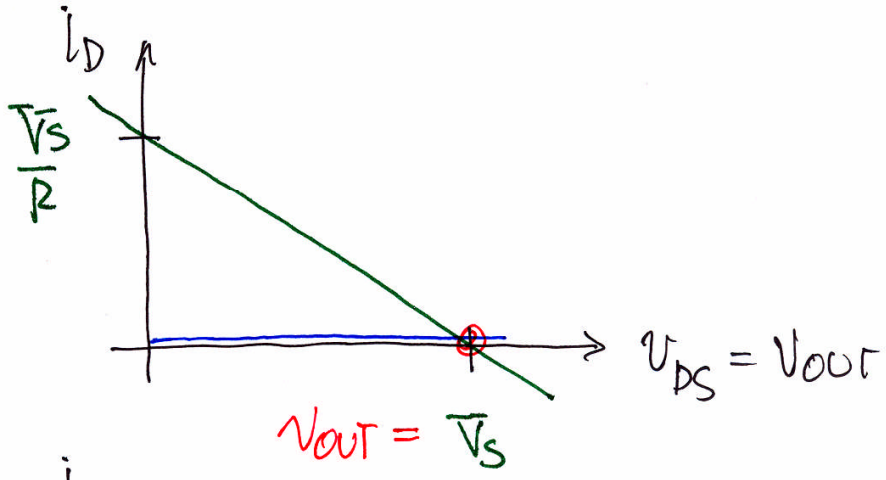
Graphical Analysis III

Cut-Off Region

$v_{GS} - V_T \leq 0$

$\uparrow$

v_{IN}

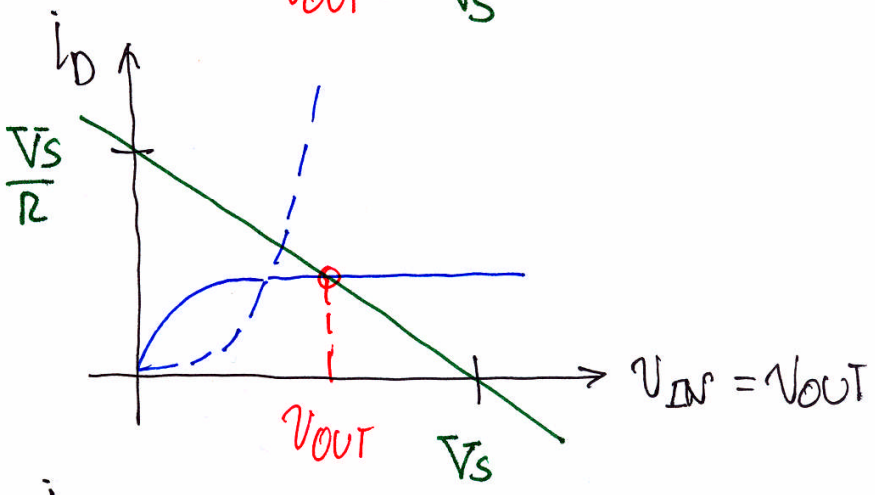


Saturation Region

$0 \leq v_{GS} - V_T \leq v_{DS}$

$\uparrow$

v_{IN}

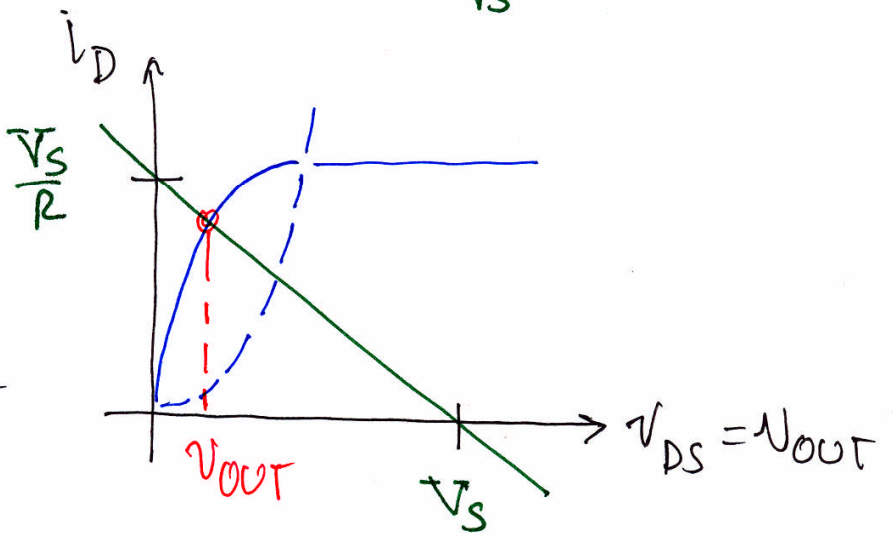


Triode Region

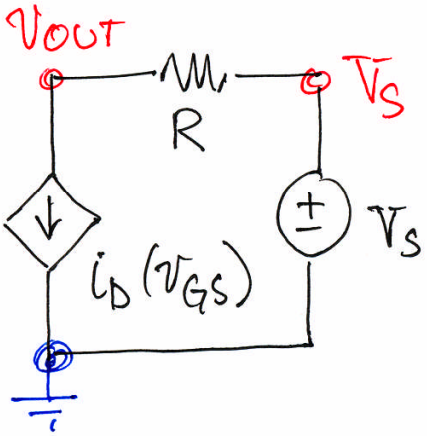
$v_{DS} \leq v_{GS} - V_T$

$\uparrow$

v_{IN}



Saturation Region:



$$i_D = \frac{K}{2}(v_{GS} - V_T)^2 \qquad (v_{IN} \downarrow)$$

$$\frac{v_{OUT} - V_S}{R} + \frac{K}{2}(v_{IN} - V_T)^2 = 0$$

$$v_{OUT} = V_S - \frac{RK}{2}(v_{IN} - V_T)^2$$

Boundaries:

$$v_{DS} \geq v_{GS} - V_T \geq 0$$

$$v_{OUT} \geq v_{IN} - V_T \geq 0$$

Triode: $v_{OUT} \geq v_{IN} - V_T$; Cut-off: $v_{IN} - V_T \geq 0$

$$\frac{\sqrt{2RKV_S + 1} - 1}{RK} \geq v_{IN} - V_T \geq 0$$

$$\frac{\sqrt{2RKV_S + 1} - 1}{RK} \leq v_{OUT} \leq V_S$$

Triode/Saturation Boundary $\Rightarrow$

$$v_{OUT} = v_{IN} - V_T$$

$$v_{OUT} = V_S - \frac{RK}{2} v_{OUT}^2$$

$$v_{OUT} = \frac{\sqrt{2RKV_S + 1} - 1}{RK}$$

Closed-Form Analysis