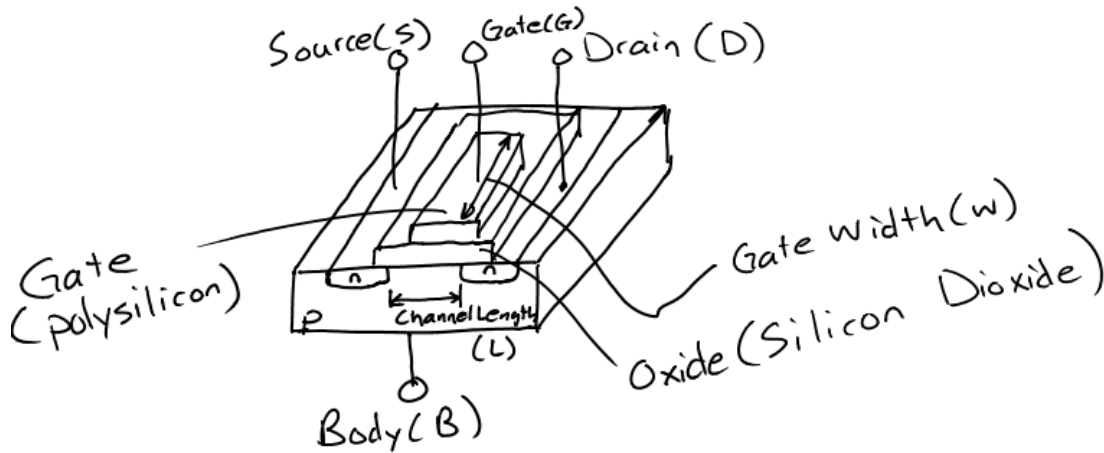


Field Effect Transistors (FET's)

- Used in Amplifiers and switches
- Two main types: The Metal Oxide Field Effect Transistor (MOSFET) and Junction Field Effect Transistor (JFET)

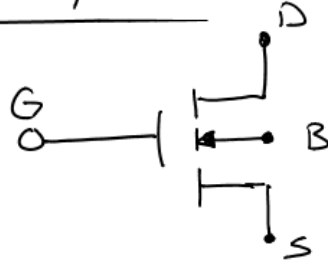
The n-channel Enhancement Mode MOSFET



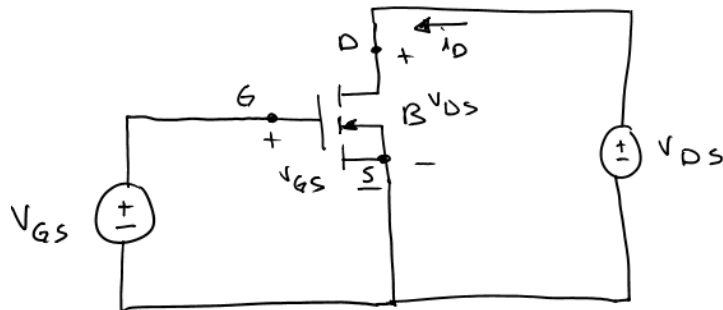
- Terminals
- Source (S)
 - Gate (G)
 - Drain (D)
 - Body (B)

Channel Length (L) \Rightarrow 0.2 to 10 μm
 Width (w) \Rightarrow 0.05 to 0.1 μm

Circuit Symbol



- Three Characteristic Regions: Cutoff, Triode, and Saturation
- Two pn-junctions: Body-Drain and Body-Source



- Cutoff Region

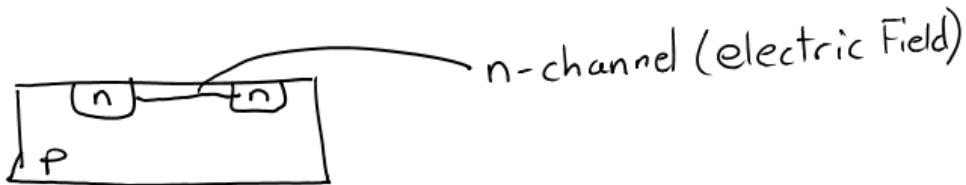
- Reverse bias caused by V_{DS}

$i_D = 0$ for $V_{GS} \leq V_{to}$
 Threshold Voltage
 (Material Property)

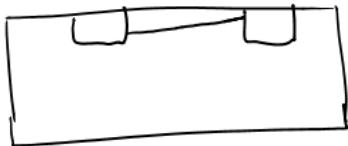
- Triode Region

- V_{GS} exceeds the threshold voltage

- An electric field is formed between the two n-type layers (Drain and Source)



- As V_{DS} increases, the channel pinches down on the drain, which results in i_D increasing more slowly



- Characteristic Equation

$$i_D = K \left[2(V_{GS} - V_{to})V_{DS} - V_{DS}^2 \right]$$

$V_{GS} > V_{to}$
 $V_{DS} < V_{GS} - V_{to}$

$$K = \left(\frac{W}{L} \right) \frac{KP}{2}$$

Gate Width
 channel Length
 One Variable

$$KP = \mu_n C_{ox}$$

Surface mobility
 Capacitance of the gate per unit area

For n-channel enhancement devices

$$KP = 50 \mu A / V^2$$

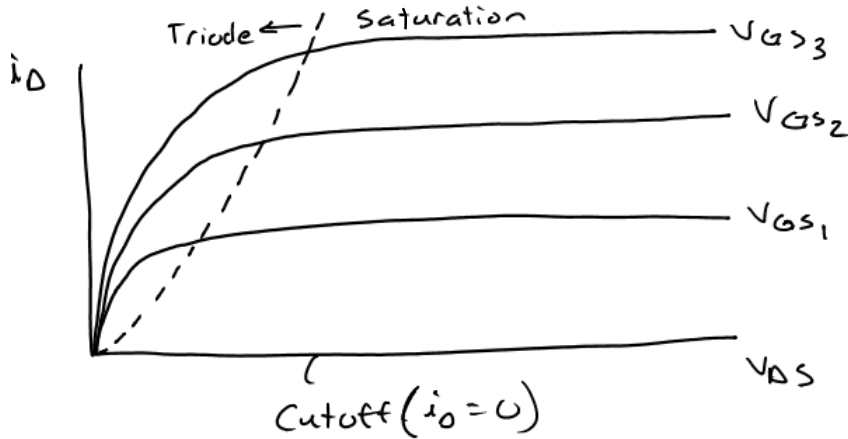
- Saturation Region

- v_{DS} exceeds the excess gate voltage ($v_{GS} - v_{t0}$)
- Characteristic Equation

$$i_D = K (V_{GS} - V_{t0})^2$$

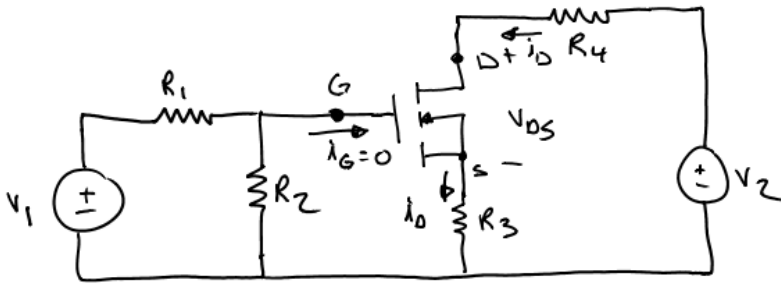
$$\begin{aligned} V_{GS} &> V_{t0} \\ v_{DS} &\geq V_{GS} - V_{t0} \end{aligned}$$

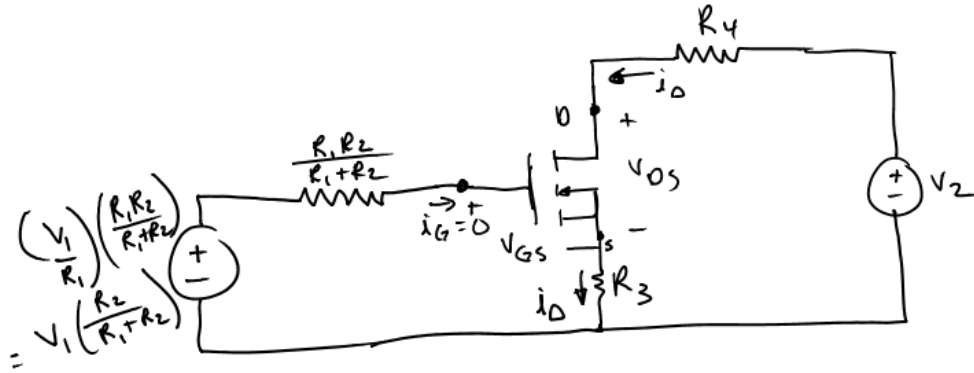
Graph of the MOSFET Characteristic Equations



Fixed-Plus Self-Bias Circuit

- Operates in the Saturation Region
- $i_G = 0$





KVL (Left)

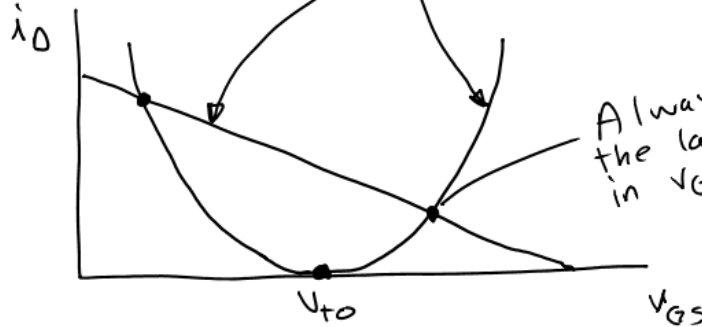
$$-V_1 \left(\frac{R_2}{R_1 + R_2} \right) + V_{GS} + i_D (R_3) = 0$$

Saturation Region

$$i_D = K (V_{GS} - V_{to})^2$$

Unknowns V_{GS}, i_D

Two Equations



KVL (Right, ccw)

$$-V_2 + i_D (R_4) + v_{DS} + i_D R_3 = 0$$

Check for Saturation

$$V_{GS} > V_{to}$$

$$v_{DS} \geq V_{GS} - V_{to}$$