

# Lecture 14

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- Metal-Oxide Semiconductor Field-Effect Transistor (MOSFET)
  - Extremely high impedance looking into the gate
    - \*  $I_G \approx 0$
  - Body is often connected to the source or to ground (substrate)
  - Cutoff Region
    - \*  $V_{GS} < V_{to}$ 
      - $V_{to}$  is the threshold voltage (technology-dependent parameter: .3[V] (new)  
- 2[V] (older))
    - \*  $I_D = 0$
  - Triode Region
    - \*  $V_{GS} > V_{to}$  and  $V_{DS} < V_{GS} - V_{to}$
    - \* Also called “linear region”
      - $I_D \propto V_{GS}$  when  $V_{DS}$  is small
      - Voltage-controlled resistance (between drain and source terminals)
  - Saturation Region
    - \*  $V_{GS} > V_{to}$  and  $V_{DS} > V_{GS} - V_{to}$
    - \*  $I_D = K(V_{GS} - V_{to})^2$  (desired mode for amplifiers)
  - Drain-Source Current:

$$I_D = \left(\frac{W}{L}\right) \left(\frac{KP}{2}\right) [2(V_{GS} - V_{to})V_{DS} - V_{DS}^2] [1 + \lambda V_{DS}]$$

- \* Parameters:
  - $L$  is the channel length,  $W$  is the channel width
  - $KP = \mu_n C_{ox} = \mu_n (\epsilon_{ox}/t_{ox})$
  - $\mu_n$  is the mobility of the electrons in the channel

- $C_{ox}$  is the oxide capacitance per unit area
  - $K = (W/L)(KP/2)$  has units of ampères per square volt
  - $\lambda$  is the channel length modulation parameter ( $\lambda = 0$  in many hand-based calculation estimates)
- Boundary between triode and saturation regions:

$$I = \left(\frac{W}{L}\right) \left(\frac{KP}{2}\right) V_{DS}^2$$