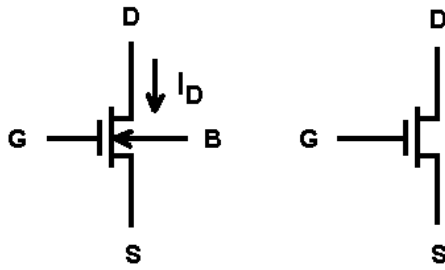
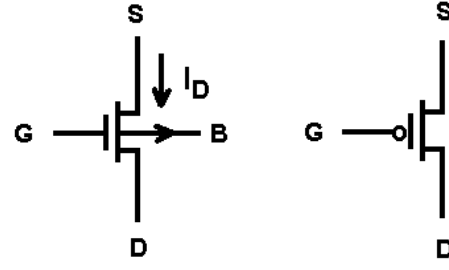


# MOS transistor

NMOS



PMOS



$V_{GS} < V_t \rightarrow I_D = 0$  NMOS in cutoff region

$V_{GS} > V_t, V_{GS} - V_t > V_{DS} \rightarrow I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} [2(V_{GS} - V_t)V_{DS} - V_{DS}^2]$  NMOS in linear region

$V_{GS} > V_t, V_{GS} - V_t < V_{DS} \rightarrow I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_t)^2 (1 + \lambda V_{DS})$  NMOS in saturation region

$k_n = \mu_n C_{ox} \frac{W}{L}$  transconductance parameter [A/V<sup>2</sup>]

$k_n' = \mu_n C_{ox}$  process transconductance parameter [A/V<sup>2</sup>]

$\mu_n$ : electron mobility [cm<sup>2</sup>/V·s]

$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} = \frac{3.9\epsilon_0}{t_{ox}}$  oxide capacitance per unit area [F/cm<sup>2</sup>]

$\epsilon_{ox}$ : dielectric constant of SiO<sub>2</sub> [F/cm]

$\epsilon_0 = 8.85 \cdot 10^{-14}$  F/cm dielectric constant of vacuum

$t_{ox}$ : oxide thickness [nm]

W, L: channel length and width [μm]

$\lambda$ : channel modulation factor [V<sup>-1</sup>]

$r_o = \frac{1}{\lambda I_D}$  output resistance [Ω]

$V_t = V_{to} + \gamma [\sqrt{V_{SB} + 2|\phi_F|} - \sqrt{2|\phi_F|}]$  threshold voltage [V]

$V_{to}$ : threshold voltage for  $V_{SB}=0$  [V]

$\gamma$ : body factor [V<sup>1/2</sup>]

$\phi_F$ : Fermi potential [V]