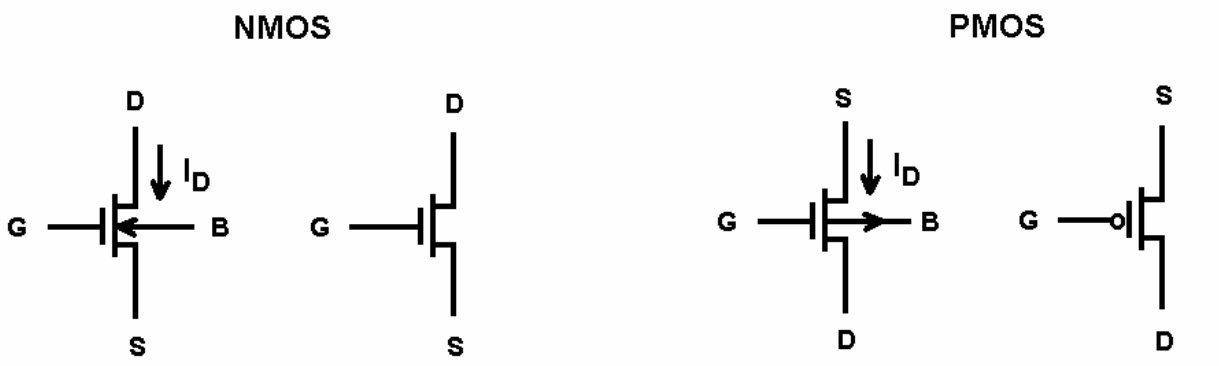
MOS transistor



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

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

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

$k_n = \mu_n C_{ox}\frac{W}{L}$ transconductance parameter [A/V²]

$k_n' = \mu_n C_{ox}$ process transconductance parameter [A/V²]

μ_n: electron mobility [cm²/V·s]

$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.9\varepsilon_0}{t_{ox}}$ oxide capacitance per unit area [F/cm²]

ε_{ox}: dielectric constant of SiO_2 [F/cm]

$\varepsilon_0 = 8.85 * 10^{-14}$ F/cm dielectric constant of vacuum

t_{ox}: oxide thickness [nm]

W, L: channel length and width [μm]

λ: channel modulation factor [V⁻¹]

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

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

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

γ: body factor [V^1/2]

ϕ_F: Fermi potential [V]