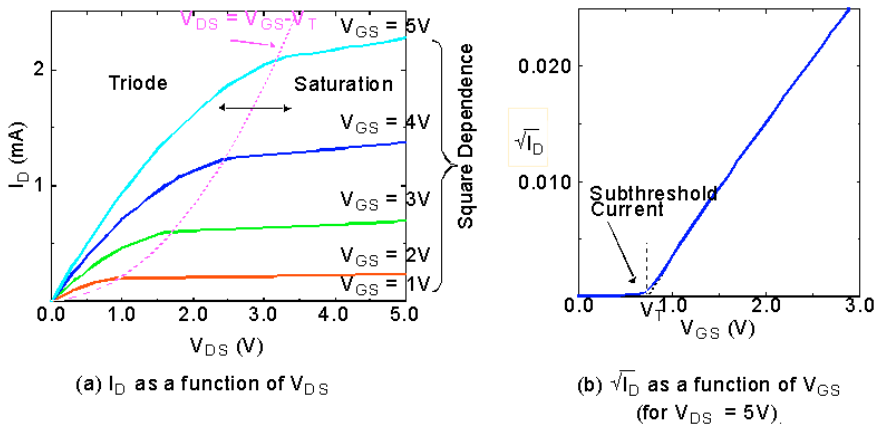
MOS transistor (3)

- As a voltage is applied between the source and drain, the inversion layer becomes thinner at the drain terminal due to interaction between V_G and V_D.
- If $V_{DS} < V_{GS} - V_T$, then the drain current Id is a function of both V_{GS} and V_{DS}. Furthermore, for a given V_{DS}, I_D increases linearly with $(V_{GS} - V_T)$. The transistor is said to be operating in its **linear** or **resistive** region.
- If $V_{DS} > V_{GS} - V_T$, then $V_{GS} < V_T$ and no inversion layer can exist at the drain terminal. The channel is said to be '***pinched-off***'. The transistor is operating in the **saturation** region, where the drain current is dependent on V_{GS} and is almost independent of V_{DS}.

I-V Relation

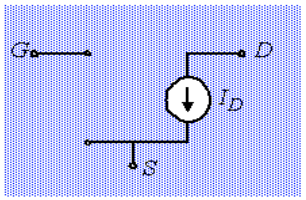


(a) I_D as a function of V_{DS}

(b) $\sqrt{I_D}$ as a function of V_{GS} (for V_{DS} = 5V)

NMOS Enhancement Transistor: W = 100 μm, L = 20 μm

A model for manual analysis



$$V_{DS} > V_{GS} - V_T$$

$$I_D = \frac{k'_n}{2}\frac{W}{L}(V_{GS} - V_T)^2(1 + \lambda V_{DS})$$

$$V_{DS} < V_{GS} - V_T$$

$$I_D = k'_n \frac{W}{L}\left((V_{GS} - V_T)V_{DS} - \frac{V_{DS}^2}{2}\right)$$

with

$$V_T = V_{T0} + \gamma\left(\sqrt{|-2\phi_F + V_{SB}|} - \sqrt{|-2\phi_F|}\right)$$

Dynamic Behavior of MOS Transistor