

CMOS Transistor Switching

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Simple Transistor Model (1)

Cutoff, subthreshold, or weak-inversion mode

When $V_{GS} < V_t$:

$$I_d = 0$$

Triode mode or linear region (the ohmic mode)

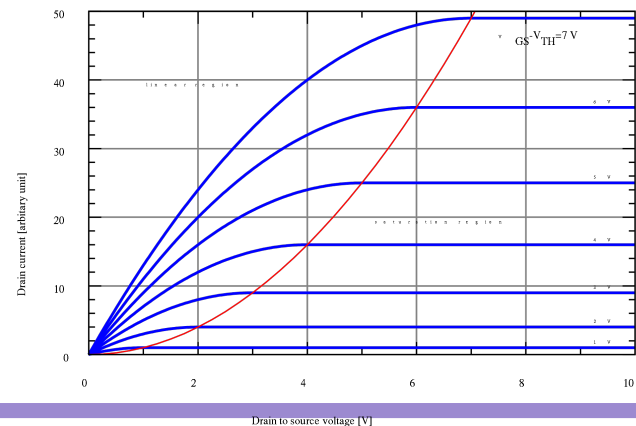
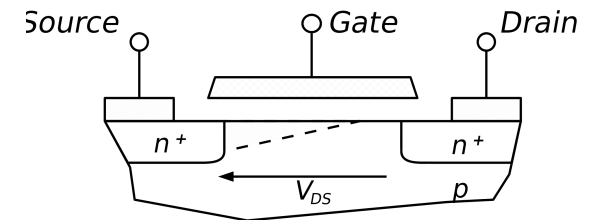
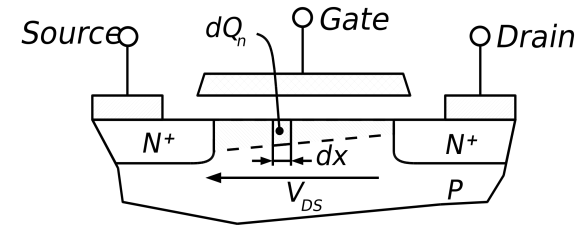
When $V_{GS} > V_t$ and $V_{DS} < (V_{GS} - V_t)$

$$I_d = k' \frac{W}{L} \left[(v_{gs} - v_t) v_{ds} - \frac{1}{2} v_{ds}^2 \right]$$

Saturation or active mode

When $V_{GS} > V_t$ and $V_{DS} \geq (V_{GS} - V_t)$

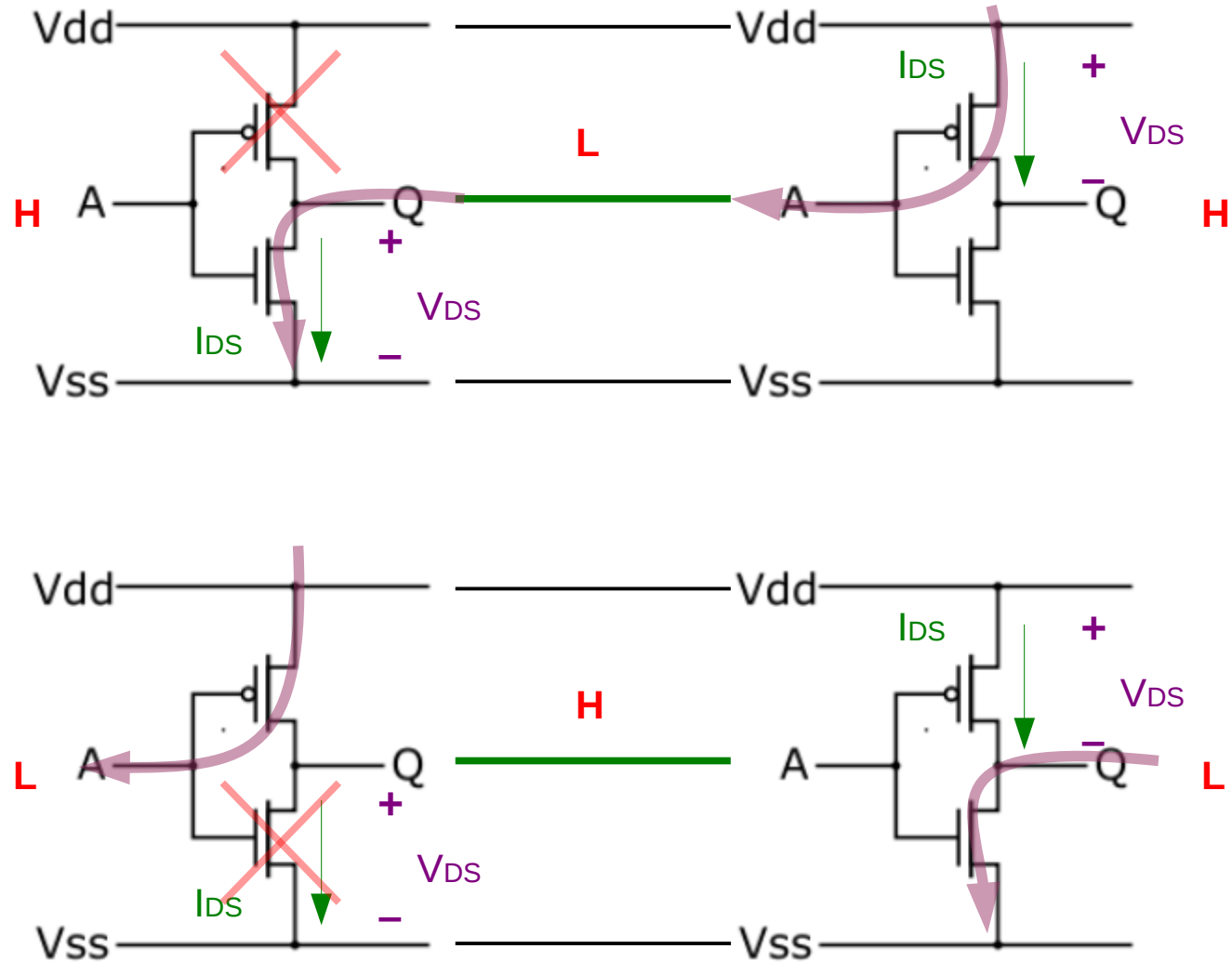
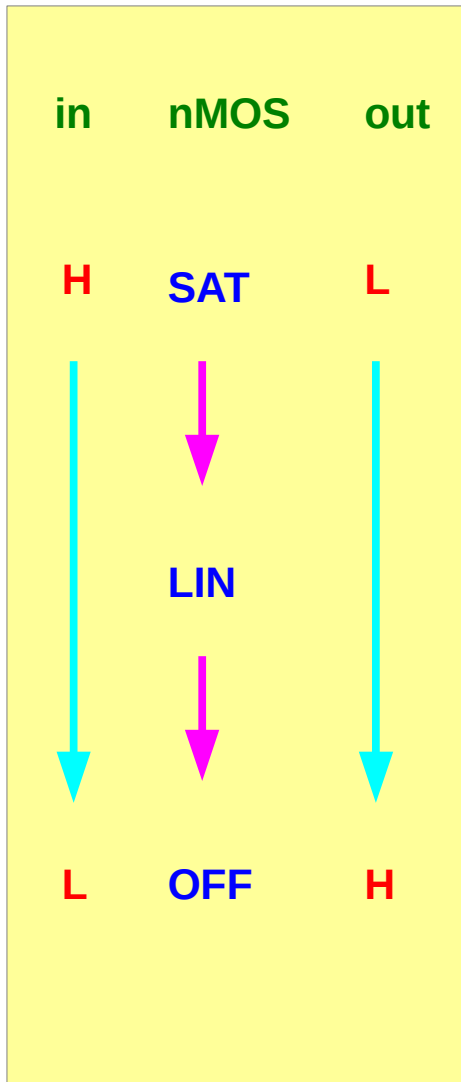
$$I_d = \frac{1}{2} k' \frac{W}{L} (v_{gs} - v_t)^2$$



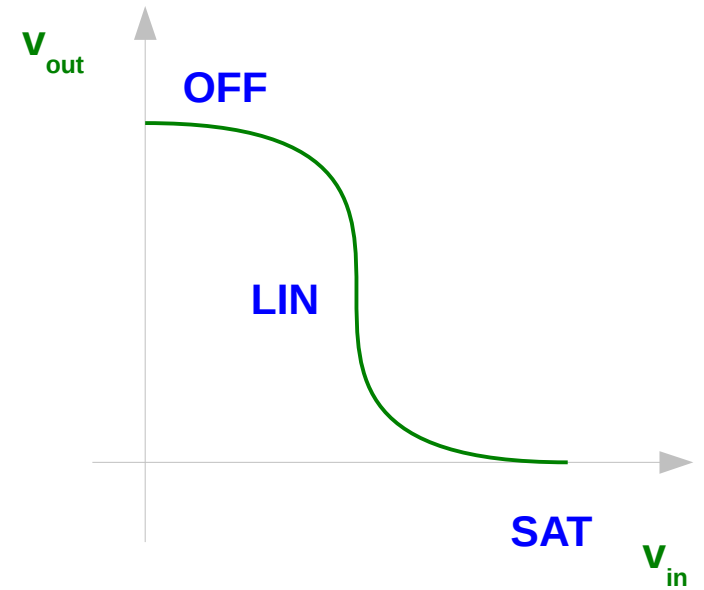
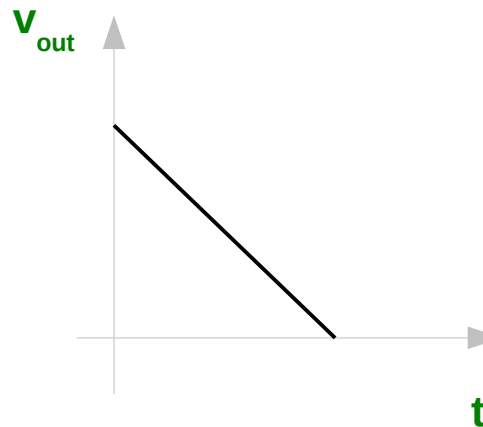
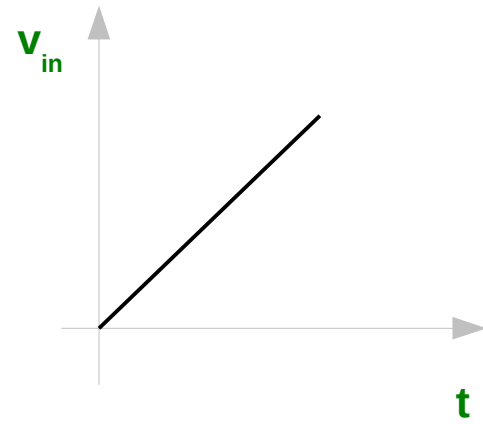
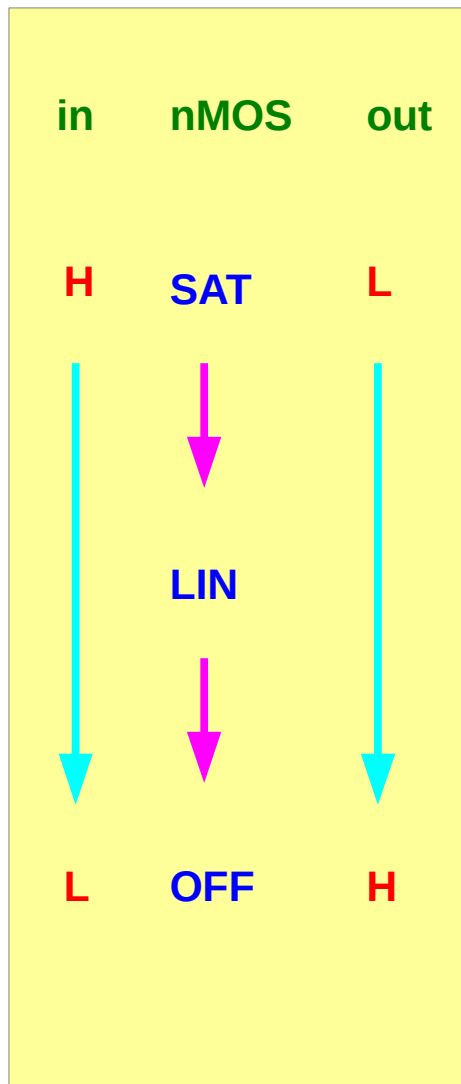
Logic Level

Characteristic Curve

Voltage Transfer Curve (1)



Voltage Transfer Curve (2)



Spice Model

References

- [1] <http://en.wikipedia.org/>
- [2] <http://www.allaboutcircuits.com/>
- [3] W. Wolf, "Modern VLSI Design : Systems on Silicon"
- [4] N. Weste, D. Harris, "CMOS VLSI Design: A Circuits and Systems Perspective"