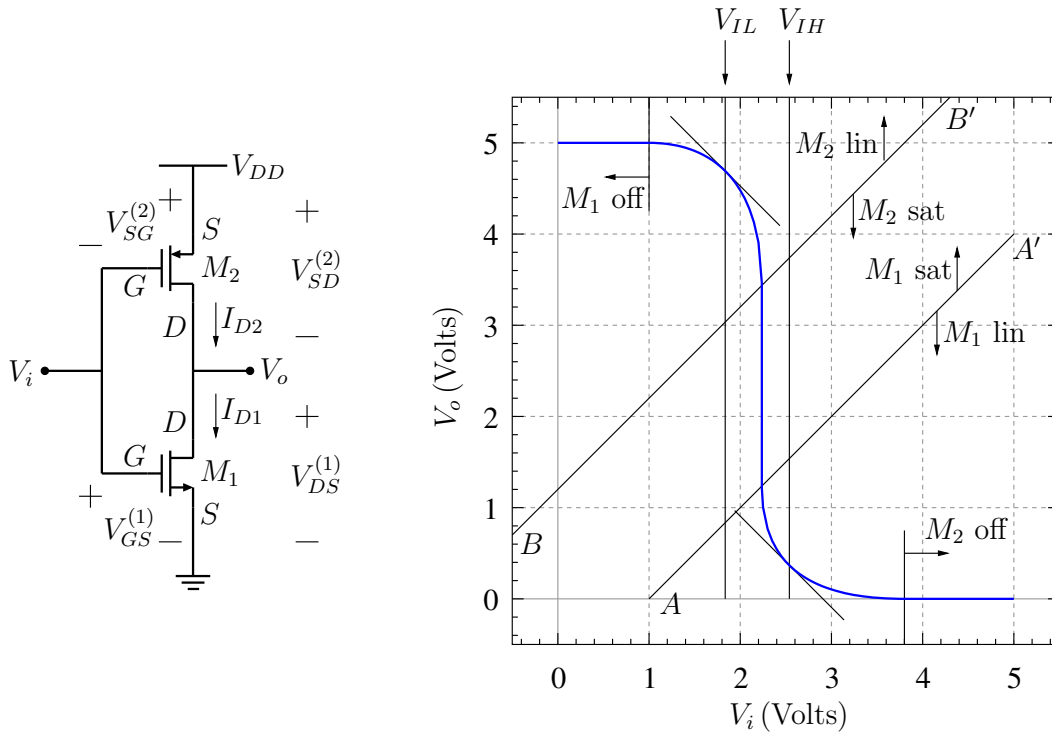


# mos\_inverter\_dc.sqproj



Shown in the figure is a CMOS inverter circuit. Let  $V_{Tn}$  and  $V_{Tp}$  be the threshold voltages of  $M_1$  and  $M_2$ , respectively. If  $V_i < V_{Tn}$ ,  $M_1$  does not conduct, and  $V_o$  gets pulled up to  $V_{DD}$ . When  $V_{DD} - V_i < -V_{Tp}$ , i.e.,  $V_i > V_{DD} + V_{Tp}$ ,  $M_2$  does not conduct<sup>1</sup>, and  $V_o$  gets pulled down to 0V. Between these two limits, both  $M_1$  and  $M_2$  conduct. The modes of operation of the transistors are summarised in the figure for a representative example.

## Exercise Set

1. Plot qualitatively  $I_D$  versus  $V_i$ .
2. How would the  $V_o$  versus  $V_i$  curve change if
  - (a)  $V_{Tn}$  is increased by 0.5 V.
  - (b)  $V_{Tp}$  is increased (in magnitude) by 0.5 V.
  - (c) The width of  $M_1$  is doubled.

<sup>1</sup>Note that  $V_{Tn}$  and  $V_{Tp}$  are the actual values of the threshold voltages, and not the absolute values. Typically  $V_{Tn}$  is positive, and  $V_{Tp}$  is negative.

(d) The width of  $M_2$  is doubled.

(e) The channel length modulation parameter  $\lambda$  is changed from  $0 \text{ V}^{-1}$  to  $0.5 \text{ V}^{-1}$ .

3. Check your answers against simulation results.

## References

1. H. Taub and D. Schilling, *Digital Integrated Electronics*, McGraw-Hill, 1977.
2. M.B. Patil, *Basic Electronic Devices and Circuits*, Prentice-Hall India, 2013.