Outline of Section 1.3

1.1 Analog Amplifiers

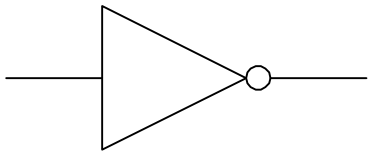
1.2 Frequency Response of Amplifiers

1.3 Digital Logic Inverters

- Voltage transfer characteristic
- Noise margins
- Ideal Inverter

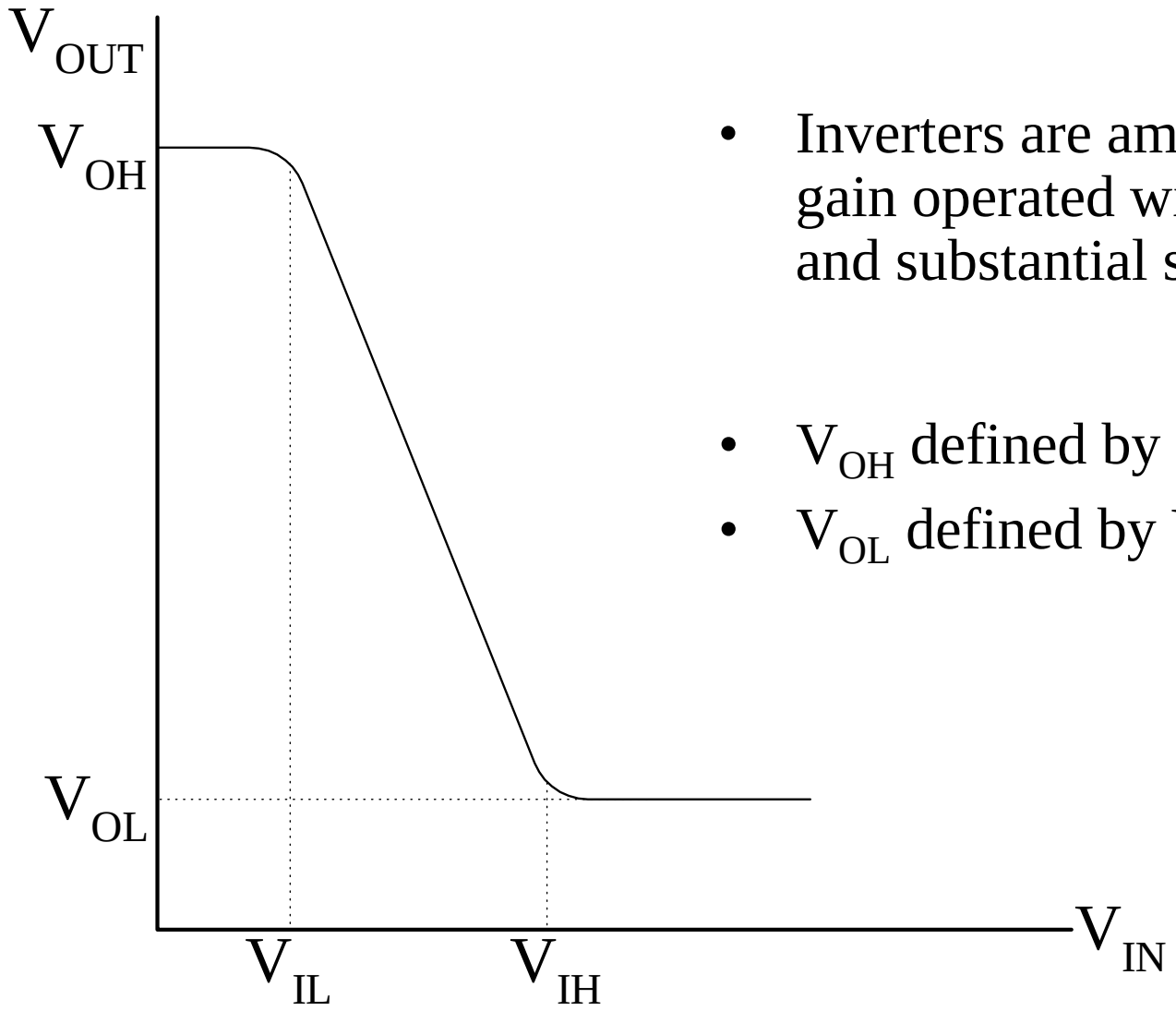
Inverter

- Inverts the logic value of the input signal
  - logical ‘0’ input becomes a logical ‘1’ at the output
  - logical ‘1’ input becomes a logical ‘0’ at the output
- Logic levels represented by voltage magnitudes:
  - $\mathbf{V_{IH}}$: minimum input voltage corresponding to logical ‘1’
  - $\mathbf{V_{IL}}$: maximum input voltage corresponding to logical ‘0’
  - $\mathbf{V_{OH}}$: minimum output voltage corresponding to logical ‘1’
  - $\mathbf{V_{OL}}$: maximum output voltage corresponding to logical ‘0’

Symbol: 

Digital circuits enjoy reduced sensitivity to exact value of the input than their analog amplifier counterparts

Voltage Transfer Characteristic

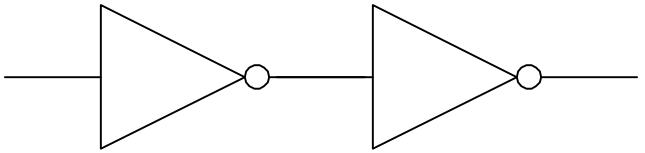


- Inverters are amplifiers with negative gain operated with large signal inputs and substantial signal distortion

- V_{OH} defined by V_{OUT} for $V_{IN} \leq V_{IL}$
- V_{OL} defined by V_{OUT} for $V_{IN} \geq V_{IH}$

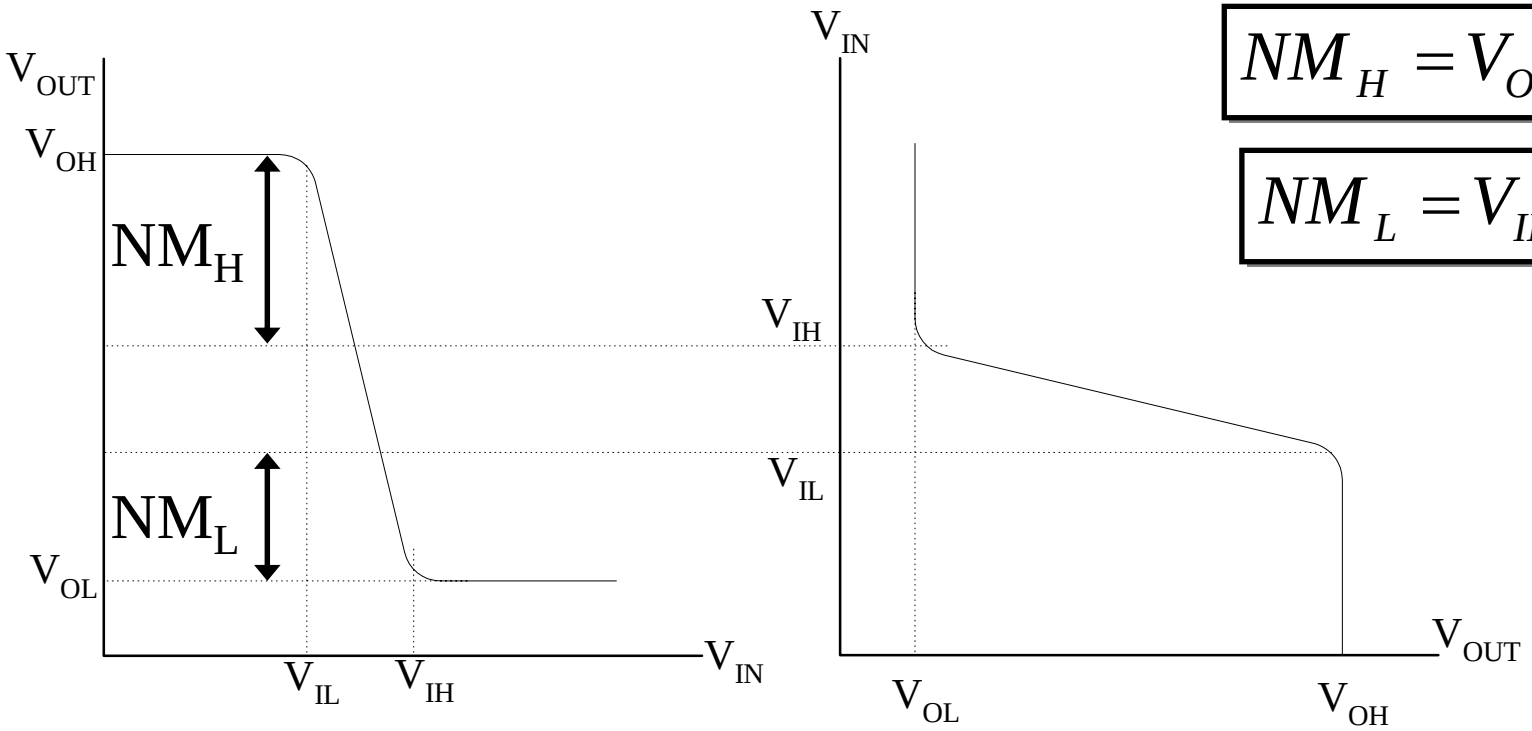
Noise Margins - Cascaded Inverters

- Noise margins a measure of the ability of digital circuits to be cascaded and their sensitivity to noise
- Consider scenario where one inverter drives an identical inverter



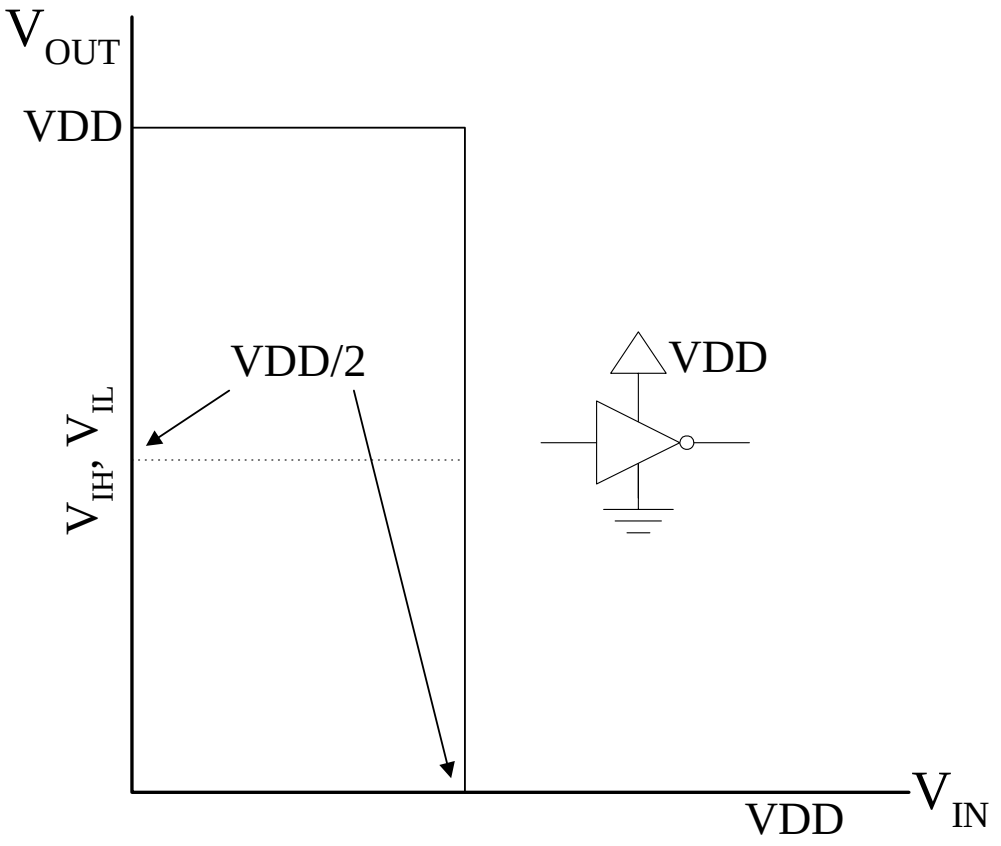
$$NM_H = V_{OH} - V_{IH}$$

$$NM_L = V_{IL} - V_{OL}$$



Ideal Inverter

- The ideal inverter has the following characteristics:
  - Symmetric VTC
  - V_{OH} and V_{OL} correspond to the supply voltages
  - Equal NM_H and NM_L
  - $V_{IH} = V_{IL} = VDD/2$



Corresponds to infinitely steep linear region

Simple Inverter Model

- Fig 1.31 Text book: Voltage controlled switch

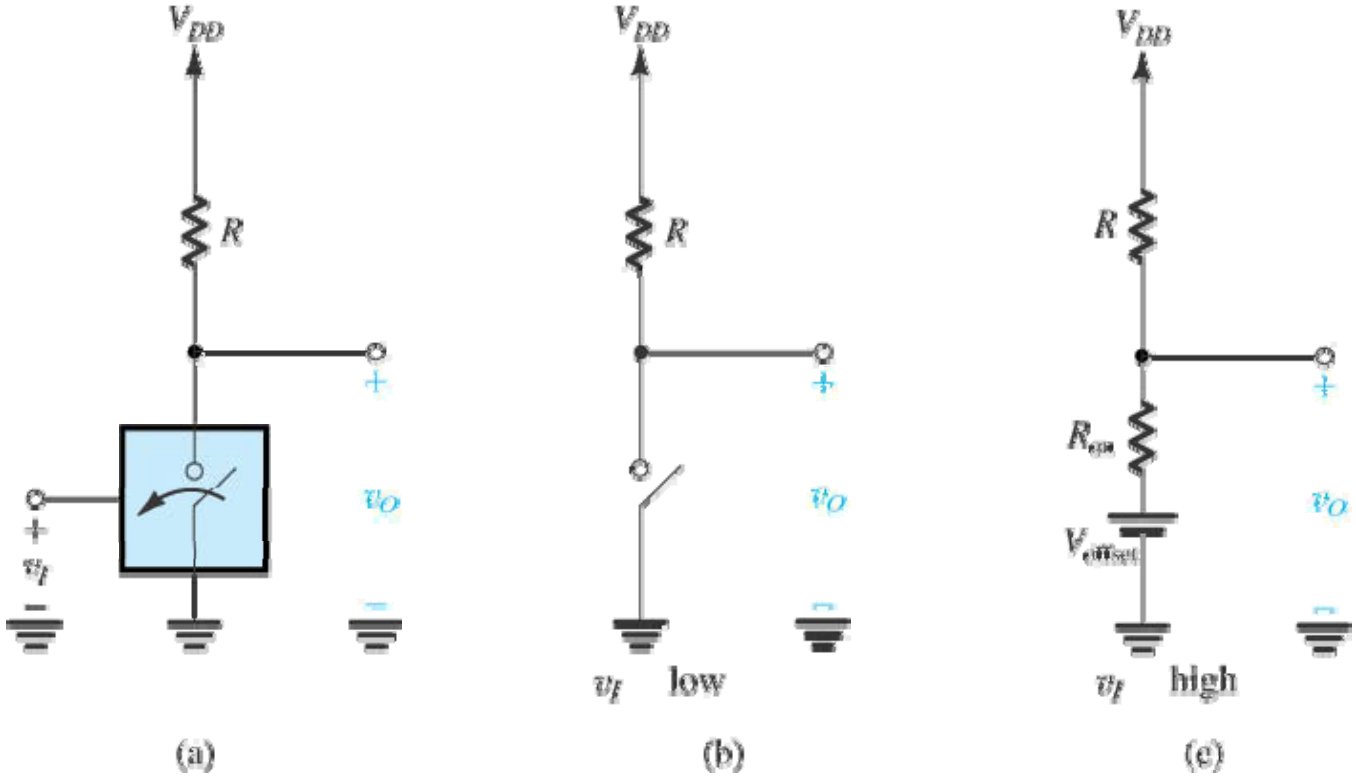
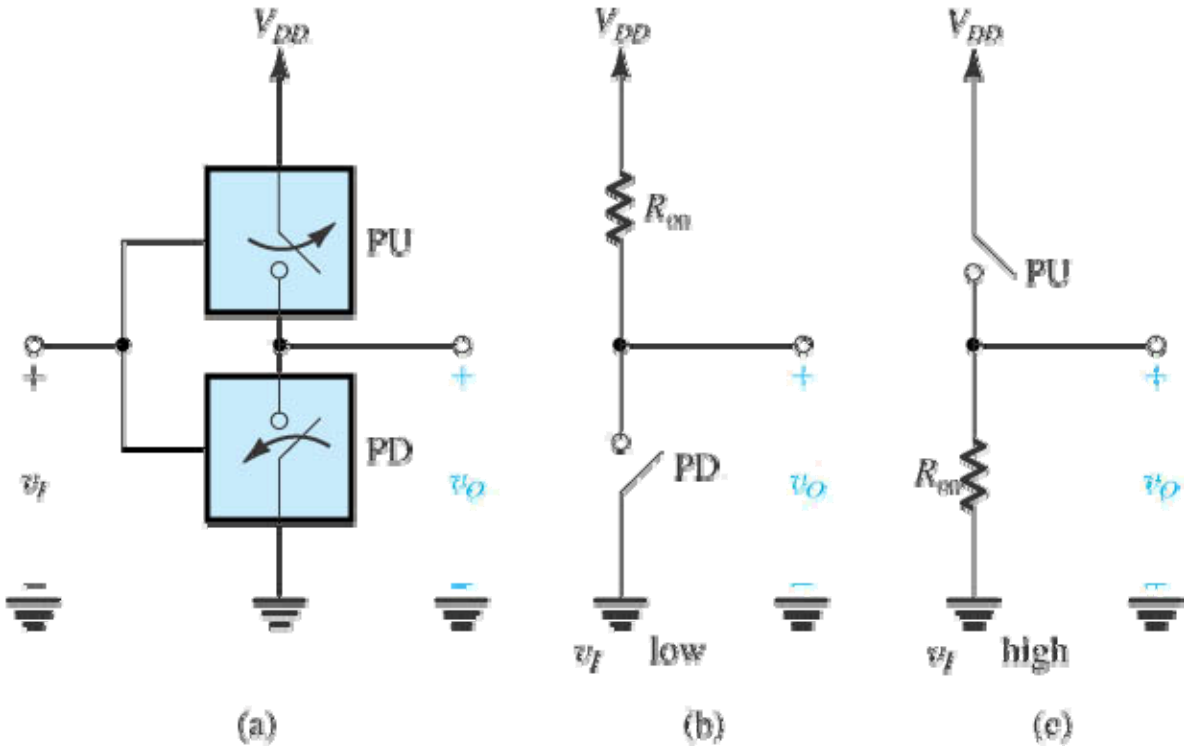


Figure 1.31 **(a)** The simplest implementation of a logic inverter using a voltage-controlled switch; **(b)** equivalent circuit when v_I is low; and **(c)** equivalent circuit when v_I is high. Note that the switch is assumed to close when v_I is high.

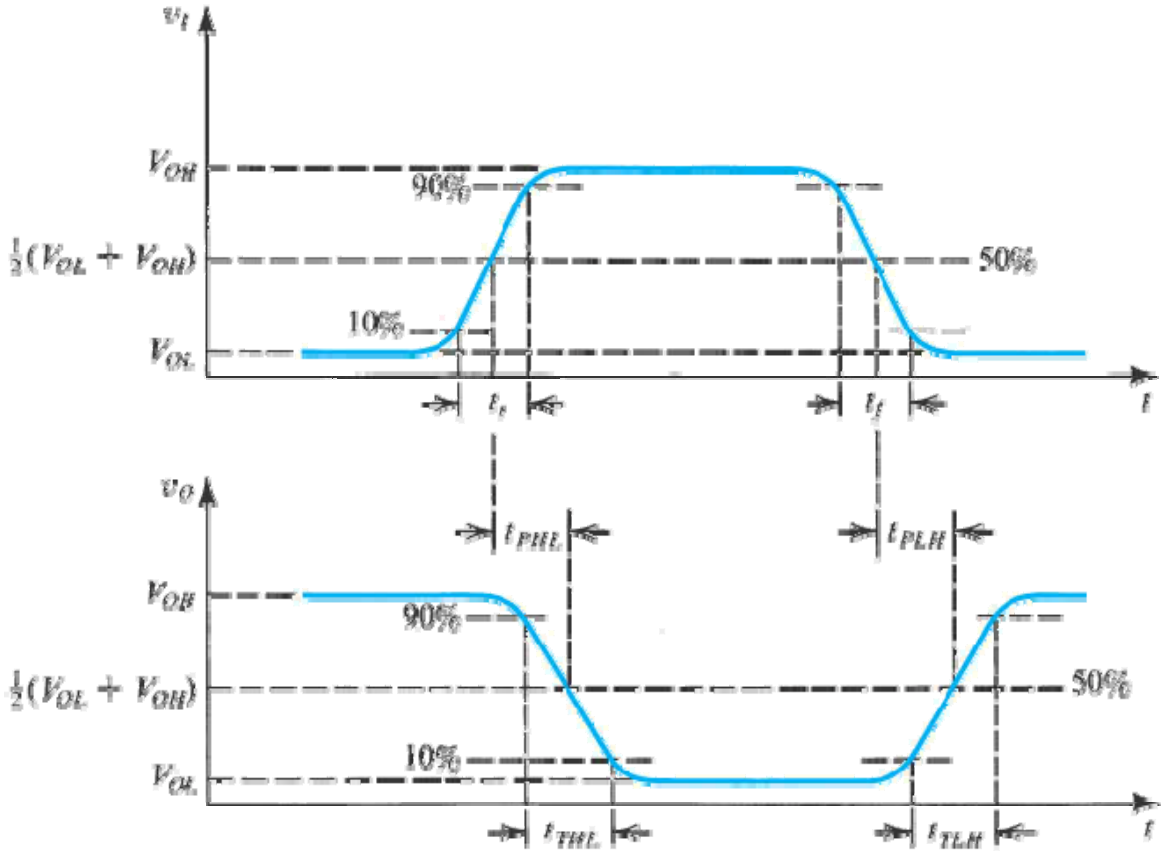
Simple Inverter Model

- Fig 1.32 Text book: Two complementary switches- The basic model for a CMOS inverter



Inverter Timing

- Fig 1.35 Text book: Definitions of propagation delays and transition times of the logic inverter.



1.3 Digital Logic Inverters - Summary

- Basic function of an inverter
- Input and output high and low voltages
- Voltage transfer characteristic of an inverter
- Meaning of noise margins
- Characteristics of an ideal inverter
- Simple inverter model