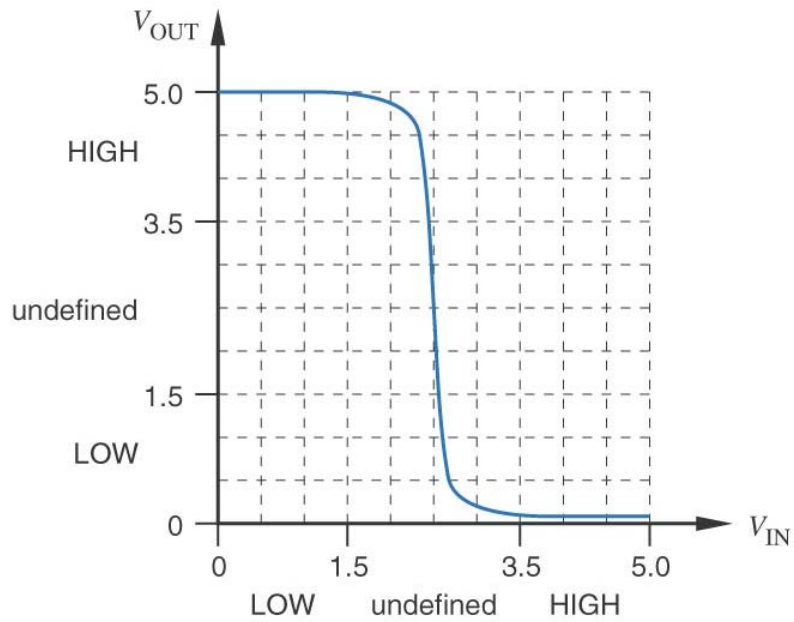
Digital Circuits Characteristics

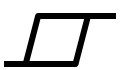


Not guaranteed

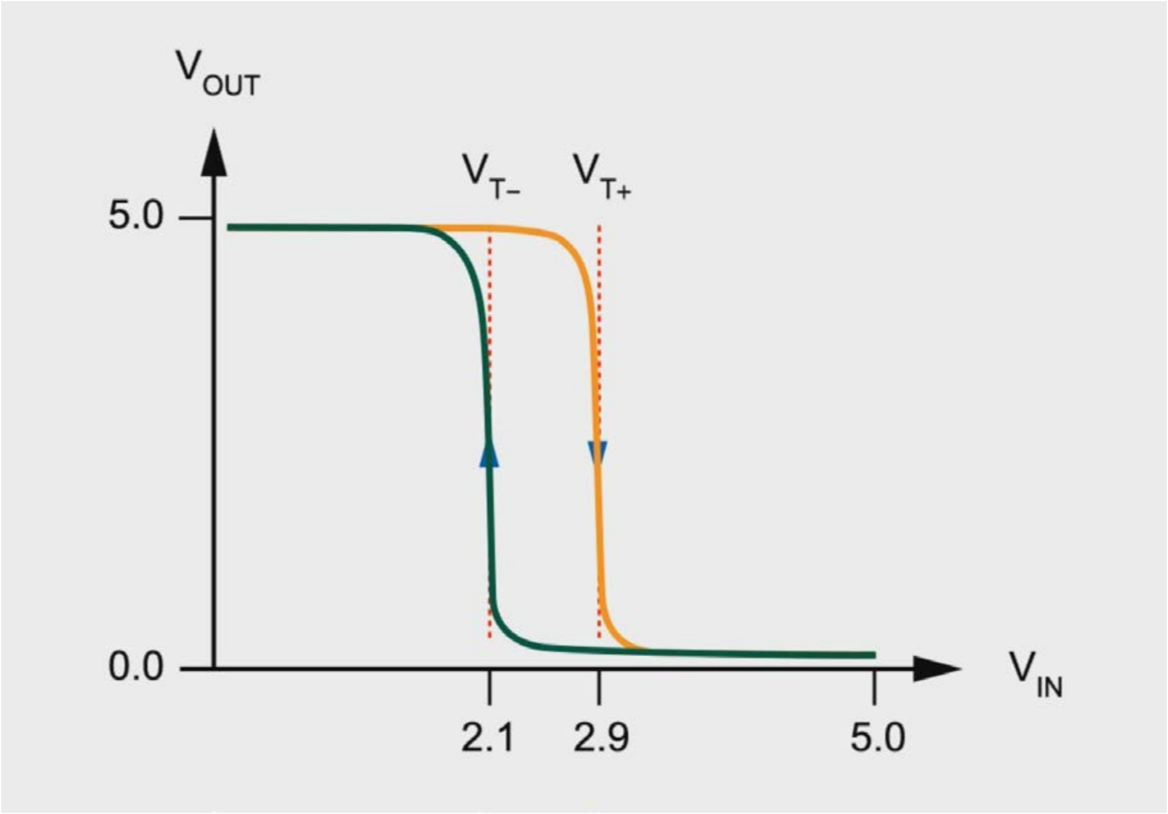
Fig. 3-25 Typical input-output transfer characteristic of a CMOS inverter

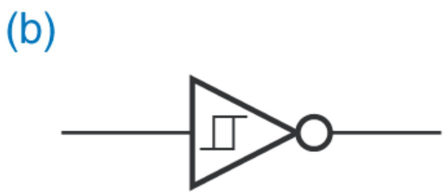
Schmitt-Trigger Inputs

Fig. 3-47

- **A Schmitt-Trigger inverter is characterised by 2 threshold voltages: VT- and VT+**
- **When input voltage V_{IN} rises above VT+, output V_{OUT} will switch to low.**
- **When input voltage V_{IN} drops below VT-, output V_{OUT} will switch to high.**
- **This non-symmetric behaviour is called hysteresis.**
- **The symbol  indicates Schmitt-Trigger input.**

Schmitt-Trigger Inverter





(a) input-output transfer characteristic **(b) logic symbol**

Fig. 3-47 Schmitt-trigger inverter

Schmitt-Trigger Inverter

- Fig. 3-48
- When input voltage (V_{IN}) rises slowly, or has minor fluctuations around VT, a standard inverter will give unstable, fluctuating output.
- The output of a Schmitt-Trigger inverter in such situations has clean transitions and does not fluctuate.

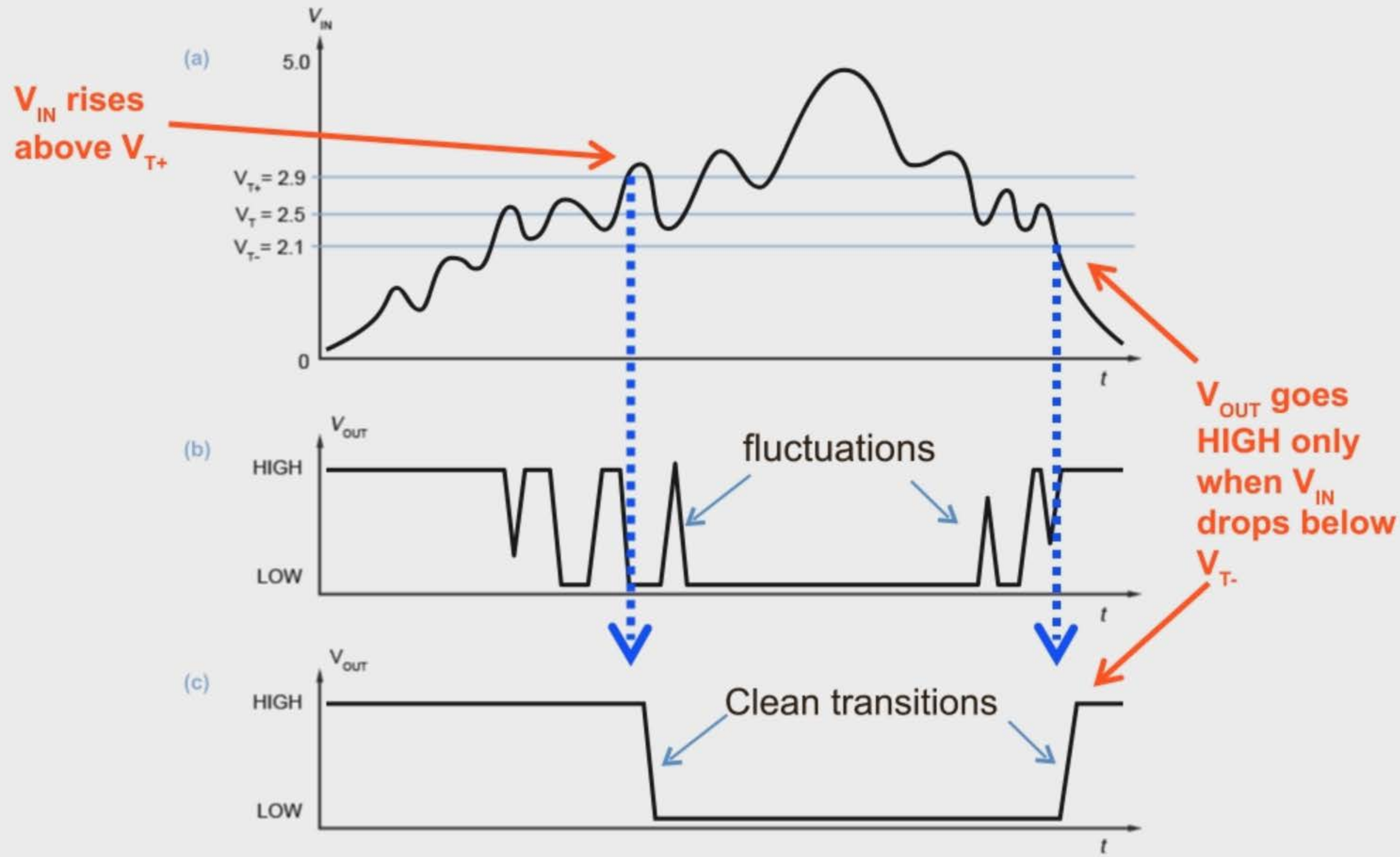


Fig. 3-48 Device operation with slowly changing inputs: (a) a noisy, slowly changing input; (b) output produced by an ordinary inverter; (c) output produced by an inverter with 0.8V of hysteresis.

Combinational PLA

- PLD = Programmable Logic Devices
- Examples are PLA, PAL, CPLD, FPGA
- PLA: Programmable Logic Array
- PAL: Programmable Array Logic
- CPLD: Complex PLD
- FPGA: Field Programmable Gate Array
- SOM/SOP Boolean expressions can be easily implemented on a PLA

PLA Example

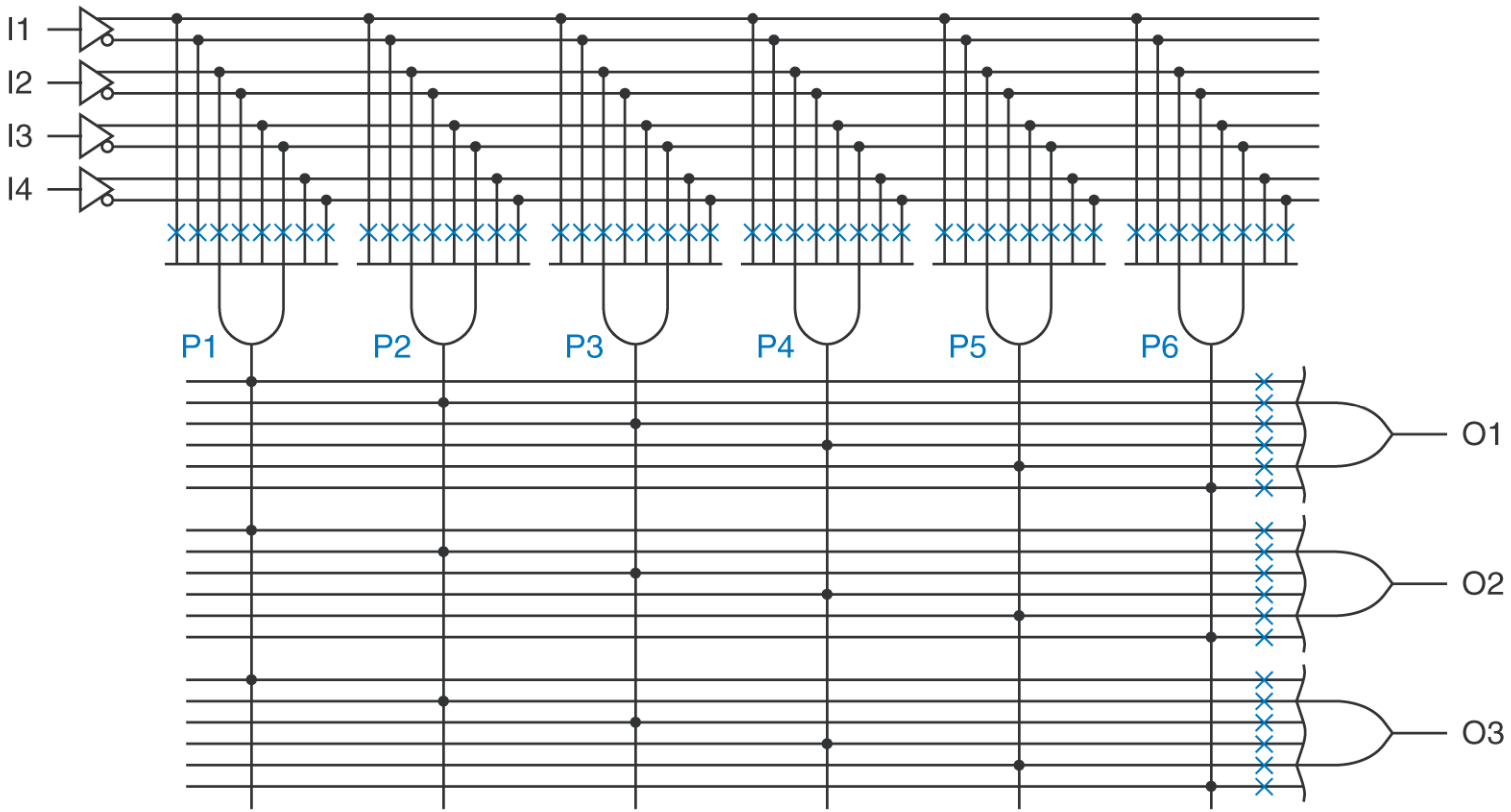


Figure 6-21

A 4 × 3 PLA with six product terms.

X : indicate programmable connections

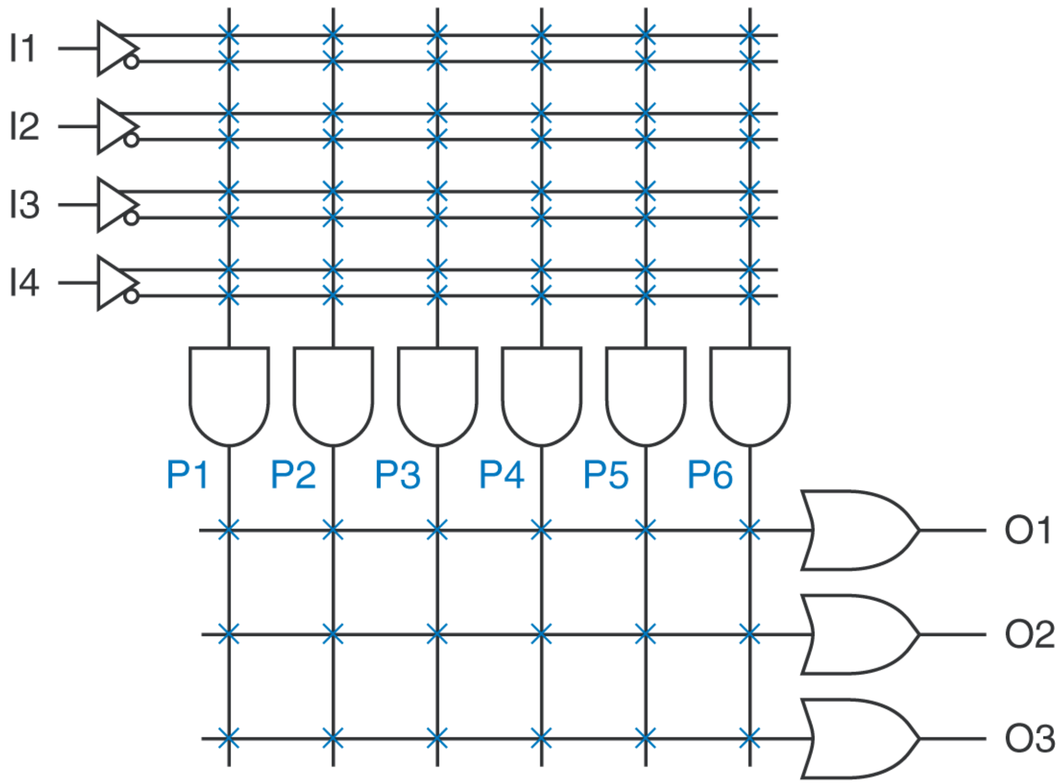
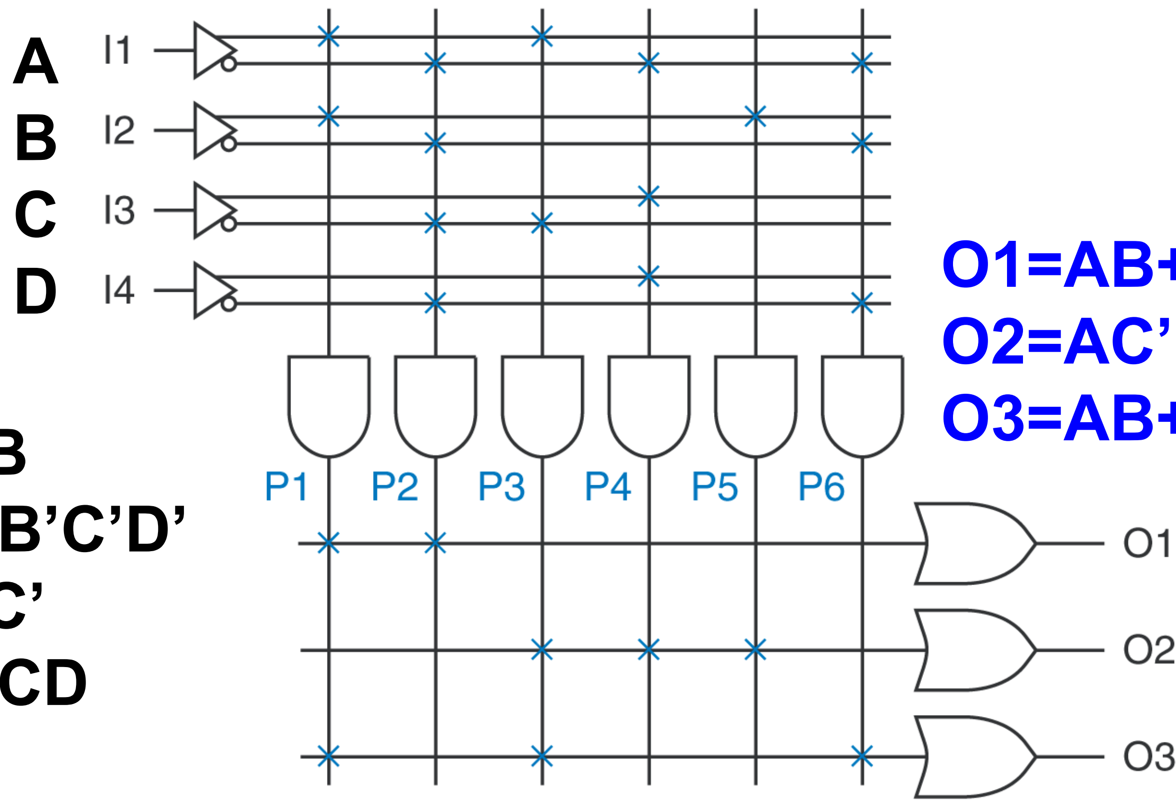


Figure 6-22

Compact representation of a 4 × 3 PLA with six product terms.

From *Digital Design*: *Principles and Practices*, Fourth Edition, John F. Wakerly, ISBN 0-13-186389-4.

PLA Example: SOP implementation



P1=AB
P2=A'B'C'D'
P3=AC'
P4=A'CD
P5=B
P6=A'B'D'

O1=AB+A'B'C'D'
O2=AC'+A'CD+B
O3=AB+AC'+A'B'D'

Figure 6-23

A 4 × 3 PLA programmed with a set of three logic equations.

PLA Example (truth table)

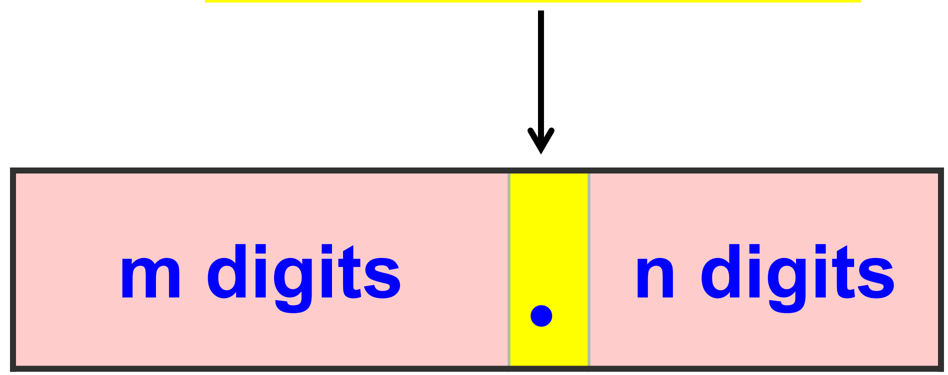
A	B	C	D	O1	O2	O3
0	0	0	0	1	0	1
0	0	0	1	0	0	0
0	0	1	0	0	0	1
0	0	1	1	0	1	0
0	1	0	0	0	1	0
0	1	0	1	0	1	0
0	1	1	0	0	1	0
0	1	1	1	0	1	0
1	0	0	0	0	1	1
1	0	0	1	0	1	1
1	0	1	0	0	1	0
1	0	1	1	0	1	0
1	1	0	0	1	1	1
1	1	0	1	1	1	1
1	1	1	0	1	1	1
1	1	1	1	1	1	1

Fixed-point numbers

Examples:

- 102_{10}
- 123.456_{10}
- $2000.AD_{16}$
- 1001.0101_{2}

The radix point has a fixed position among the integer and fraction digits



- **Fixed-point numbers are usually used for representing integers only**

- **Disadvantages of using fixed-point arithmetic for non-integers:**
  - **relatively small range of numbers that can be represented**
  - **possible loss of significant digits during computation**

Floating-point numbers

Machine equivalent of scientific notation

A floating-point number Z is represented as:

$$S \times R^{E}$$

e.g. 2.99792458×10^{5}

$$S \times R^E$$

Where

- **S is the *significand*, usually a signed fractional fixed-point number**
- **R is the *radix* (e.g. 2 for binary, 8 for octal, 10 for decimal, etc.)**
- **E is the *exponent*, usually a signed fixed-point integer**

Example: the IEEE Standard 754 on floating-point arithmetic

Single precision (32 bits):

bit

31 30 22 0

*	Exponent	Significand (mag)

Double precision (64 bits):

bit

63 62 51 0

*	Exponent	Significand (mag)

- * is the sign bit of significand
- radix is 2
- significand is in sign-magnitude notation
- exponent is in 2’s complement notation