



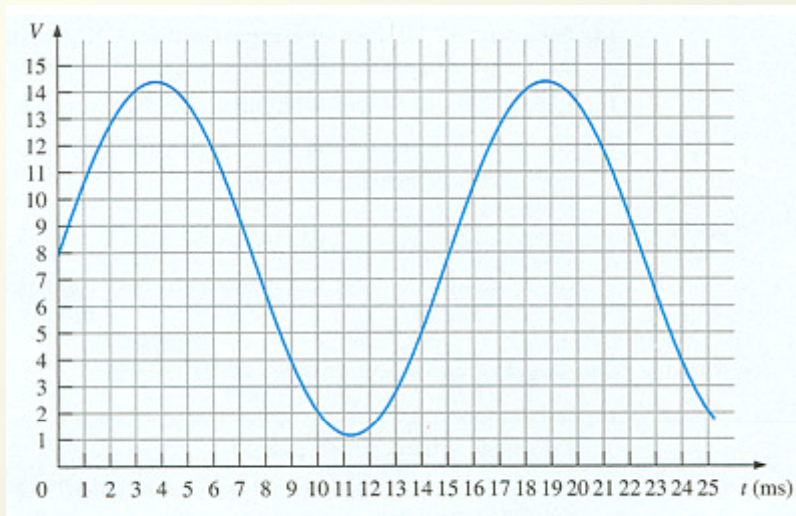
Introduction to Digital Circuits and Design

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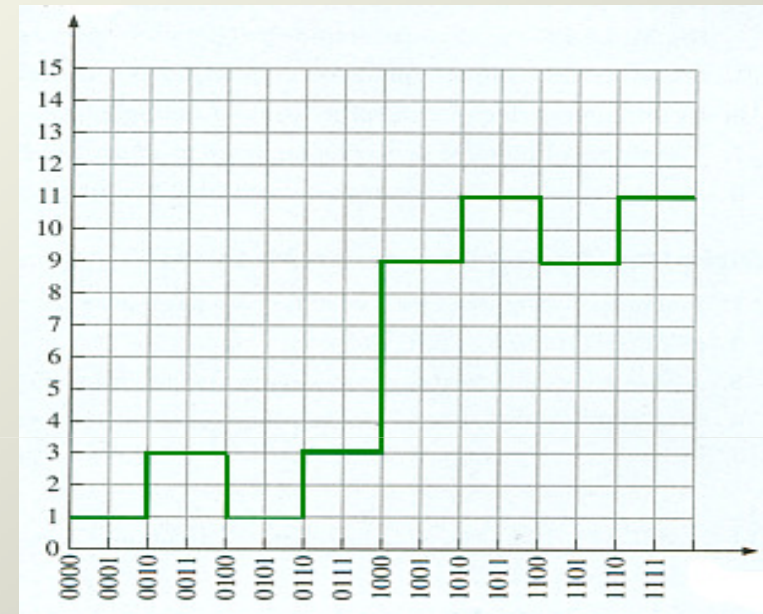
Digital and Analog Quantities

- Analog quantities have continuous values
- Digital quantities have discrete sets of values

Digital and Analog Quantities



Analog quantities
have continuous
values

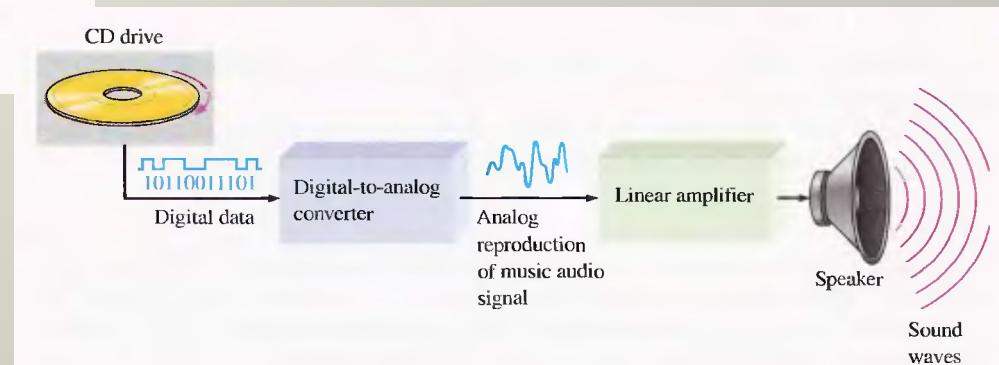
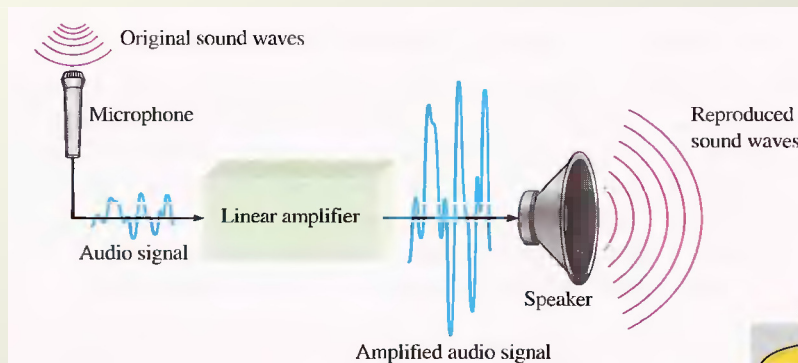


Digital quantities
have discrete
sets of values

Digital and Analog Quantities

Types of electronic devices or instruments:

- Analog
- Digital
- Combination analog and digital



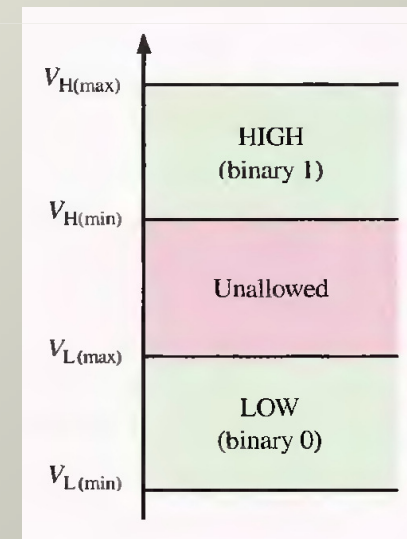
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Binary Digits, Logic Levels, and Digital Waveforms

- The conventional numbering system uses ten digits: 0,1,2,3,4,5,6,7,8, and 9.
- The binary numbering system uses just two digits: **0** and **1**.

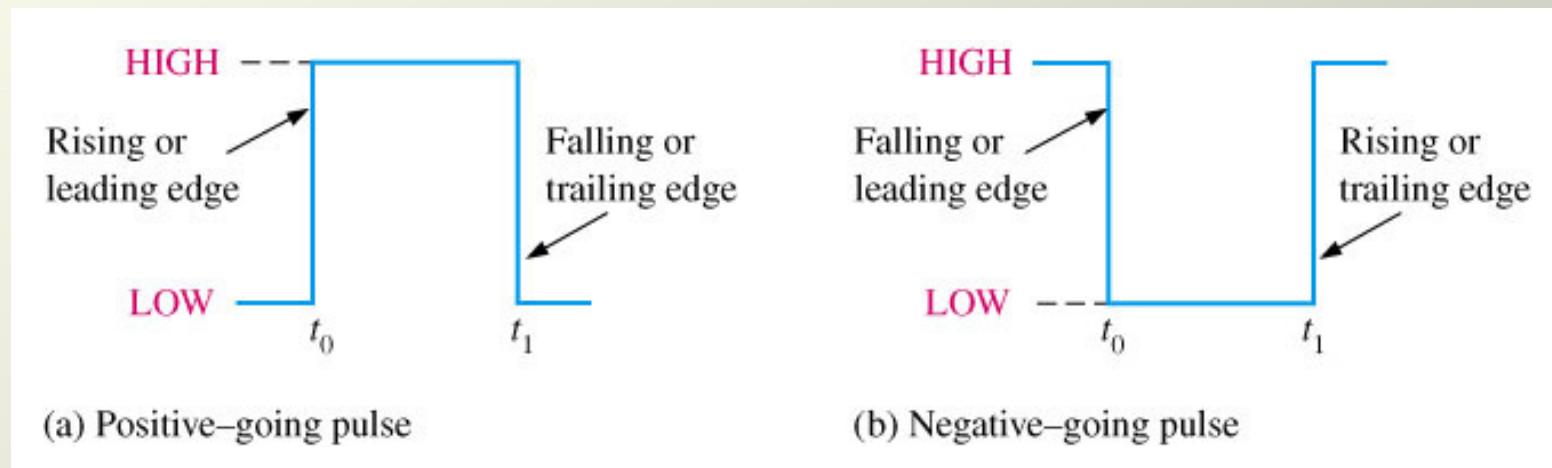
Binary Digits, Logic Levels, and Digital Waveforms

- The two binary digits are designated **0** and **1**
- They can also be called LOW and HIGH, where **LOW = 0** and **HIGH = 1**



Binary Digits, Logic Levels, and Digital Waveforms

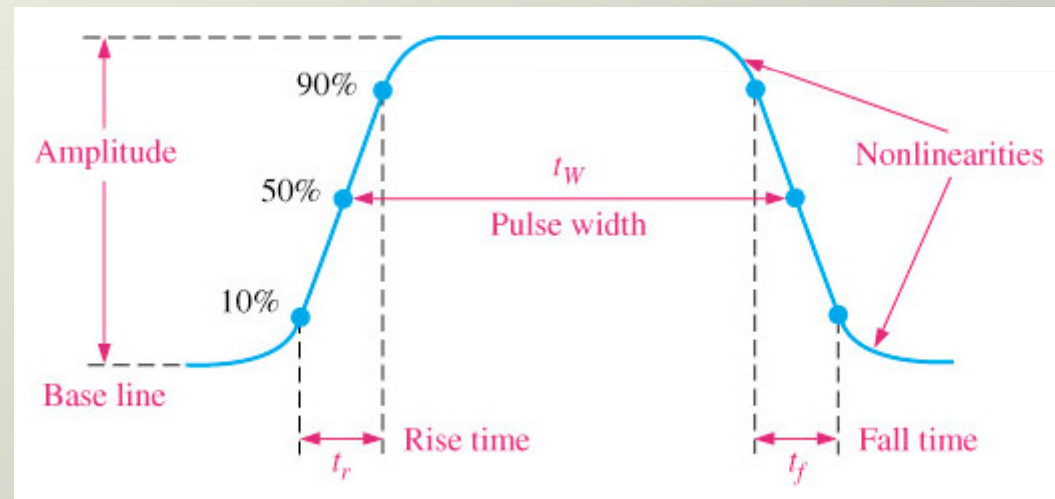
Binary values are also represented by voltage levels



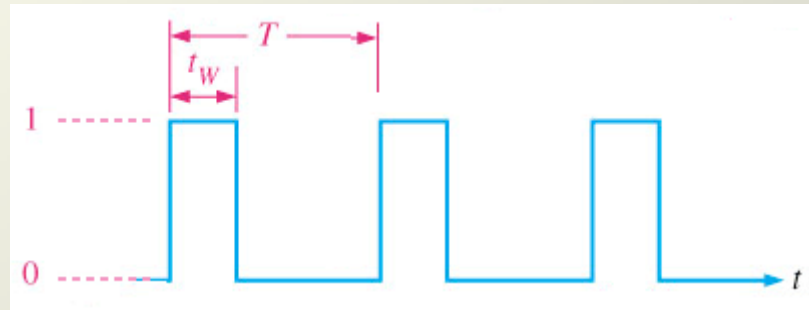
Binary Digits, Logic Levels, and Digital Waveforms

Major parts of a digital pulse

- Base line
- Amplitude
- Rise time (t_r)
- Pulse width (t_w)
- Fall time (t_f)



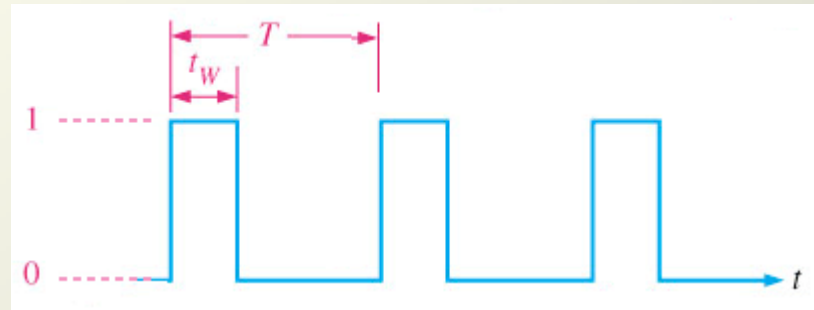
Binary Digits, Logic Levels, and Digital Waveforms



- t_w = pulse width
- T = period of the waveform
- f = frequency of the waveform

$$f = \frac{1}{T}$$

Binary Digits, Logic Levels, and Digital Waveforms

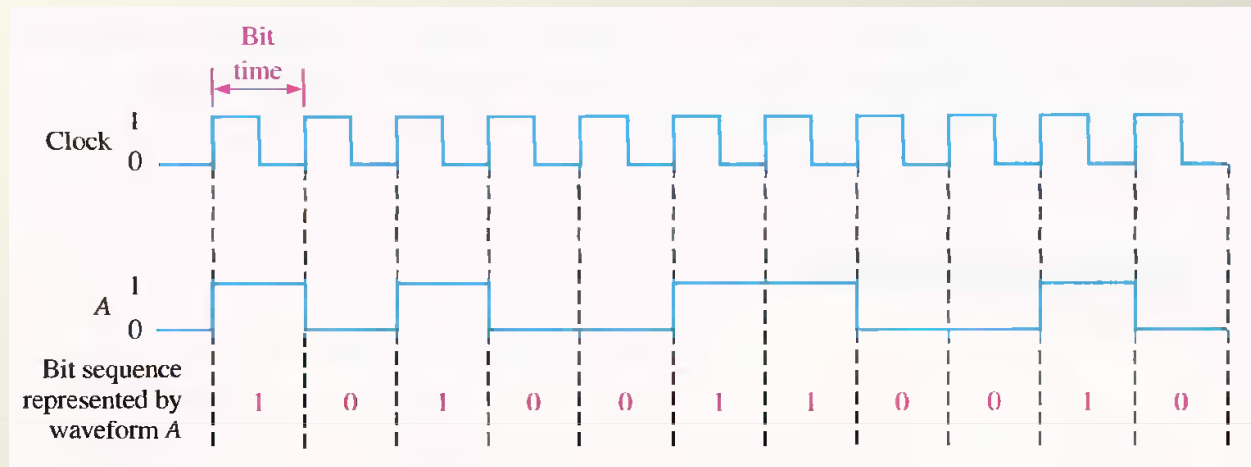


The duty cycle of a binary waveform is defined as:

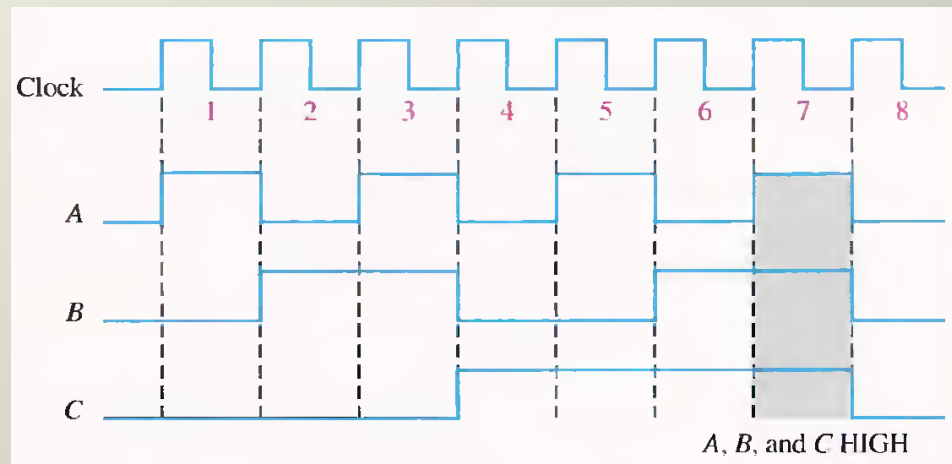
$$\text{Duty cycle} = \left(\frac{t_w}{T} \right) 100\%$$

Binary Digits, Logic Levels, and Digital Waveforms

EXAMPLE:
Clock
waveform &
sequence
of bits

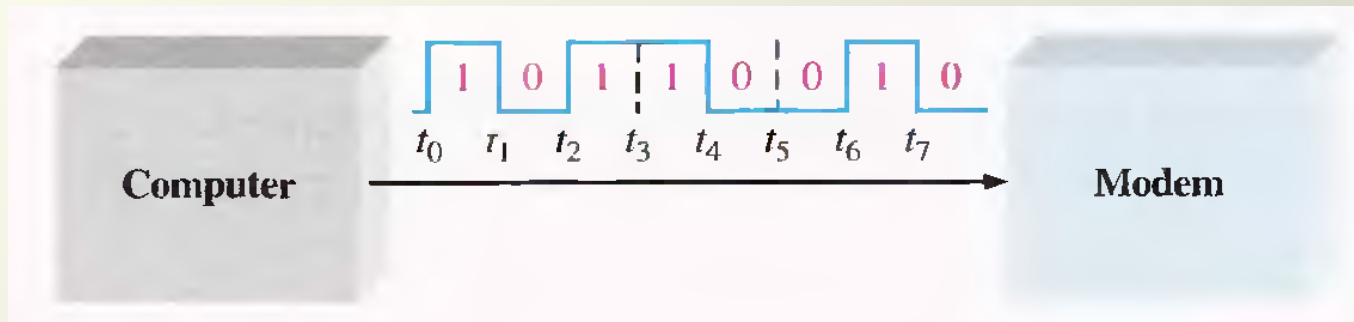


EXAMPLE:
Timing
Diagram

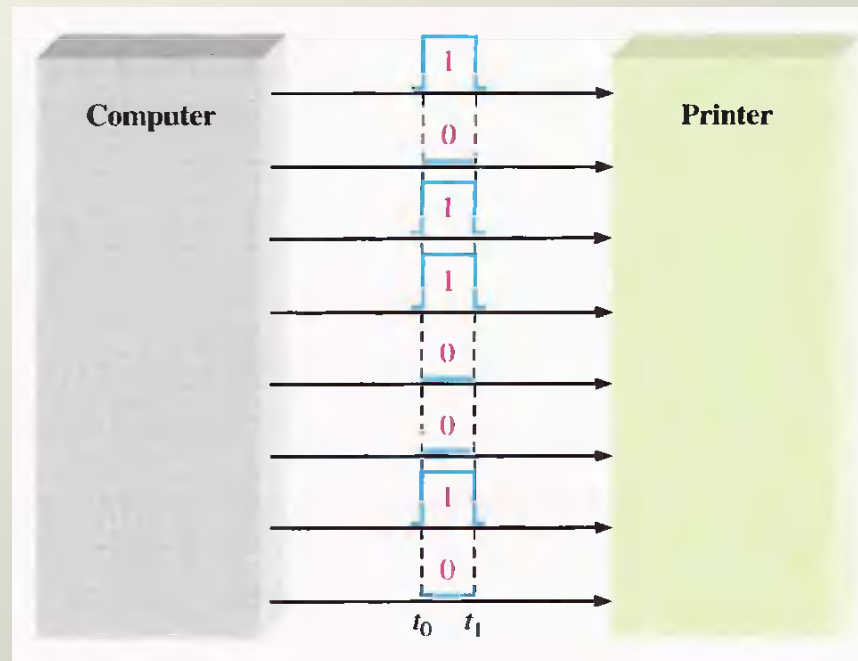


Data Transfer

Serial

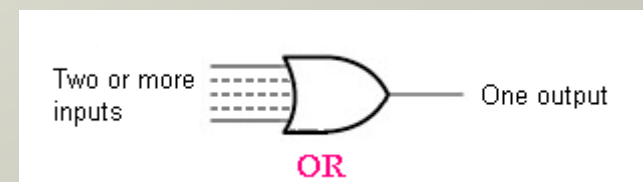
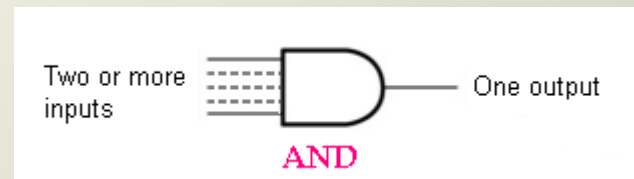
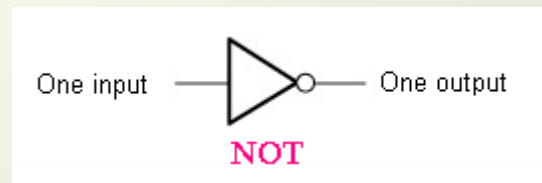


Parallel



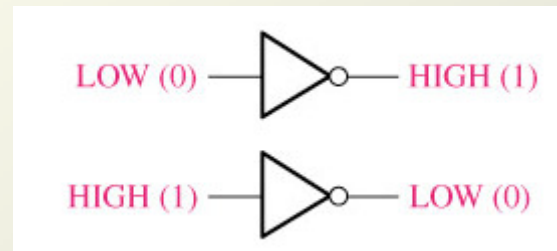
Basic Logic Operations

There are only three basic logic operations:



Basic Logic Operations

The NOT operation

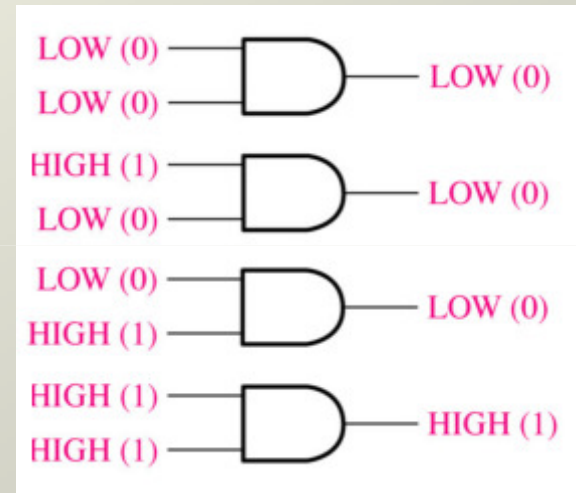


- When the input is LOW, the output is HIGH
- When the input is HIGH, the output is LOW

**The output logic level
is always opposite the
input logic level.**

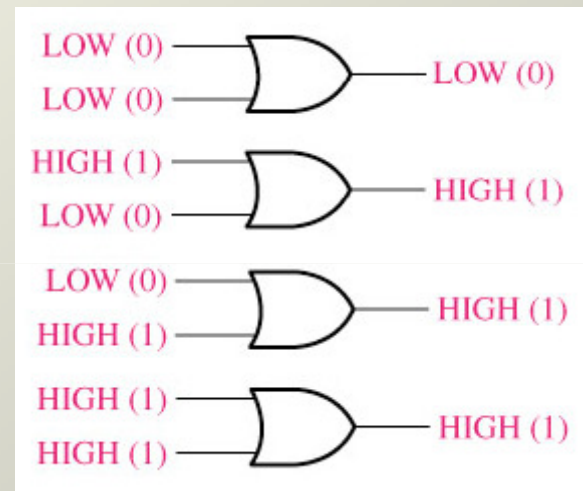
Basic Logic Operations

- The AND operation
 - When any input is LOW, the output is LOW
 - When both inputs are HIGH, the output is HIGH



Basic Logic Operations

- The OR operation
 - When any input is HIGH, the output is HIGH
 - When both inputs are LOW, the output is LOW



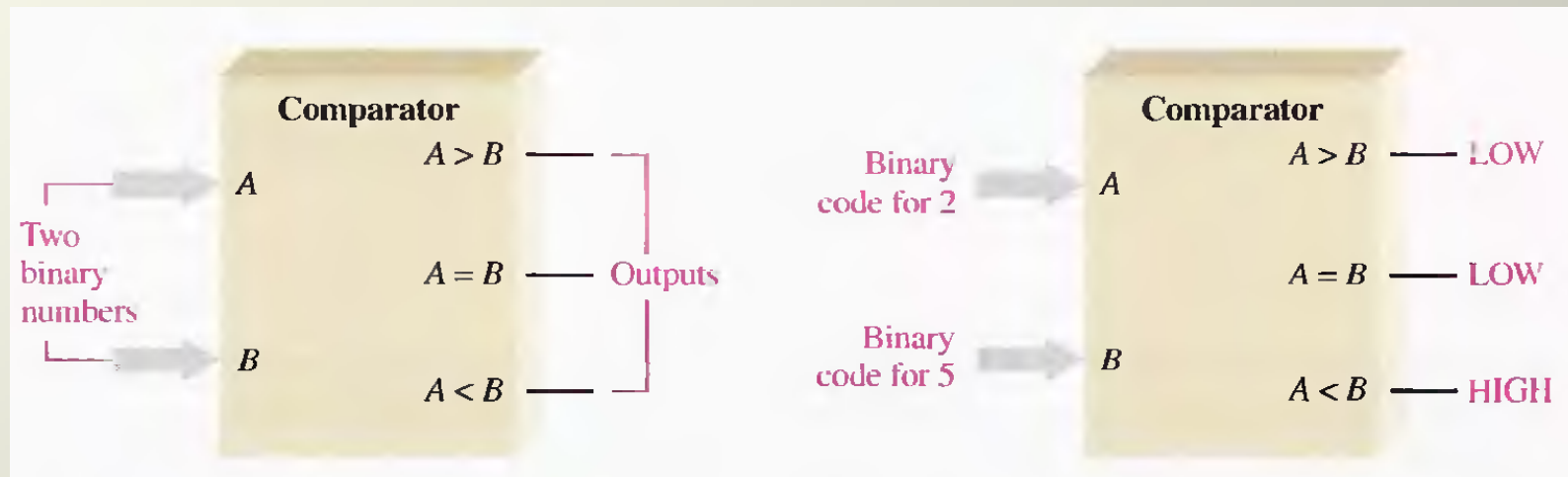
Overview of Basic Logic Functions

- Comparison function
- Arithmetic functions
- Code conversion function
- Encoding function
- Decoding function
- Data selection function
- Data storage function
- Counting function

Overview of Basic Logic Functions

Comparison function

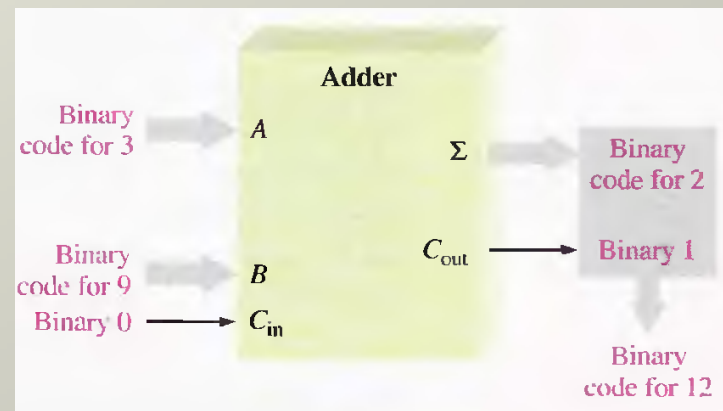
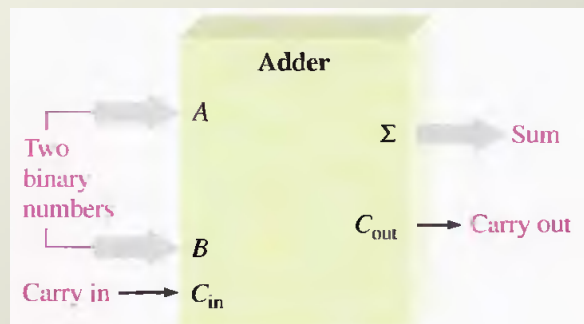
- Compares two binary values and determines whether or not they are equal



Overview of Basic Logic Functions

Arithmetic functions

- Perform the basic arithmetic operations on two binary values:
 - Addition
 - Subtraction of two values
 - Multiplication
 - Division

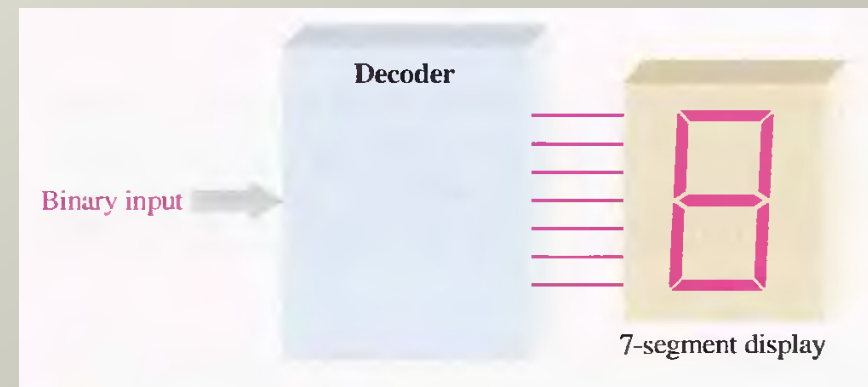
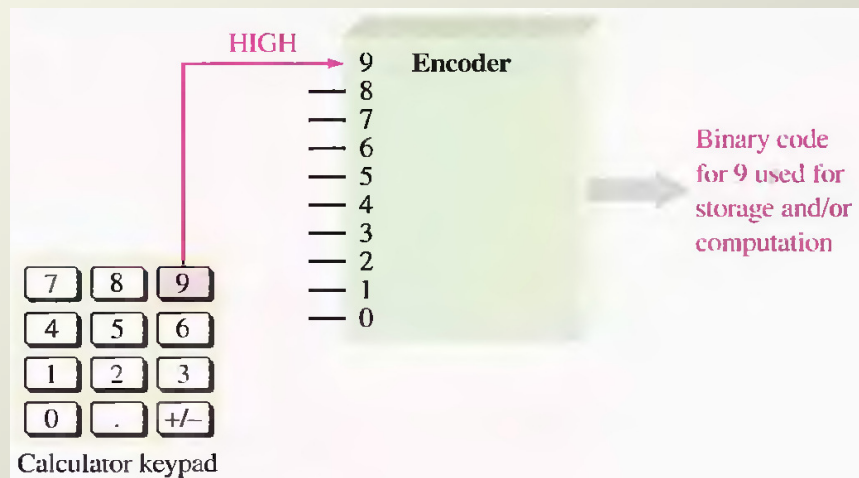


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Overview of Basic Logic Functions

Code conversion function

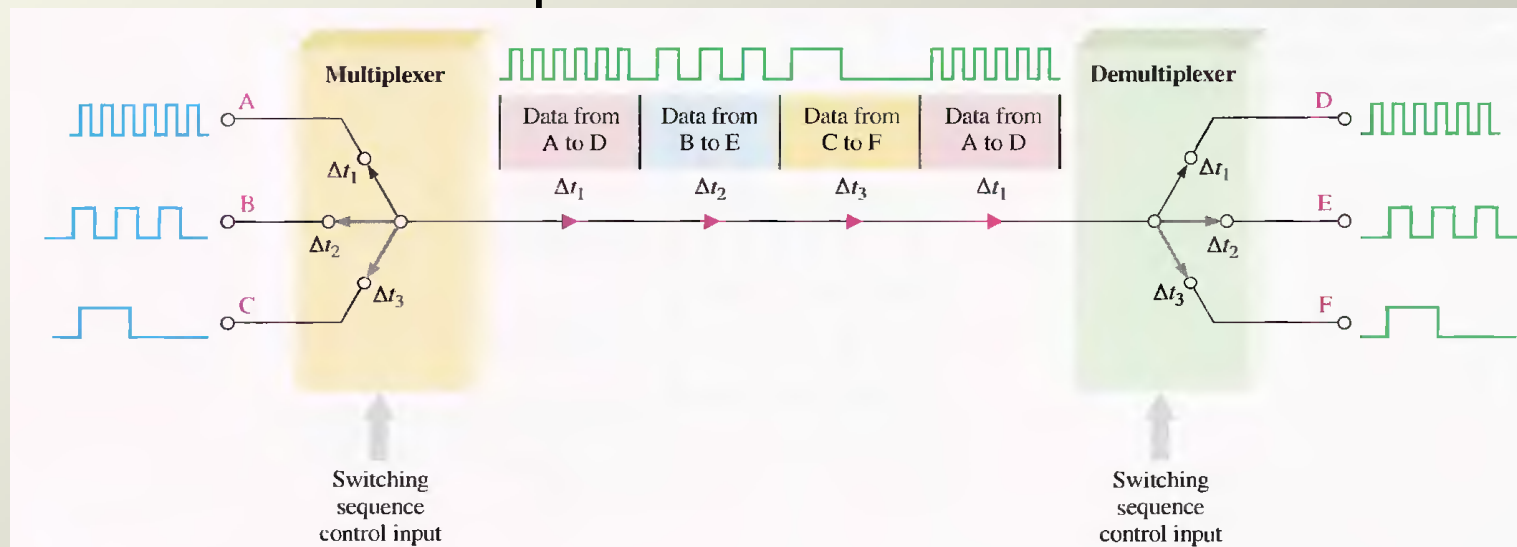
- Converts, or translates, information from one code format to another
- Encoding function : Converts non-binary information into a binary code
- Decoding function : Converts binary-coded information into a non-binary form



Overview of Basic Logic Functions

Data selection function

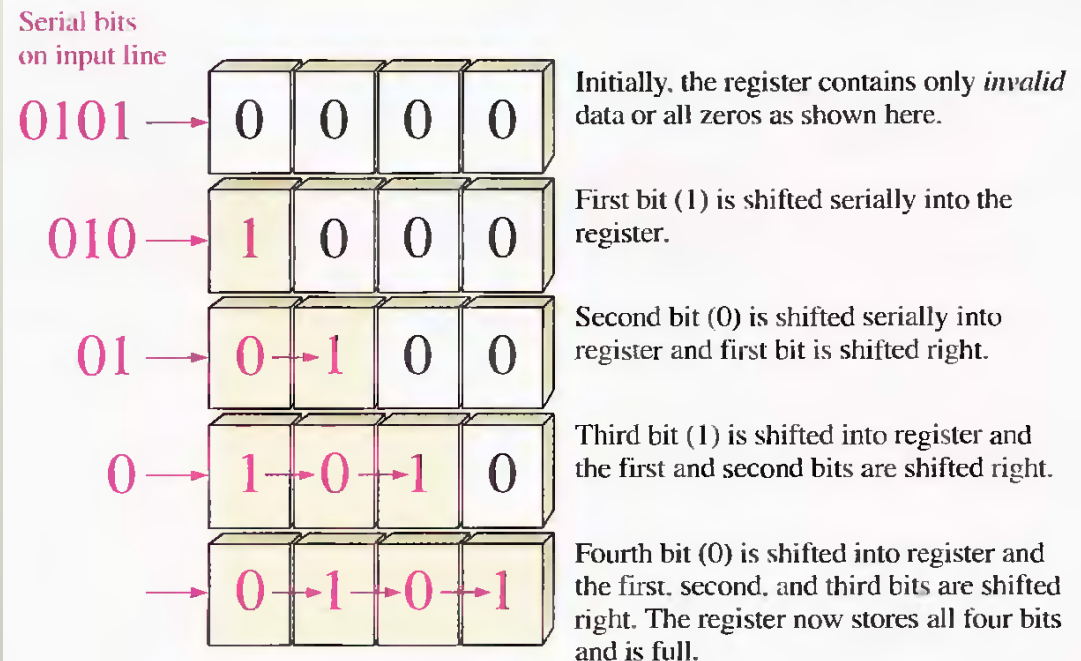
- Multiplexer (mux)
 - Switches digital data from any number of input sources to a single output line
- Demultiplexer (demux)
 - switches digital data from a single input to any number of output lines



Overview of Basic Logic Functions

Data storage function

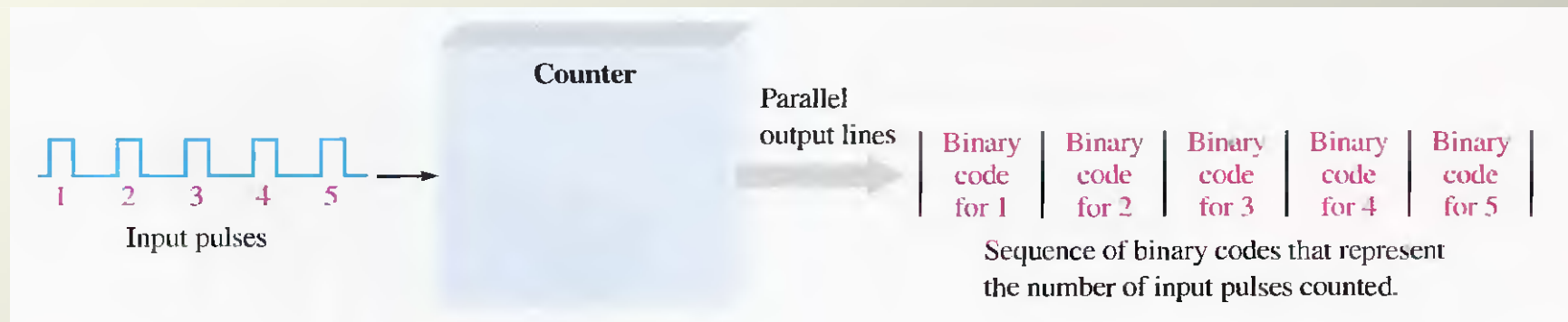
- Retains binary data for a period of time
 - Flip-flops (bistable multivibrators)
 - Registers
 - Semiconductor memories, Magnetic-media memories, Optical-media memories



Overview of Basic Logic Functions

Counting function

- Generates sequences of digital pulse that represent numbers



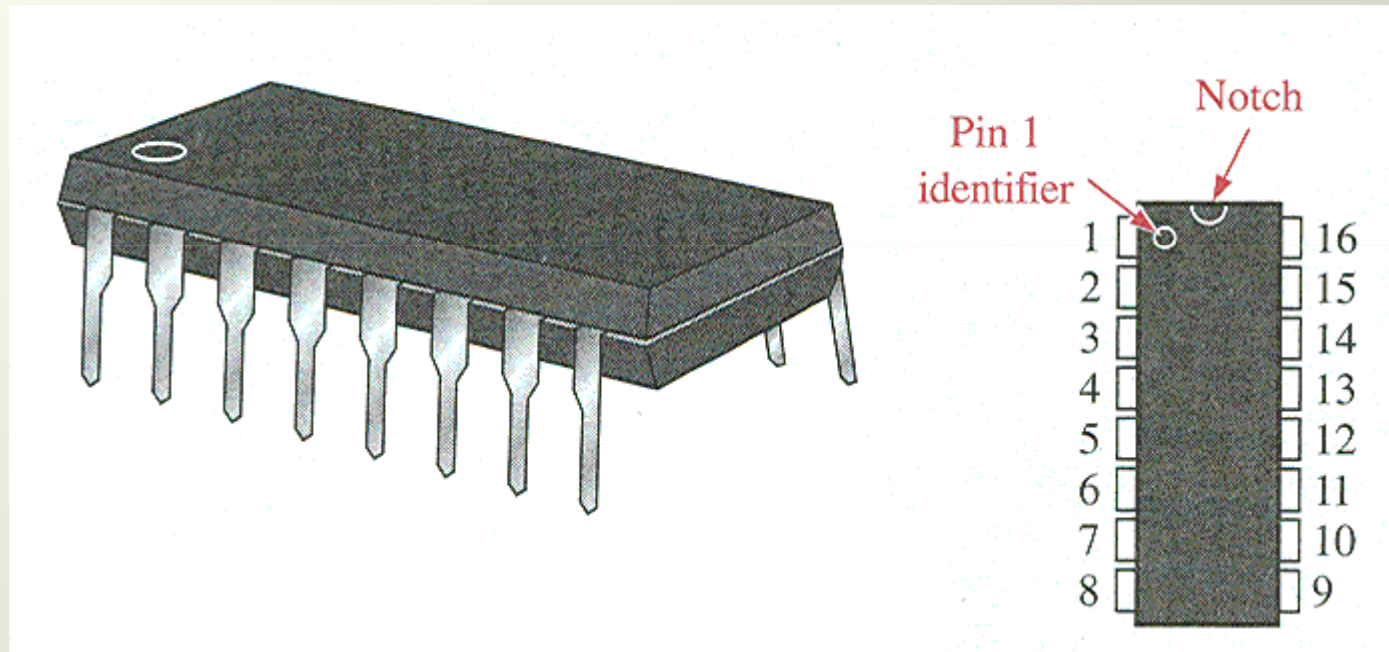
Fixed-Function Integrated Circuits

IC package styles

- Dual in-line package (DIP)
- Small-outline IC (SOIC)
- Flat pack (FP)
- Plastic-leaded chip carrier (PLCC)
- Leadless-ceramic chip carrier (LCCC)

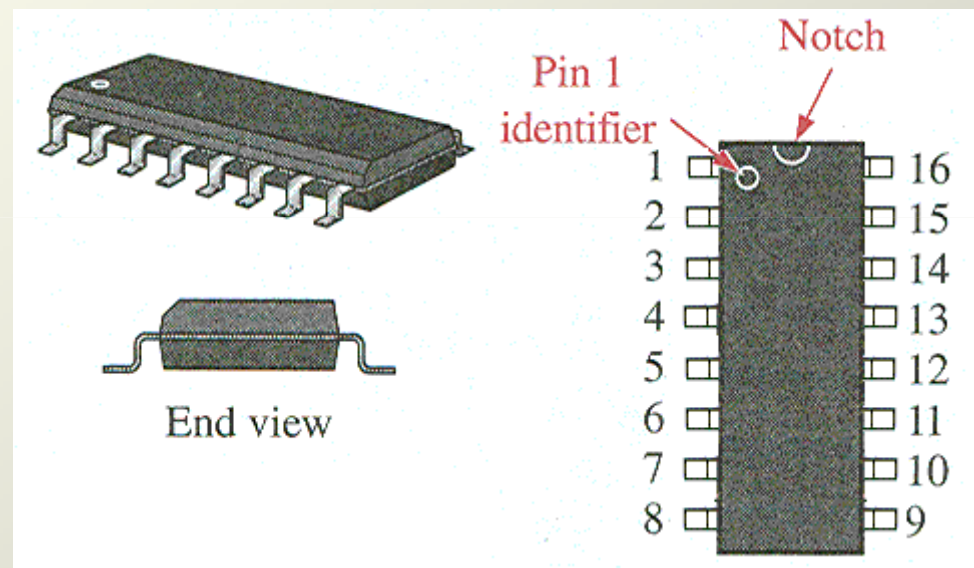
Fixed-Function Integrated Circuits

- Dual in-line package (DIP)



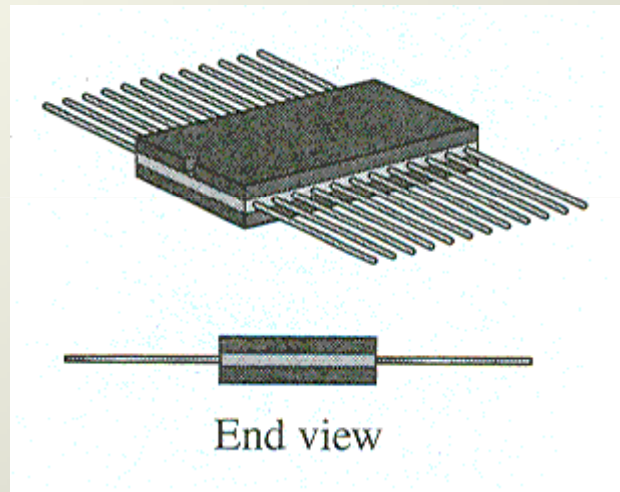
Fixed-Function Integrated Circuits

- Small-outline IC (SOIC)



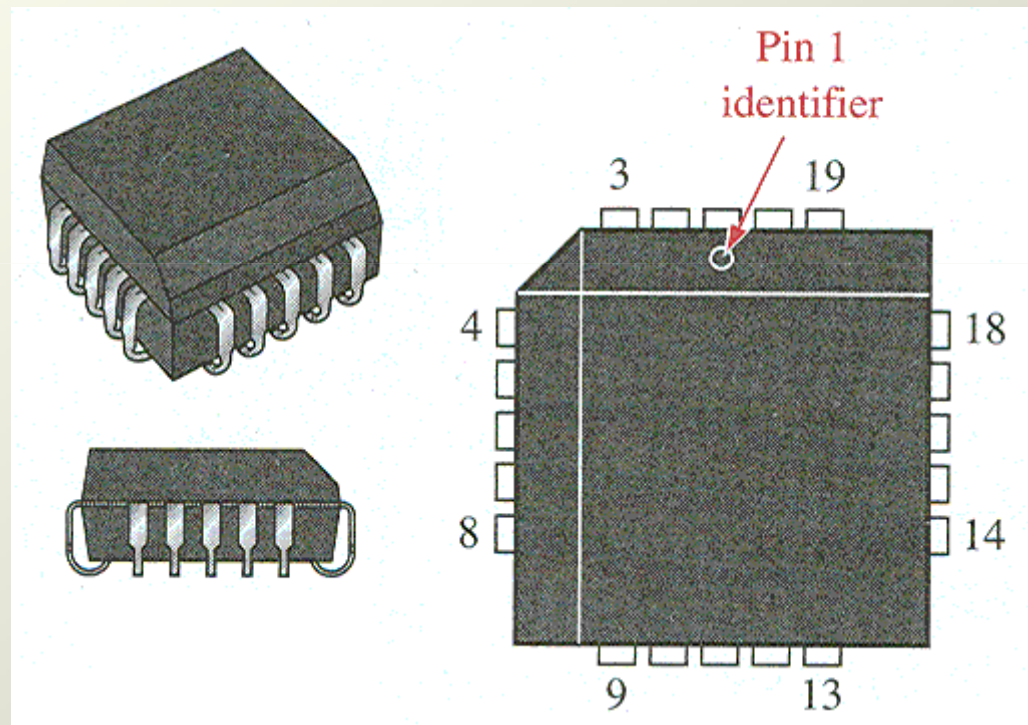
Fixed-Function Integrated Circuits

- Flat pack (FP)



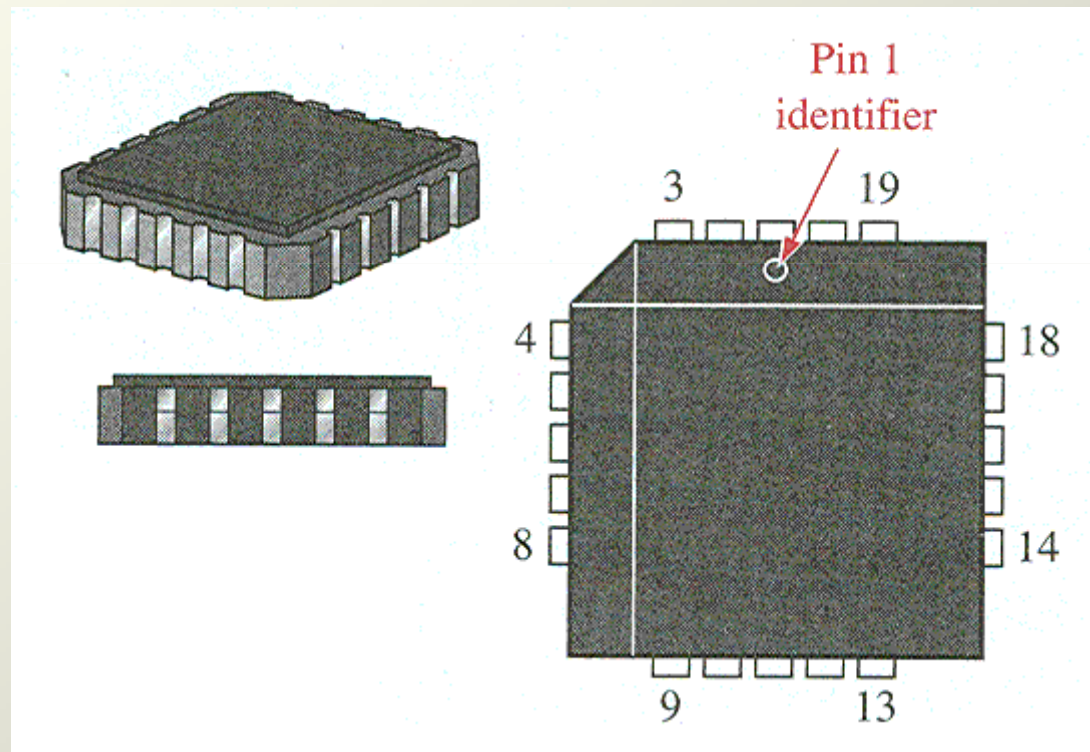
Fixed-Function Integrated Circuits

- Plastic-leaded chip carrier (PLCC)



Fixed-Function Integrated Circuits

- Leadless-ceramic chip carrier (LCCC)



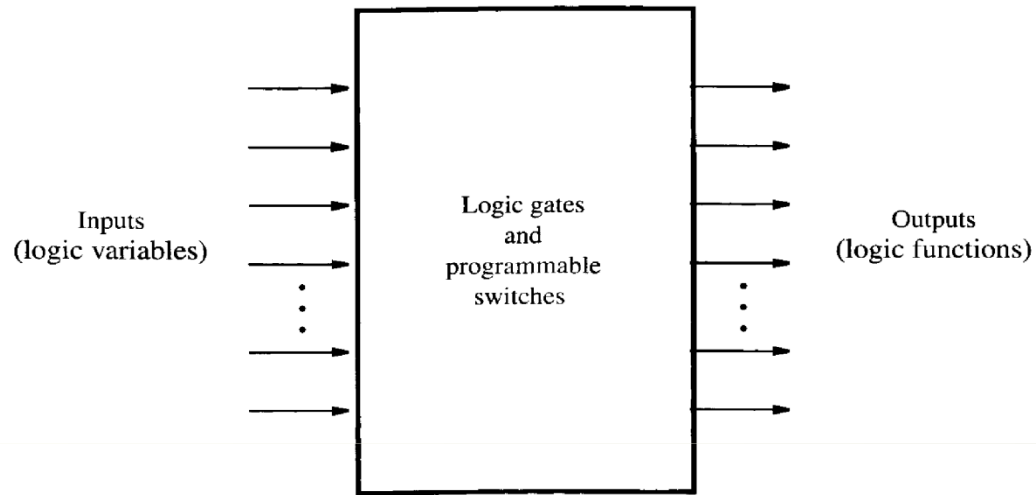
Introduction to Programmable Logic

- SPLD—Simple programmable logic devices
- CPLD—Complex programmable logic devices
- FPGA—Field-programmable gate arrays

Introduction to Programmable Logic

- SPLD
 - PAL (programmable array logic)
 - GAL (generic array logic)
 - PLA (programmable logic array)
 - PROM (programmable read-only memory)

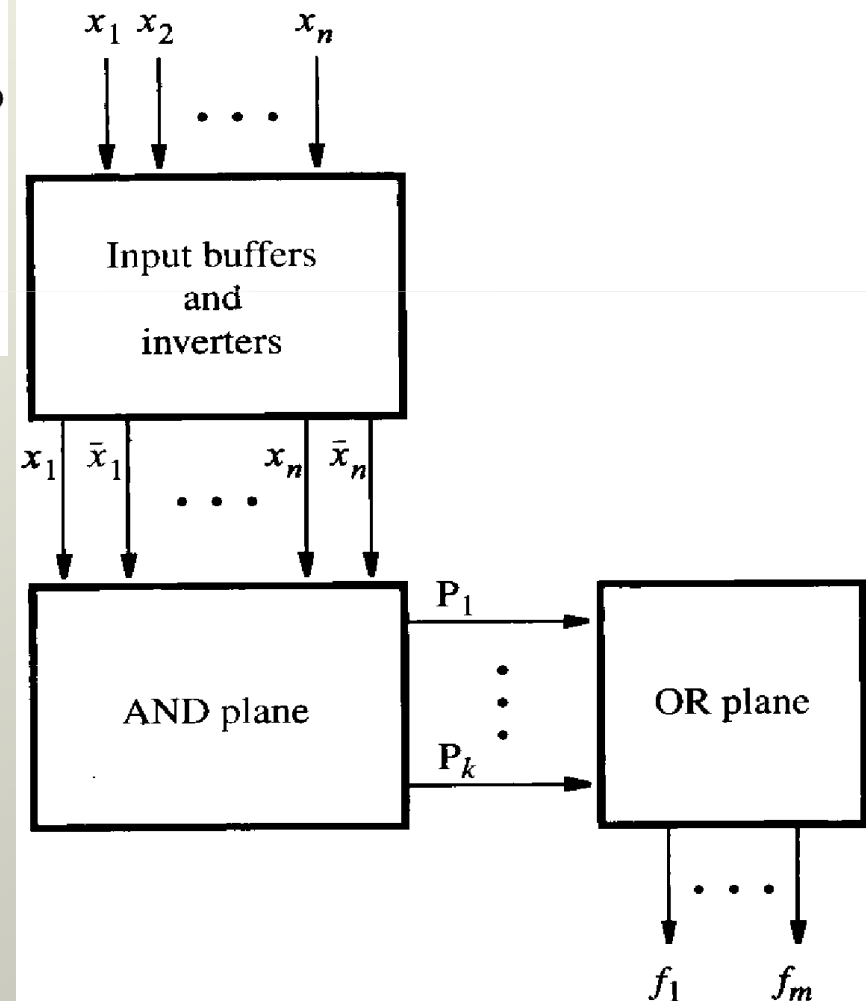
Programmable Logic Array



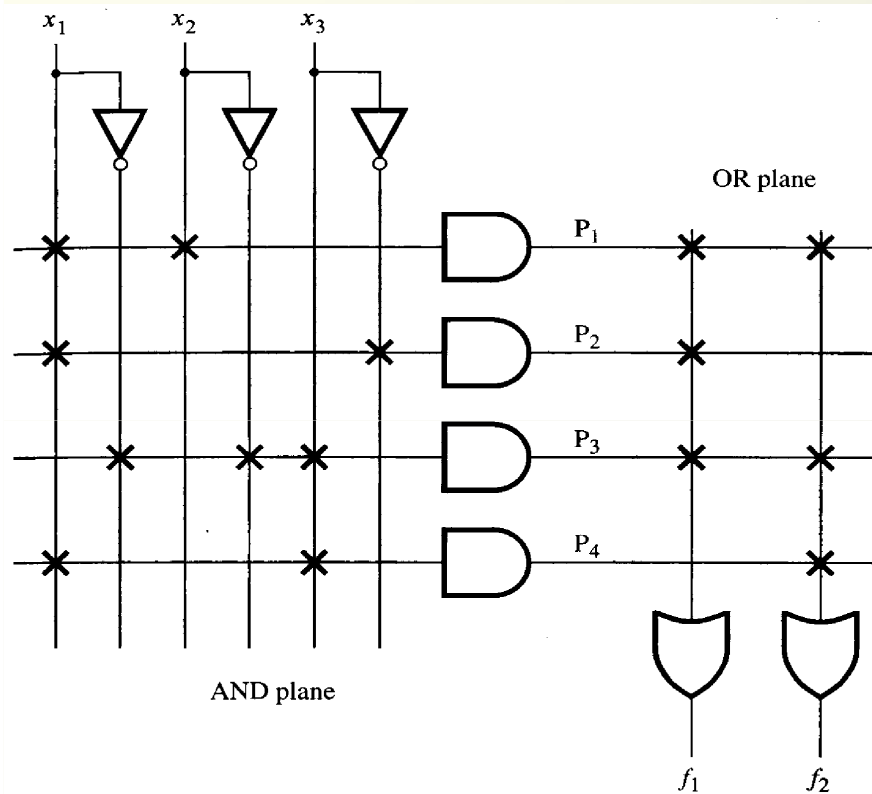
General Concept

From Brown & Vranesic's fundamentals of digital logic

General Structure

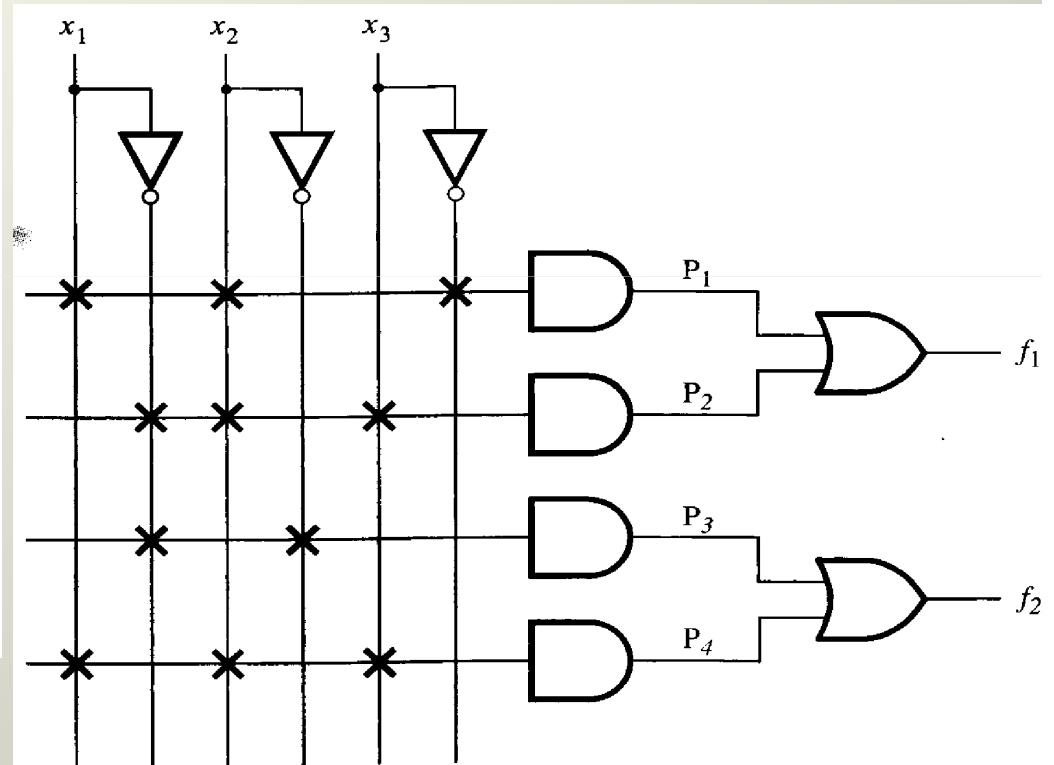


PLA & PAL



PLA example

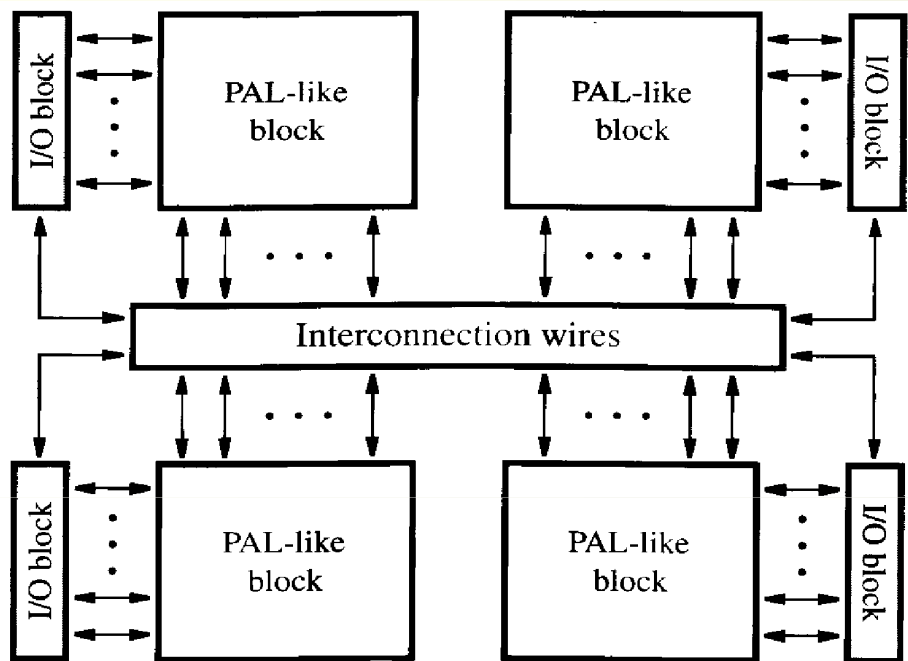
PAL example



From Brown & Vranesic's fundamentals of digital logic

Note : PAL is similar to PLA except OR plane is not programmable.

CPLD & FPGA

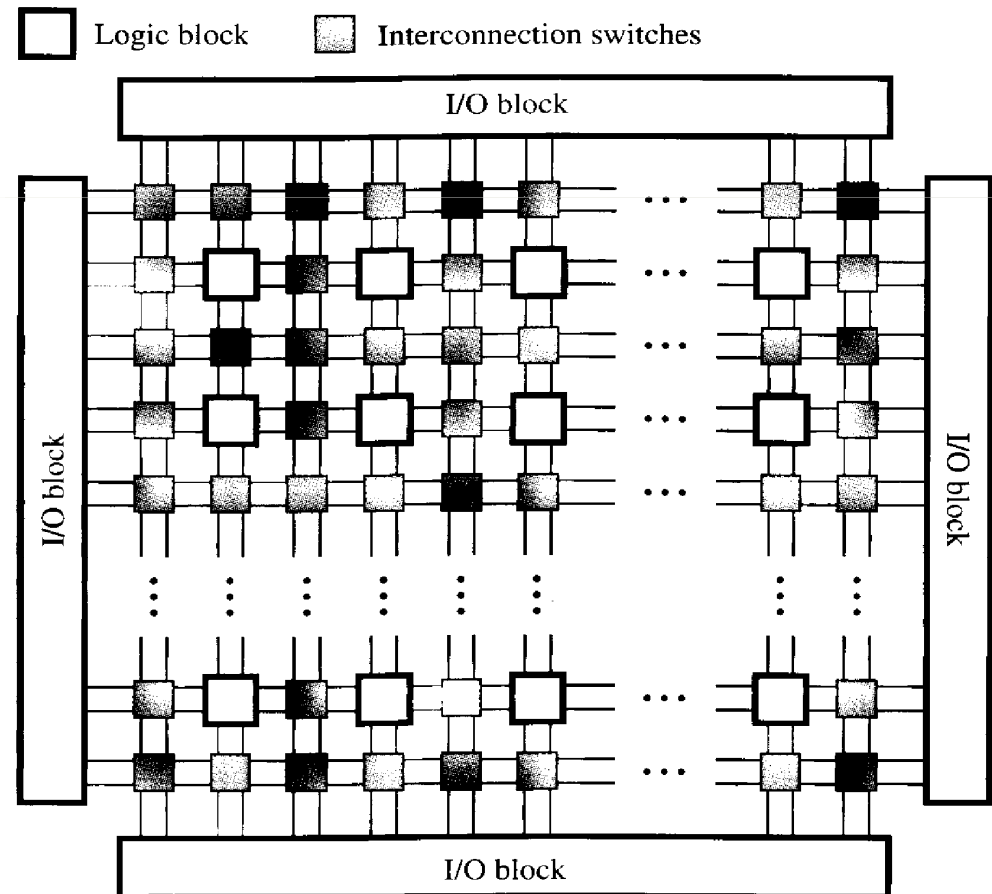


CPLD
general structure

From Brown & Vranesic's fundamentals of digital logic

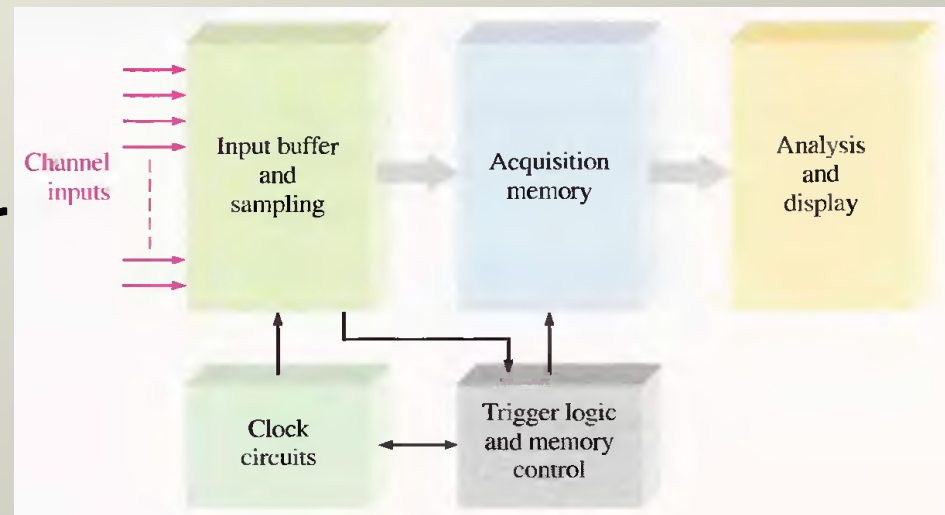
Slide

FPGA
general structure

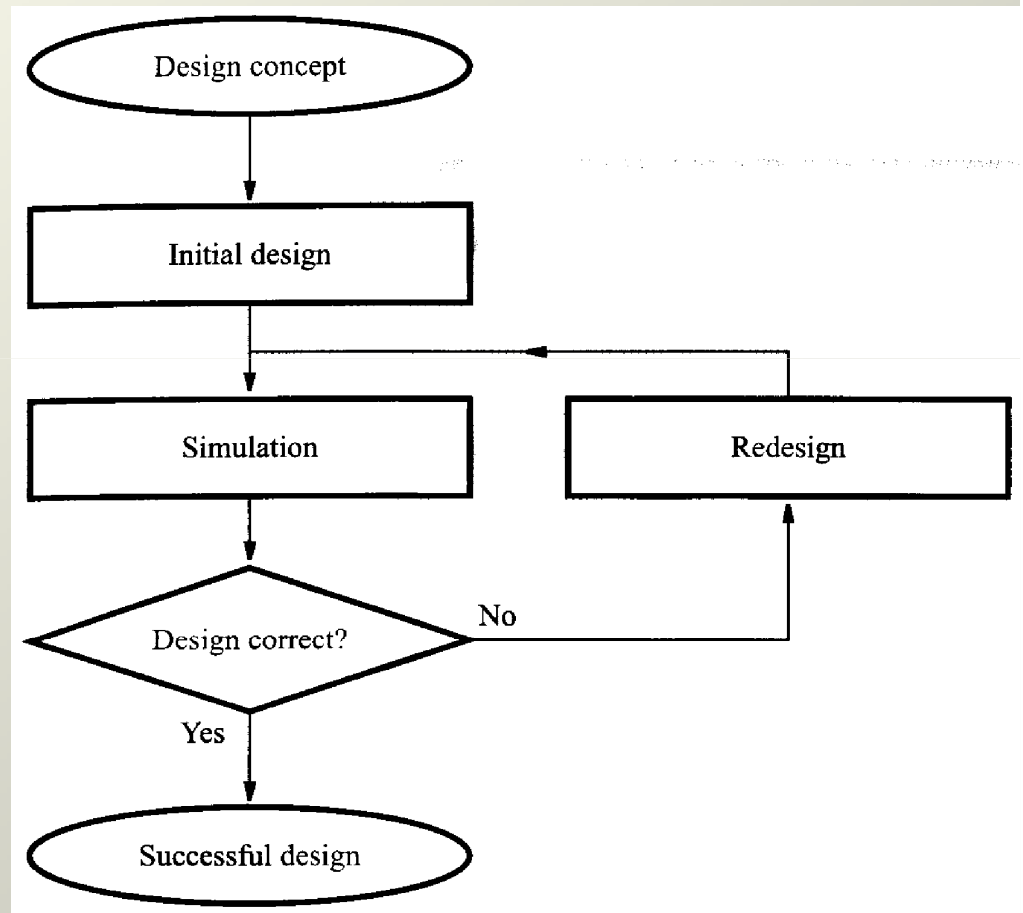
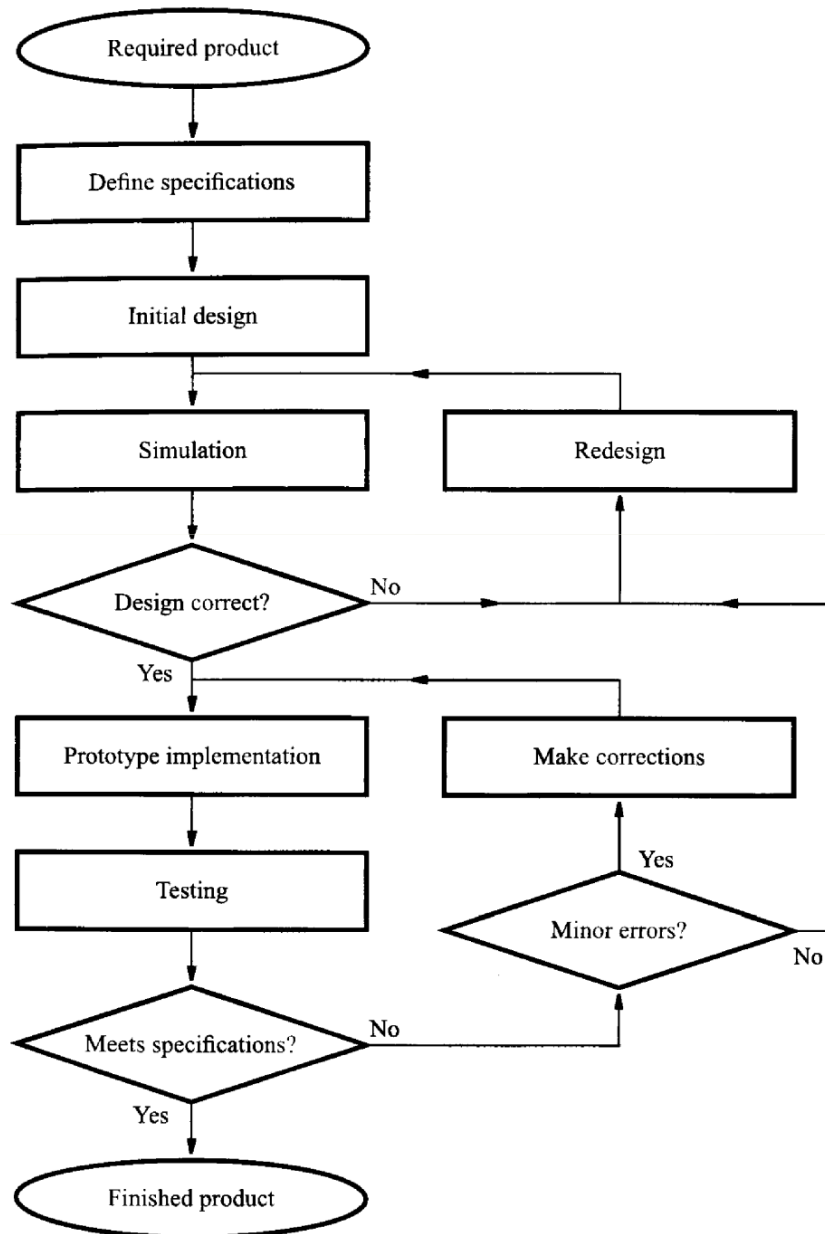


Test and Measurement Instruments

- Analog Oscilloscope
- Digital Oscilloscope
- Logic Analyzer
- Logic Probe, Pulser, and Current Probe
- DC Power Supply
- Function Generator
- Digital Multimeter



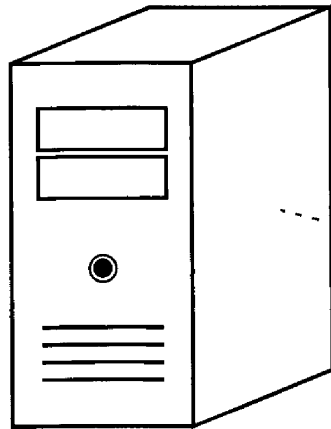
General Design Process



Basic Design Loop

Computer System

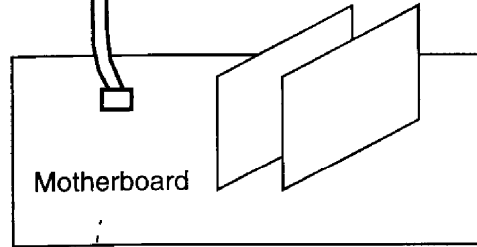
Computer



Power supply

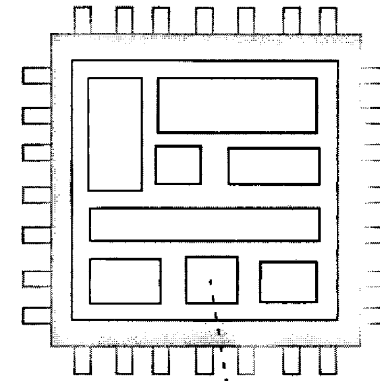


Motherboard

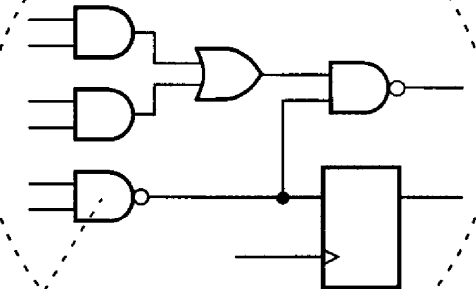


Printed circuit boards

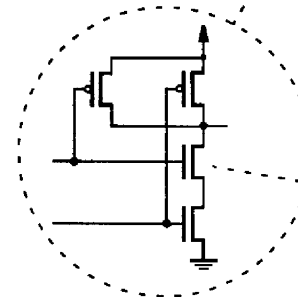
Subcircuits in a chip



Logic gates



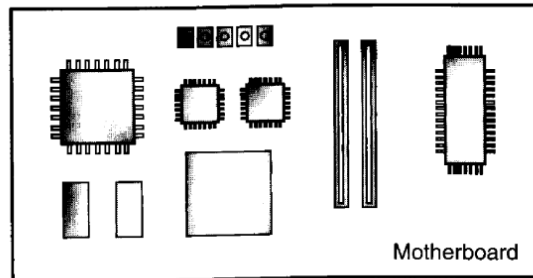
Transistor circuit



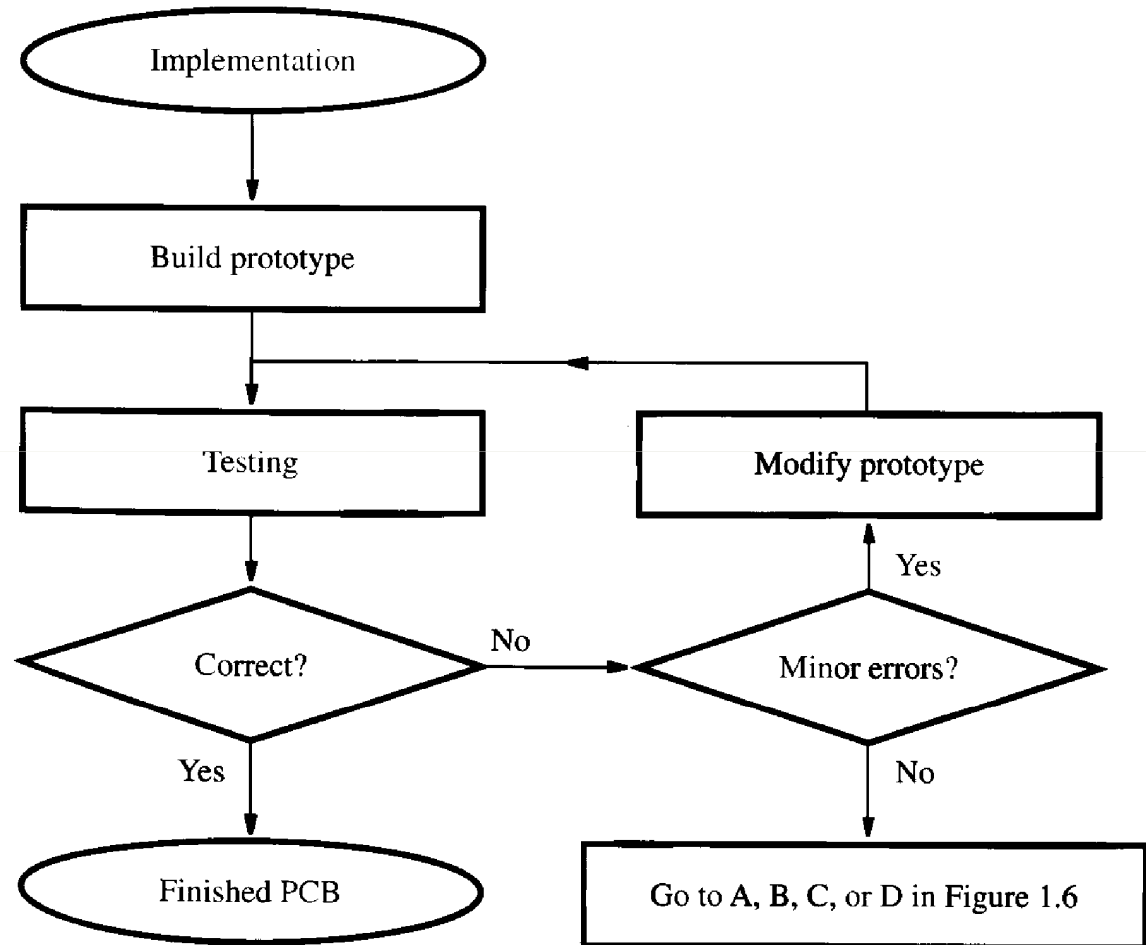
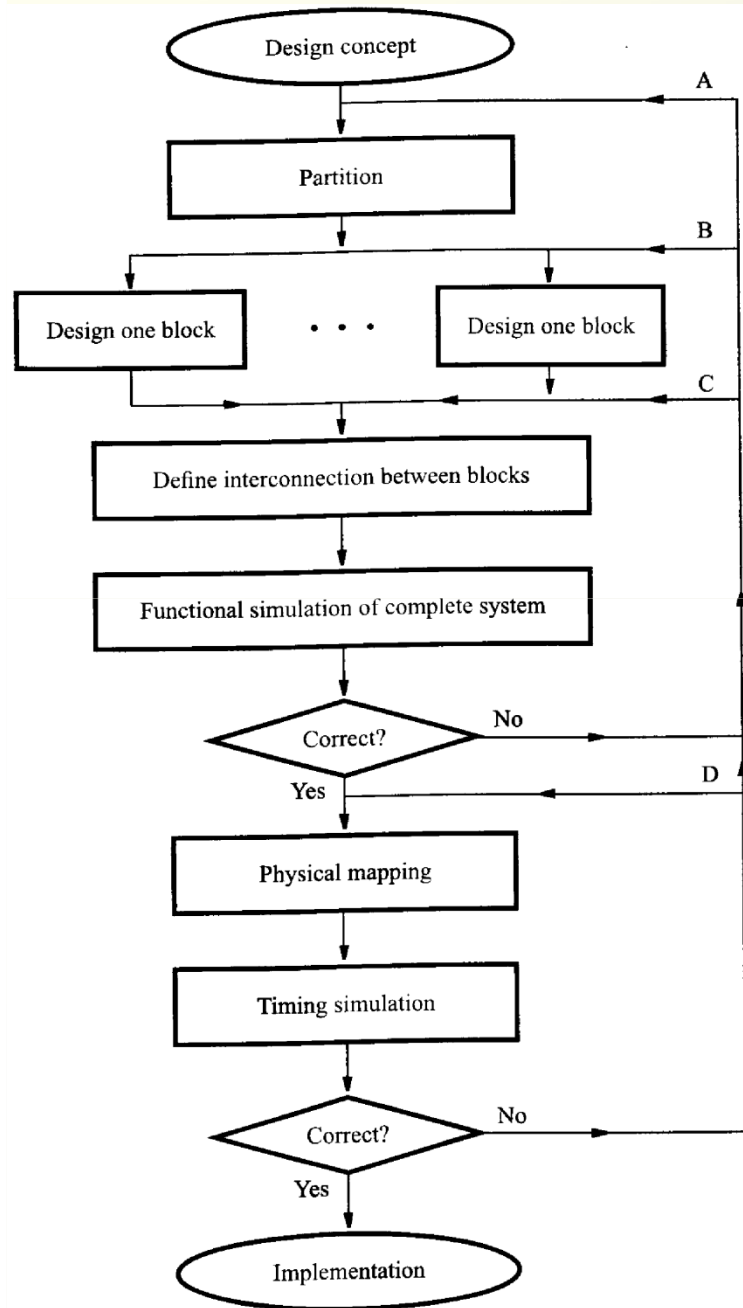
Transistor on a chip



Integrated circuits, connectors, and components



Design Process



PCB development