EEE130 Digital Electronics I
Lecture #1_2

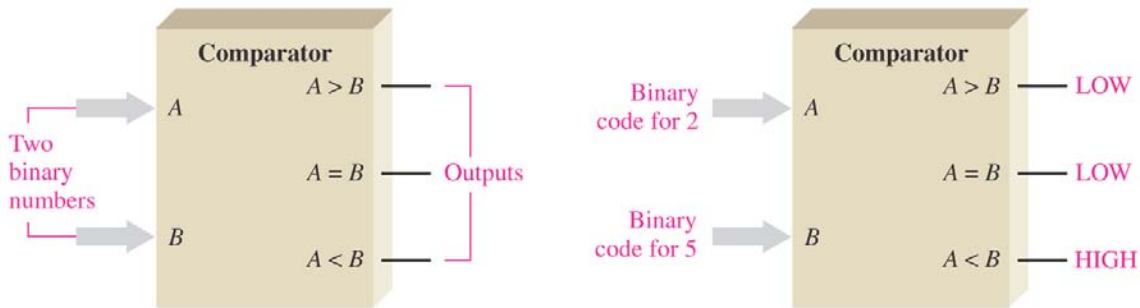
Dr. Shahrel A. Suandi

1-4 Overview of Basic Logic Functions

- Digital systems are generally built from combinations of NOT, AND and OR logic elements
- The combinations of these elements can be used for the followings:
  - Comparison, arithmetic, codes conversion, encoding, decoding, data selection, storage and
- This section will only give introduction to these common logics, while the details will be explained in future chapters (Chapter 6)

Comparator

- Used to compare two binary inputs and give results as HIGH where the logic is TRUE
- Example: if binary forms of number 2(A)and 5(B) are input into a comparator, then the result TRUE (HIGH) shall be given at the output terminal having 2<5(A<B)

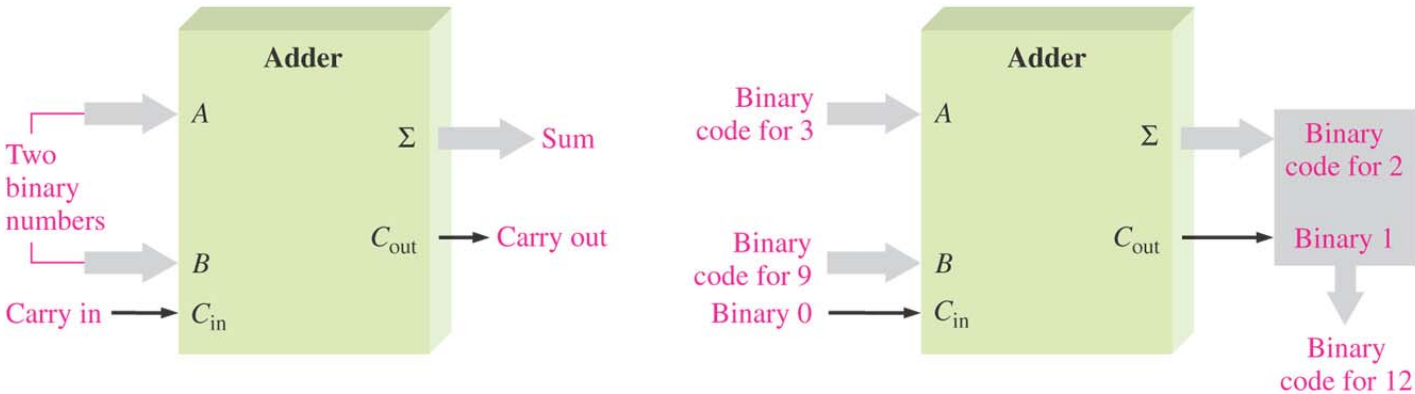


(a) Basic magnitude comparator

(b) Example: A is less than B ($2 < 5$) as indicated by the HIGH output ($A < B$)

The Arithmetic Functions – Adder

- What is arithmetic function?
  - Normal mathematical operations, like addition, subtraction, multiplication, division
- Addition – to add numbers and known as ***adder***
  - Add 2 numbers and generate two outputs, a sum and a carry



(a) Basic adder

(b) Example: *A* plus *B* (3 + 9 = 12)

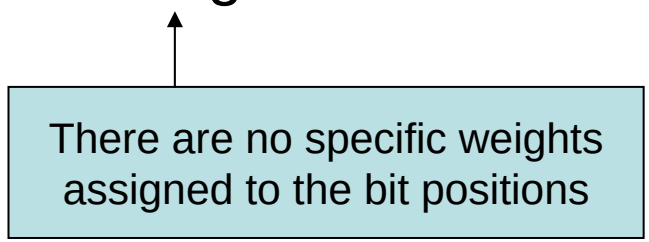
Subtractor, multiplier and divider

- Do you know ALU??
  - Arithmetic Logic Unit – a unit where all arithmetic operations are done in a microprocessor

- Subtractor is used for subtraction
  - Requires 3 inputs:
    - 2 inputs
    - 1 borrow input
- Multiplier is used for multiplication
  - Two inputs/numbers are multiplied at a time
  - Multiplication is actually a process of multiple time of addition, so *we can also use adder* for this purpose
- Divider is used for division
  - Two inputs/numbers are used for this purpose
  - The outputs generated are the quotient and the remainder
  - Similar to multiplier, divider is actually series of subtractions, comparisons, and shifts → *adder can be used* in conjunction with other circuits for this purpose

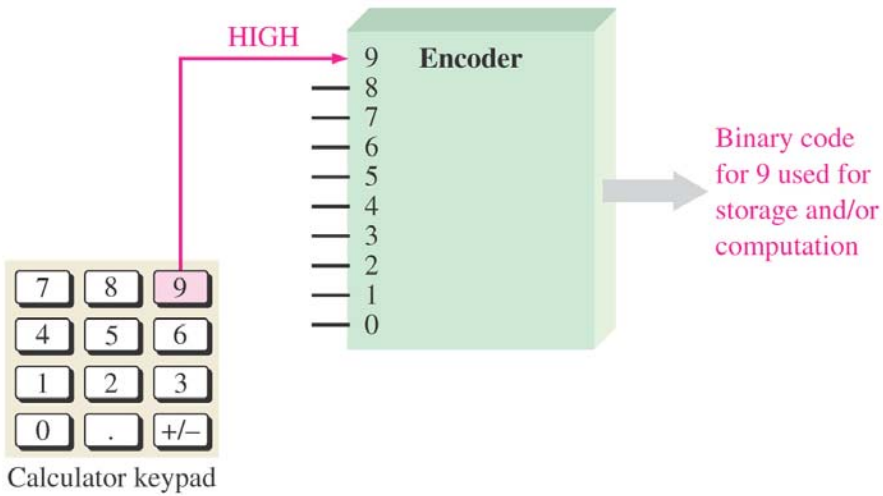
The Code Conversion Function

- Code – set of bits arranged in a unique pattern and used to represent specified information
- Function of code converter – to convert one code to another form of code
- Example:
  - Binary → BCD (binary coded decimal)
  - Binary → gray code
- BCD – binary codes that represent decimal digits. There are only 10 code groups in the BCD systems
- Gray Code – used to minimize error, especially in servo (shaft position encoders). Is unweighted and is not an arithmetic code.



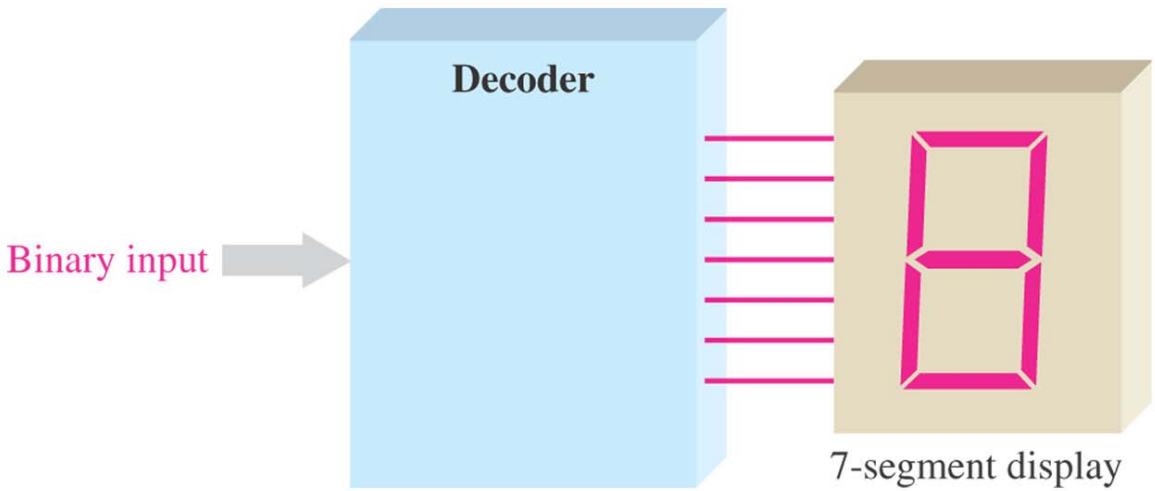
The Encoding Function

- Encoder – converts information from one form to another form
- Example:
  - Calculator: when button “9” is pressed, then the terminal is HIGH and being as the input to an encoder. This number “9” is then converted into binary, for example “1001” (BCD)



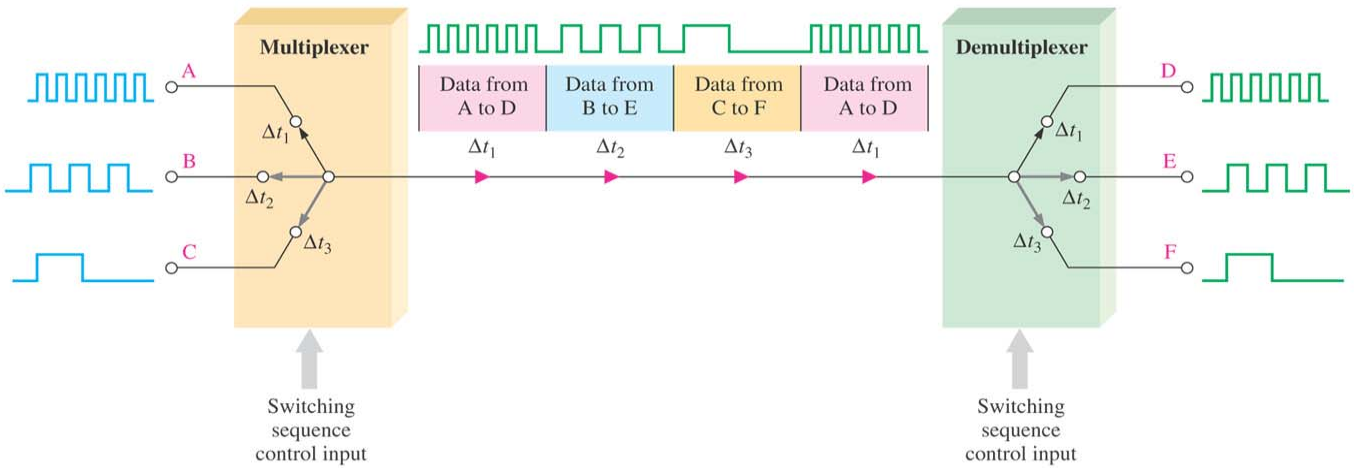
The Decoding Function

- Decoder – performs decoding function
- Example:
  - decode a binary number into a non-coded form, such as a decimal form



The Data Selection Function

- Two types: multiplexer and demultiplexer
- Multiplexer
  - Known as mux
  - Switches digital data from several input lines onto a single output line in a specified time sequence
- Demultiplexer
  - Known as demux
  - Switches digital data from one input line to several output lines in a specified time sequence
- Usage:
  - When data from several sources are to be transmitted over one line to a distant location and redistributed to several destinations

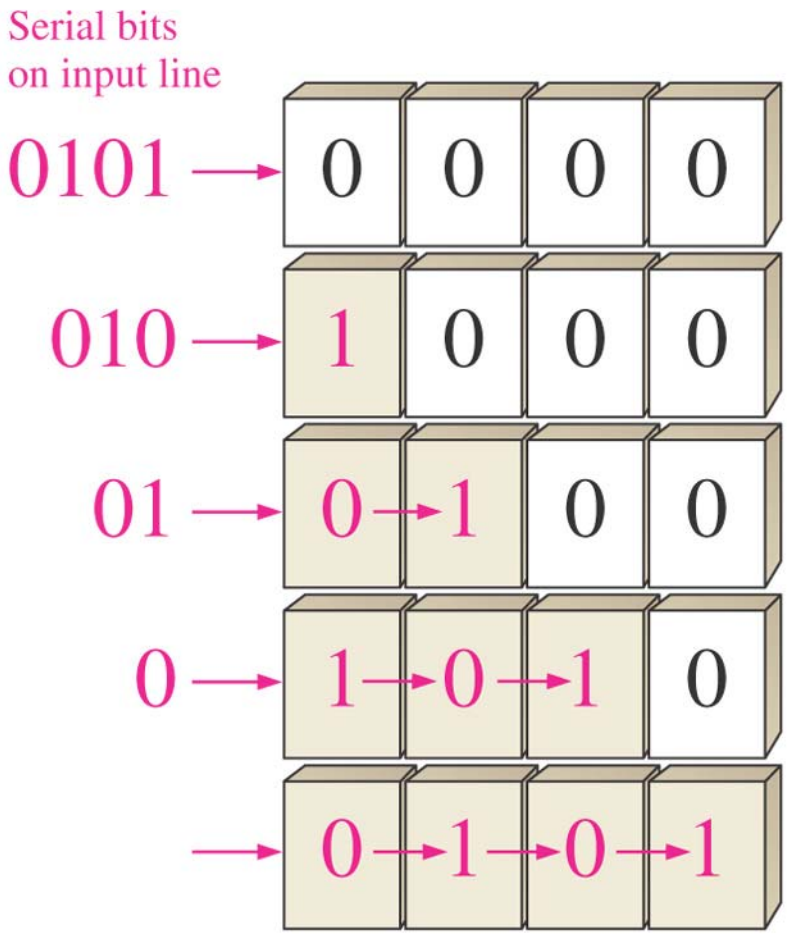


Time division multiplexing (TDM)

The Storage Function

- Usage: to retain binary data for a period of time
- Example of storage devices:
  - Flip-flops, registers, semiconductor memories, magnetic disks, magnetic tape, and optical disks (CDs)
- Flip-flops – a bistable logic circuit that can store only one bit at a time, either 1 or 0
- Registers
  - a combination of several flip-flops forms registers, 8-bit register is constructed from eight flip-flops
  - Shift registers are registers used to shift the bits from one position to another within the register or out of the register to another circuit
- Semiconductor memories – used for storing large numbers of bits. E.g.: ROM (permanently or semipermanently stored), RAM (temporarily stored)
- Magnetic memories – used for mass storage of binary data. E.g.: floppy disk

Examples of registers(1)
- serial shift register -



Initially, the register contains only *invalid* data or all zeros as shown here.

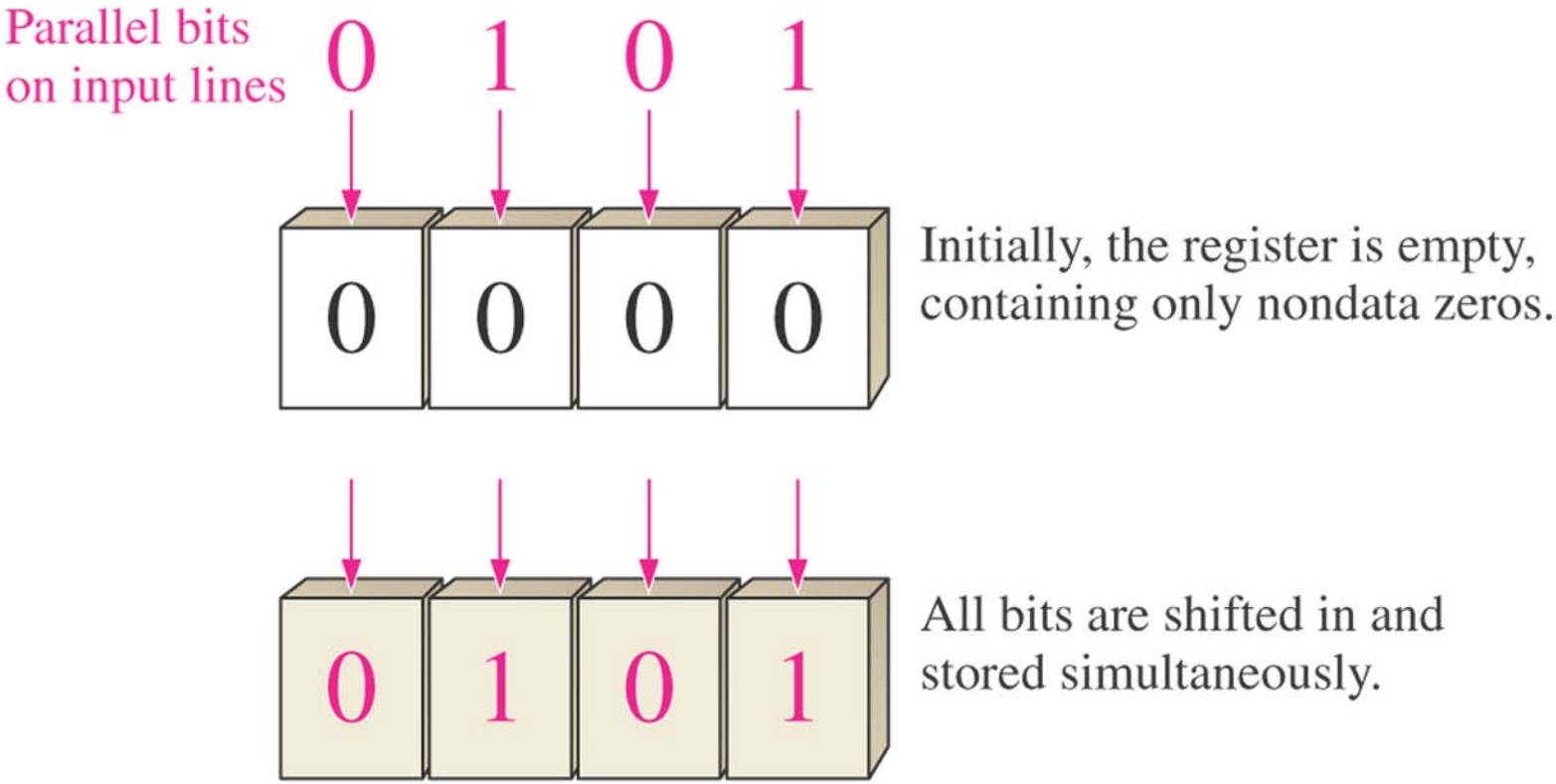
First bit (1) is shifted serially into the register.

Second bit (0) is shifted serially into register and first bit is shifted right.

Third bit (1) is shifted into register and the first and second bits are shifted right.

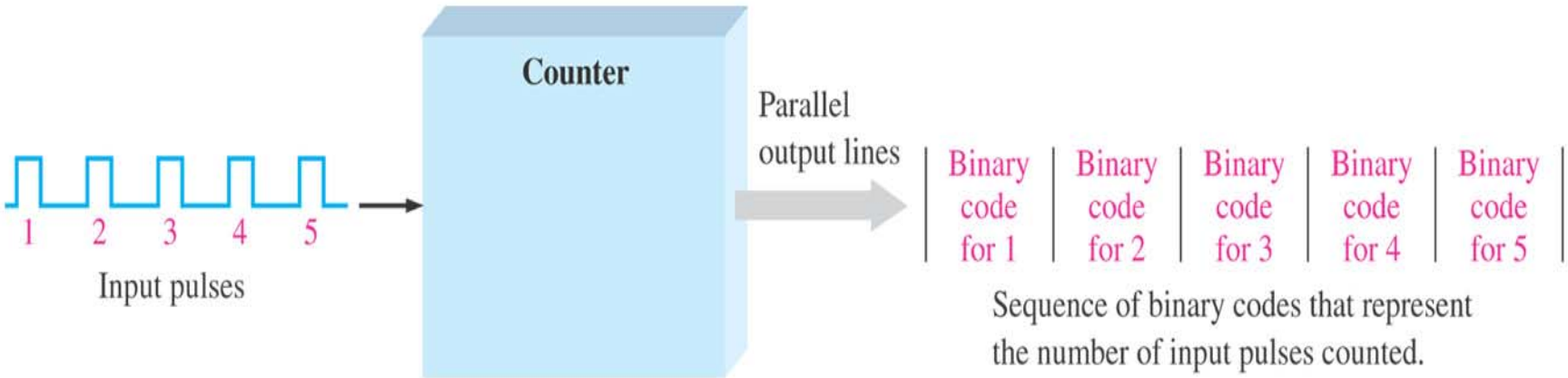
Fourth bit (0) is shifted into register and the first, second, and third bits are shifted right. The register now stores all four bits and is full.

Examples of registers(2)
- parallel shift register -



The Counting Function

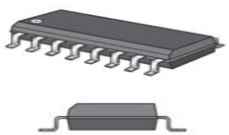
- As its' name, the counter is used to count events represented by changing levels or pulses
- Important characteristics: storage capabilities
- Flip-flop are used to implement counting



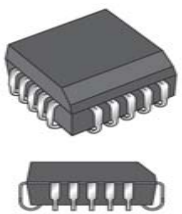
1-5 Fixed Function Integrated Circuit (IC) (1)

- Logic elements and functions can be found available in integrated circuit (IC) form because
  - Small size, high reliability, low cost, low power consumption

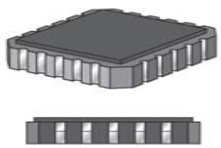
- Monolithic IC – an eletronic circuit that is constructed entirely on a single chip of silicon
- Digital IC can be divided into 2:
  - Fixed-function logic – logic function have been fixed by the manufacturer. Need to refer spec sheet before using it / cannot be changed
  - Programmable logic – logic function can be changed based on the program that we write into the IC
- IC Packages
  - DIP (Dual In Line) – the most common
  - SMT (Surface Mount Technology) – eg. Small outline integrated circuit (SOIC), PLCC (Plastic leaded chip carrier), LCCC (Leadless ceramic chip carrier).
  - others: SSOP, TSSOP and TVSOP



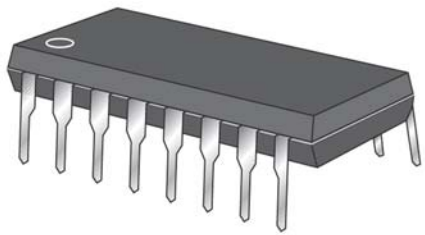
(a) SOIC with "gull-wing" leads

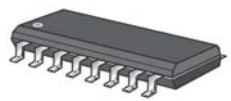


(b) PLCC with J-type leads



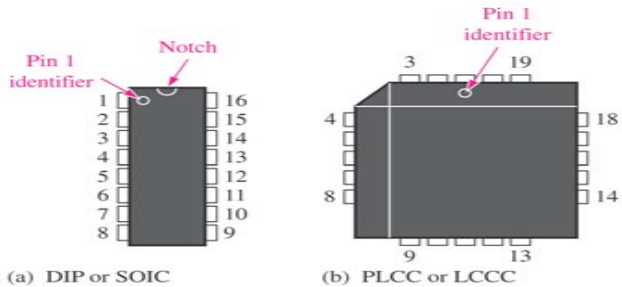
(c) LCCC with no leads (contacts are part of case)


(a) Dual in-line package (DIP)


(b) Small-outline IC (SOIC)

1-5 Fixed Function Integrated Circuit (IC) (2)

- Pins Numbering
  - Pin 1 always marked by an identifier like small dot, a notch, or beveled edge

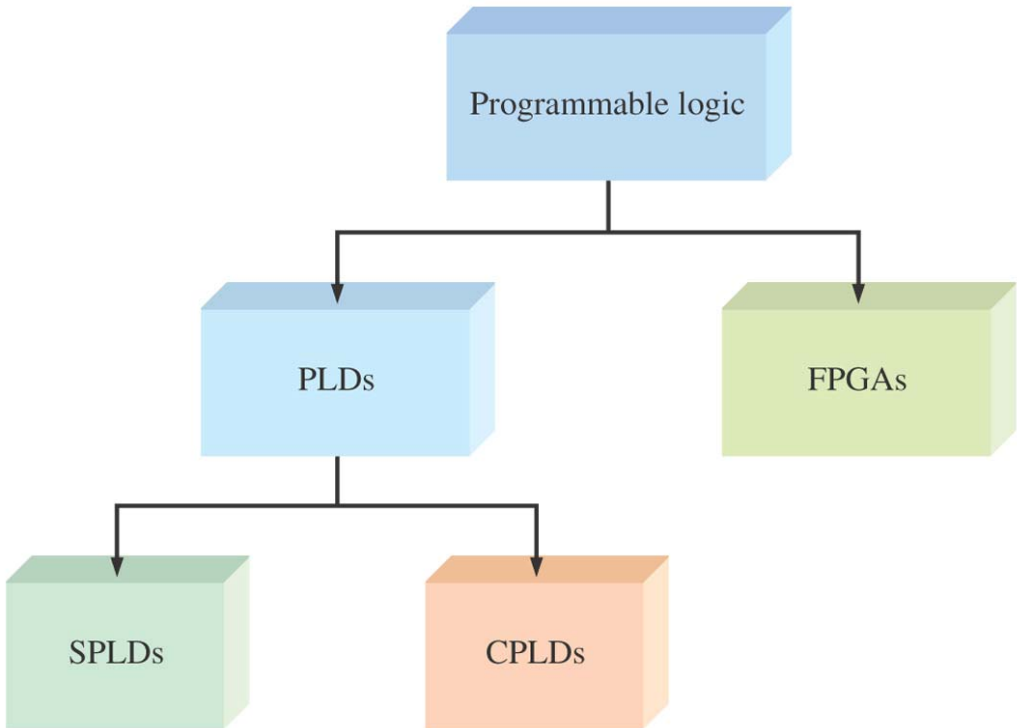


- Complexity Classification for Fixed-Function ICs
  - SSI (Small-scale integration) – 10 gates
  - MSI (Medium-scale integration) – 10—100 gates
  - LSI (Large-scale integration) – 100—10,000 gates
  - VLSI (Very large-scale integration) – 10,000—100,000 gates
  - ULSI (Ultra large-scale integration) -- >100,000 gates
- Integrated Circuits Technology
  - You will come across MOSFETs, CMOS, TTL etc. in this topic

1-6 Introduction to Programmable Logic

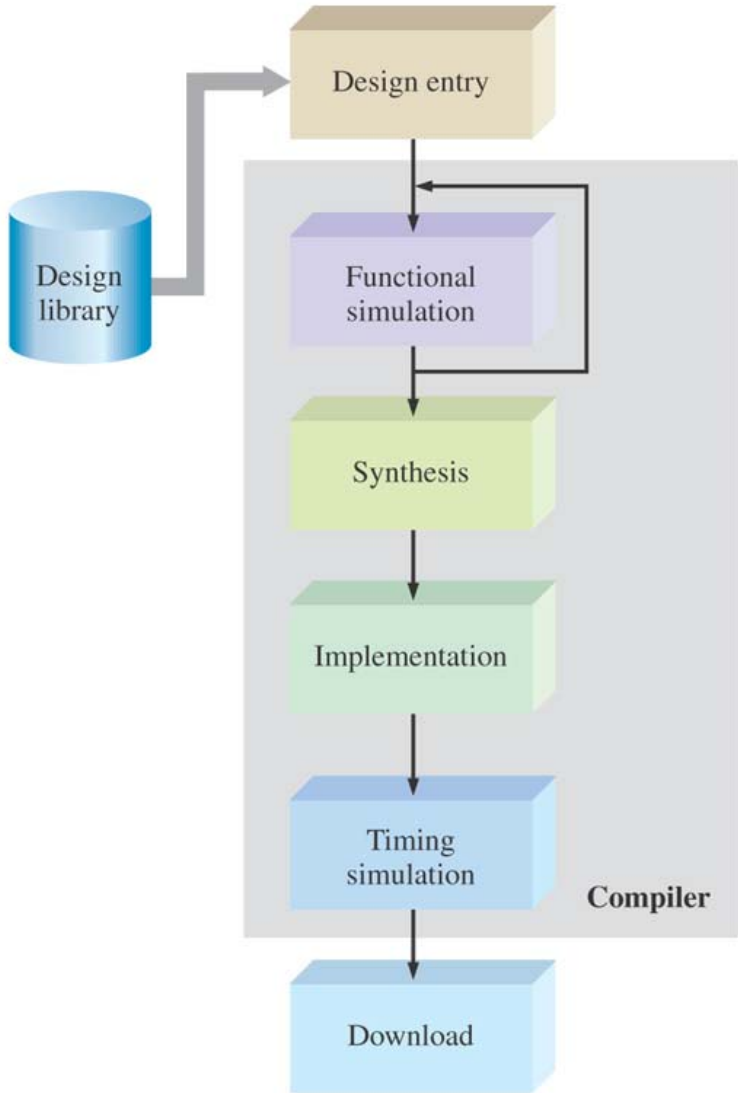
PLD (Programmable Logic Device)

- Types of Programmable Logic Devices
  - SPLD (Single Programmable Logic Device) – there are PAL and GAL
  - CPLD (Complex Programmable Logic Device)
  - FPGA (Field Programmable Gate Array)



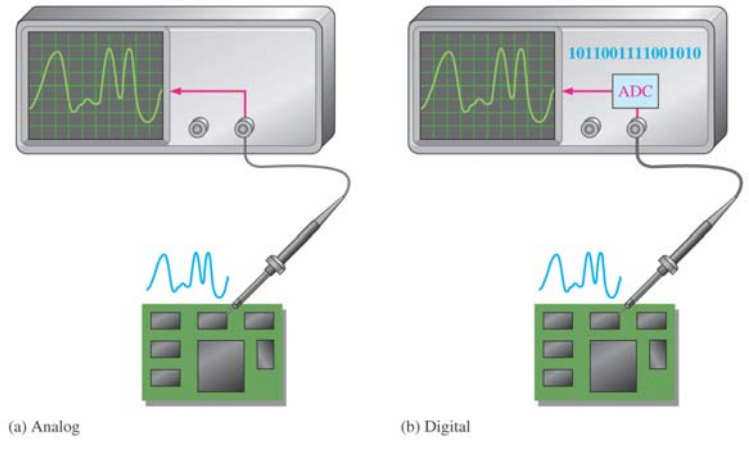
Programming Process

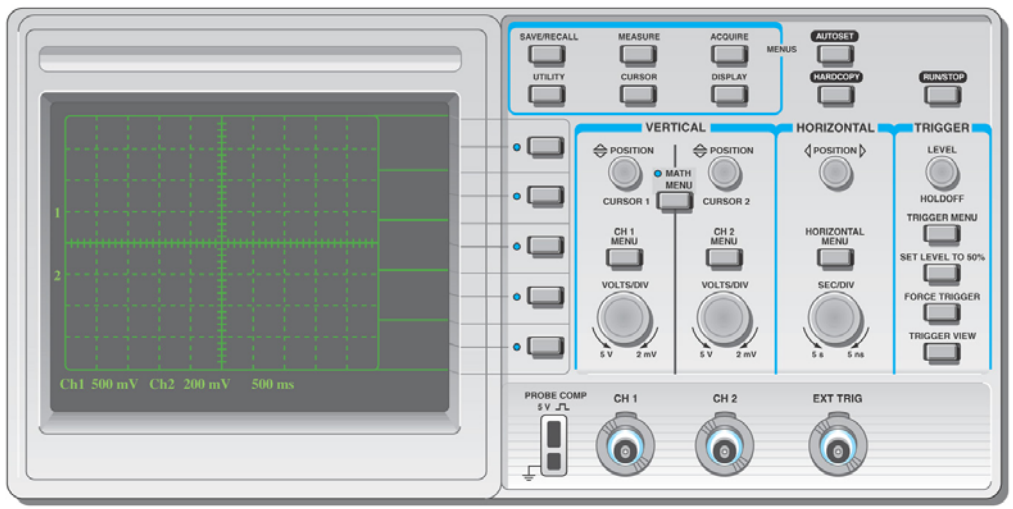
- Design Entry
- Functional Simulation
- Synthesis
- Implementation
- Timing simulation
- Download



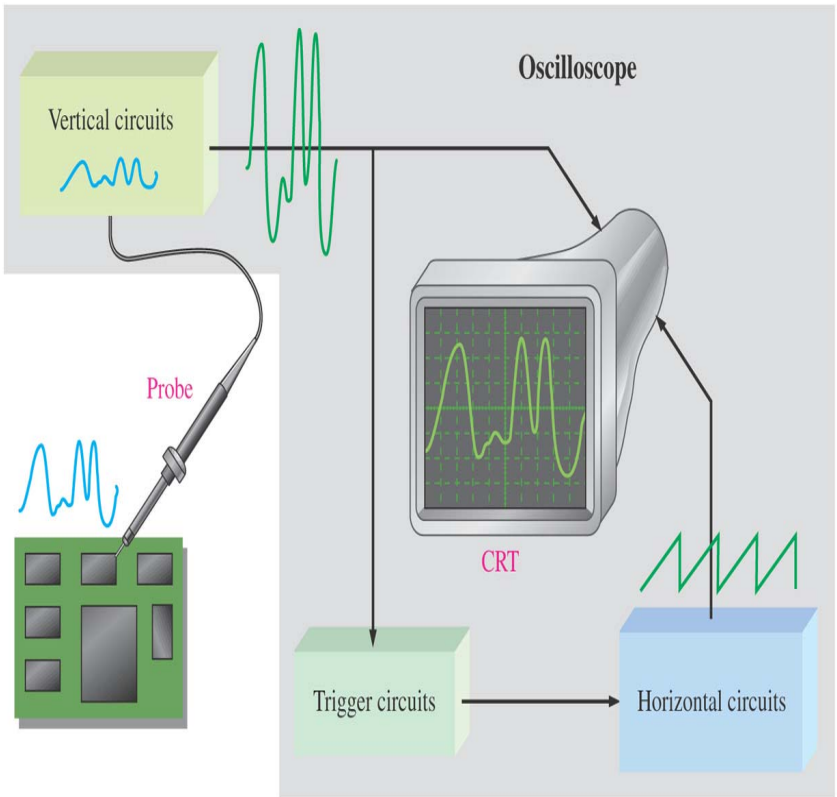
1-7 Test and Measurement Instruments

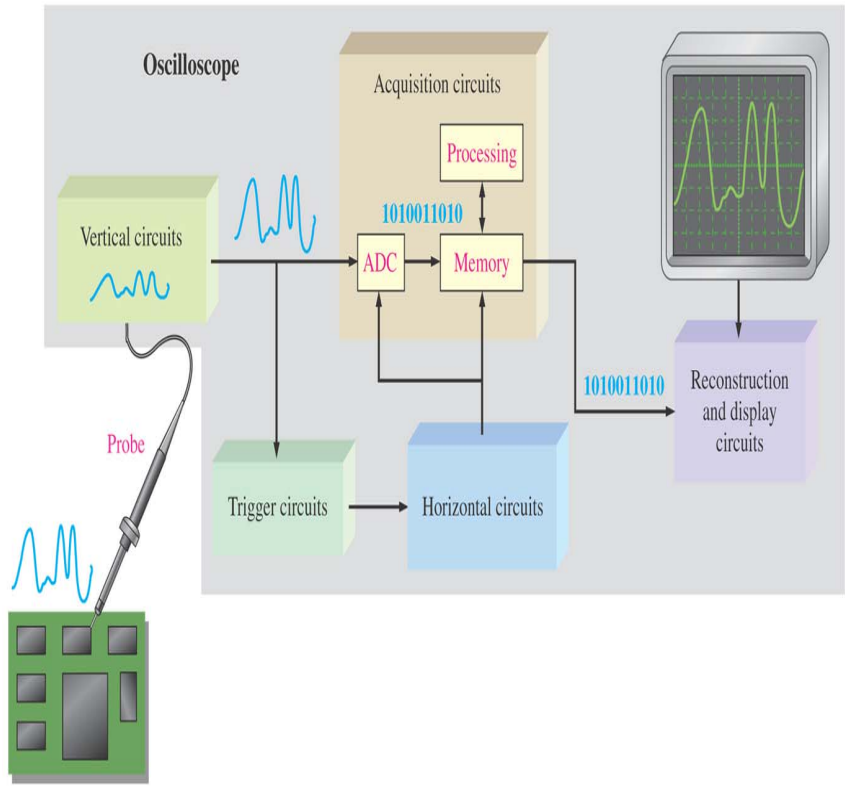
- Instruments are mainly used for testing and troubleshooting
- Troubleshooting – process of systematically isolating, identifying and correcting a fault in a circuit or system
- Oscilloscope
  - Analogue and digital





Block Diagram of Analog and Digital Oscilloscopes





Other Equipments

- The Logic Analyzer
- Signal Generator
  - Waveform generator, function generator
- Others:
  - DC Power Supply

Example Digital System