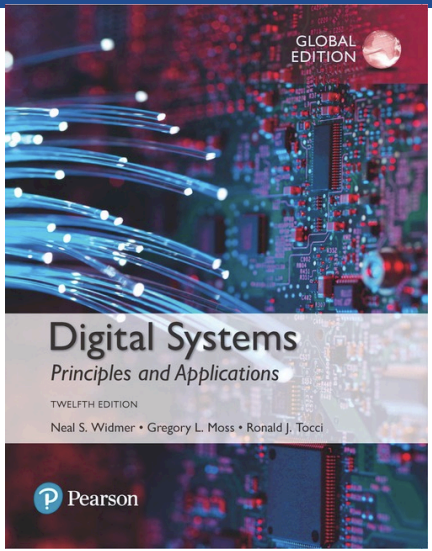
Digital Systems Principles and Applications

TWELFTH EDITION, GLOBAL EDITION



CHAPTER 1

Introductory Concepts

Chapter 1 Objectives

- Distinguish between analog and digital representations.
- Describe how information can be represented using just two states (1s and 0s).
- Cite the advantages and drawbacks of digital techniques compared with analog.

Chapter 1 Objectives

- Describe the purpose of analog-to-digital converters (ADCs) and digital-to-analog converters (DACs).
- Recognize the basic characteristics of the binary number system.
- Convert a binary number to its decimal equivalent.
- Count in the binary number system.
- Identify typical digital signals.

Chapter 1 Objectives

- Identify a timing diagram.
- State the differences between parallel and serial transmission.
- Describe the property of memory.
- Describe the major parts of a digital computer and understand their functions.
- Distinguish among microcomputers, microprocessors, and microcontrollers.

1-1 Introduction to Digital 1s and 0s

- A large part of the worldwide telecommunications system falls in the category of "digital systems."
- It started as a simple digital system that used only two states to represent information.

1-1 Introduction to Digital 1s and 0s

- The telegraph system used two distinct "symbols" to transmit any word or number.
  - Short & long electric pulses, the dots & dashes of Morse code—a digital representation of information.
- The electric signal is either ***on*** or ***off*** at all times.
  - This relates to modern digital systems that use electrical signals to represent 1s and 0s.

1-1 Introduction to Digital 1s and 0s

- A timing diagram shows which state (1 or 0) the system is in at any point in time.
- And shows the time when a change in state occurs.

1-1 Introduction to Digital 1s and 0s

- By displaying one or more digital signals using test instruments such as an oscilloscope, we can compare actual signals to expected operation.

1-2 Digital Signals

- When a circuit like this is placed in service, it will output a 1 at night and a 0 during the day. At some point around dawn, it will change from a 1 to a 0. Around dusk, it will change from a 0 to a 1. This transition between the two states is called an edge .

1-2 Digital Signals

- Digital circuits have inputs that are in one of two states: 1 or 0. The outputs are also either producing a 1 or a 0.
- When a system operates such that the time for one complete cycle is always constant, it is called a periodic system.

1-3 Logic Circuits and Evolving Technology

- The manner in which a digital circuit responds to an input is referred to as the circuit's logic.
- Digital circuits of today's technology are primarily implemented using very sophisticated integrated circuits (ICs) that are electronically configured or tailor-made for their application.

1-4 Numerical Representations

- Physical systems use quantities which must be manipulated arithmetically.
- Quantities may be represented numerically in either analog or digital form.

1-4 Numerical Representations

- Analog Representation—a continuously variable, proportional indicator.
  - Sound through a microphone causes voltage changes.
  - Automobile speedometer changes with speed.
  - Mercury thermometer varies over a range of values with temperature.

1-4 Numerical Representations

- In 1875, Alexander Graham Bell figured out how to change his voice into a continuously variable electrical signal, send it through a wire, and change it back to sound energy at the other end.
- Digital Representation—varies in discrete (separate) steps.

1-4 Numerical Representations

- Passing time is shown as a change in the display
on a digital clock at one minute intervals.
- A change in temperature is shown on a digital
display only when the temperature changes
at least one degree.

1-5 Digital and Analog Systems

- Digital system:
  - A combination of devices that manipulate values represented in digital form.
- Analog system:
  - A combination of devices that manipulate values represented in analog form.

1-5 Digital and Analog Systems

- Advantages of digital:
  - Ease of design
  - Well suited for storing information.
  - Accuracy and precision are easier to maintain.
  - Programmable operation.
  - Less affected by noise.
  - Ease of fabrication on IC chips.

1-5 Digital and Analog Systems

- There are limits to digital techniques:
- The analog nature of the world requires a time consuming conversion process:
  - Convert the physical variable to an electrical signal (analog).
  - Convert the analog signal to digital form.
  - Process (operate on) the digital information.
  - Convert the digital output back to real-world analog form.

1-5 Digital and Analog Systems

- A digital system is a combination of devices designed to manipulate logical information or physical quantities represented in digital form.
  - Quantities can take on only discrete values.
- An analog system manipulates physical quantities represented in analog form.
  - Quantities can vary over a continuous range of values.

1-5 Digital and Analog Systems

- Party-line callers encoded a person's ID by the way they cranked their telephone.
- The rotary-dial phone used a series of pulses, representing the ten decimal digits.

1-5 Digital and Analog Systems

- Chief reasons for the shift to digital technology:
  - Digital systems are generally easier to design.
  - Information storage is easy.
  - Accuracy and precision are easier to maintain throughout the system.
  - Operations can be programmed.
  - Digital circuits are less affected by noise.

1-5 Digital and Analog Systems

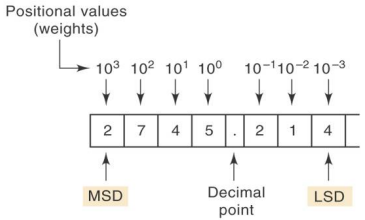
- More digital circuitry can be fabricated on IC chips.

1-6 Digital Number Systems

- Understanding digital systems requires an understanding of the decimal, binary, octal, and hexadecimal numbering systems.
  - Decimal – 10 symbols (base 10)
  - Hexadecimal – 16 symbols (base 16)
  - Octal – 8 symbols (base 8)
  - Binary – 2 symbols (base 2)

1-6 Digital Number Systems

- The Decimal (base 10) System
- 10 symbols: 0, 1, 2, 3, 4, 5, 6 , 7, 8, 9.
- Each number is a digit (from Latin for finger).

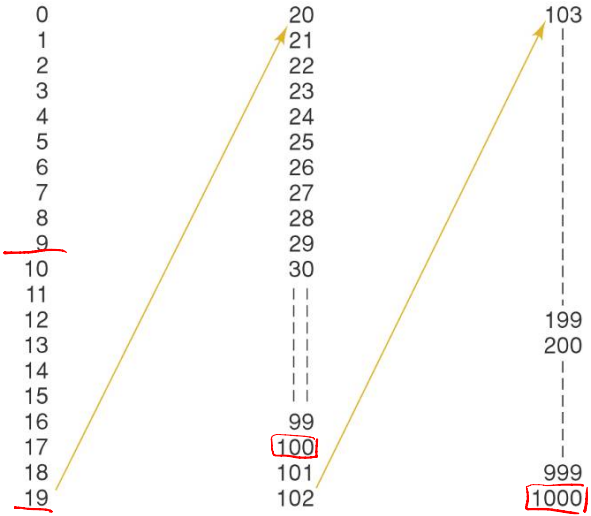


Most significant digit (MSD) & least significant digit (LSD).

Positional value may be stated as a digit multiplied by a power of 10.

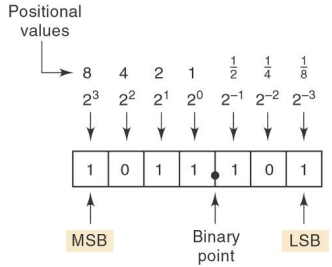
1-6 Digital Number Systems

- Decimal Counting



1-6 Digital Number Systems

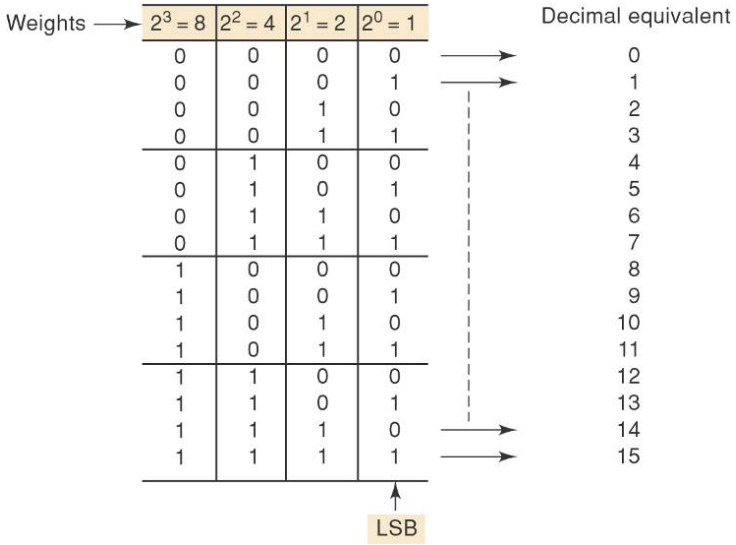
- The Binary (base 2) System
  - 2 symbols: 0,1
    - Lends itself to electronic circuit design since only two different voltage levels are required.



Positional value may be stated as a digit multiplied by a power of 2.

1-6 Digital Number Systems

Binary Counting

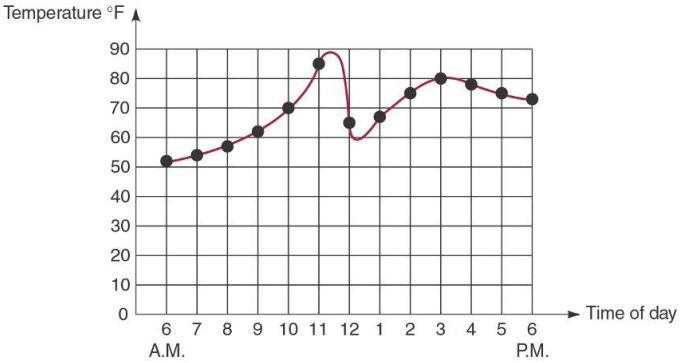


1-7 Representing Binary Quantities

- Analog signals can be converted to digital by taking measurements or "samples" of the continuously varying signal at regular intervals.
- Appropriate time between samples depends on
  the maximum rate of change of the analog signal.

1-7 Representing Binary Quantities

- Air temperature is an analog quantity.
- Recorded samples are discrete integer data.



1-7 Representing Binary Quantities

- Two state devices:
  - Light bulb (off or on)
  - Diode (conducting or not conducting)
  - Relay (energized or not energized)
  - Transistor (cutoff or saturation)
  - Photocell (illuminated or dark)

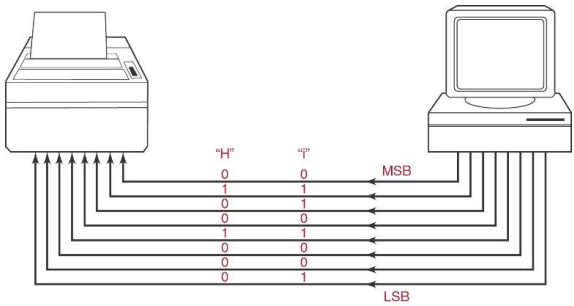
1 0

1-7 Representing Binary Quantities

- The oscilloscope and logic analyzer are used to produce timing diagrams.
- Timing diagrams show voltage versus time.
- Used to show how digital signals change with time,
  or to compare two or more digital signals.

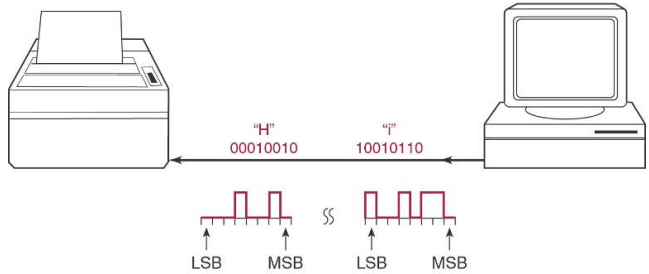
1-8 Parallel and Serial Transmission

- Parallel transmission – all bits in a binary number are transmitted simultaneously.
- A separate line is required for each bit.



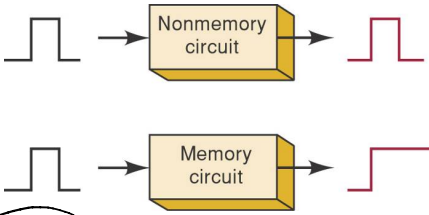
1-8 Parallel and Serial Transmission

- Serial transmission – each bit in a binary number is transmitted, per some time interval.



1-9 Memory

- A circuit which retains a response to a momentary input is displaying memory.
- Memory is important because it provides a way to store binary numbers temporarily or permanently.



hard disk

tape

Memory elements: magnetic, optical, electronic latching circuits.

1-10 Digital Computers

- A computer is a system of hardware that performs arithmetic operations, manipulates data, and makes decisions.
- Performs operations based on instructions in the form of a program at high speed, and with a high degree of accuracy.

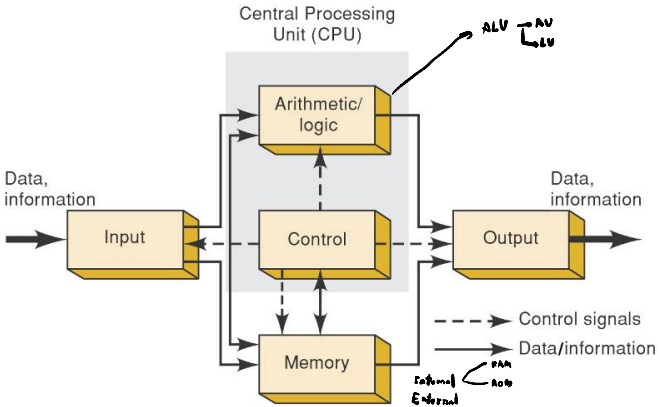
1-10 Digital Computers

- Major parts of a computer:
- Input unit—Processes instructions and data into the memory.
- Memory unit—Stores data and instructions.
- Control unit—Interprets instructions and sends appropriate signals to other units as instructed.

1-10 Digital Computers

- Arithmetic/logic unit—arithmetic calculations and logical decisions are performed.
- Output unit—presents information from the memory to the operator or process.

1-10 Digital Computers



The control and arithmetic/logic units are often treated as one and called the central processing unit (CPU).

1-10 Digital Computers

- Types of computers:
  - Microcomputer.
    - Most common (desktop PCs).
    - Has become very powerful.
  - Minicomputer (workstation).
  - Mainframe.
  - Microcontroller.
    - Designed for a specific application.

1-10 Digital Computers

- Dedicated or embedded controllers.
- Used in appliances, manufacturing processes, auto ignition systems, ABS systems, and many other applications.

1-10 Digital Computers

- When you speak into your phone, the voice signal is converted to a string of digital (binary) numbers.
- Signals get separated and routed to the proper place by digital multiplexers and demultiplexers.

1-10 Digital Computers

- There are many needs in the world that digital technology can meet.
- You will be able to become one of the pioneers on these new frontiers of technology.