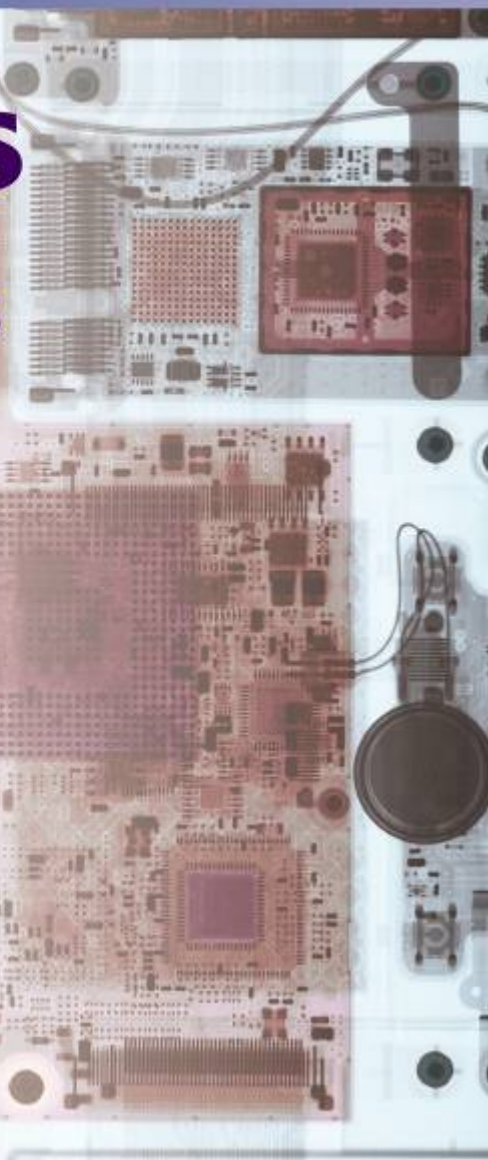
Chapter 1 – Introductory Concepts-skipped Dr. Xu

ELEVENTH EDITION

Digital Systems

Principles and Applications



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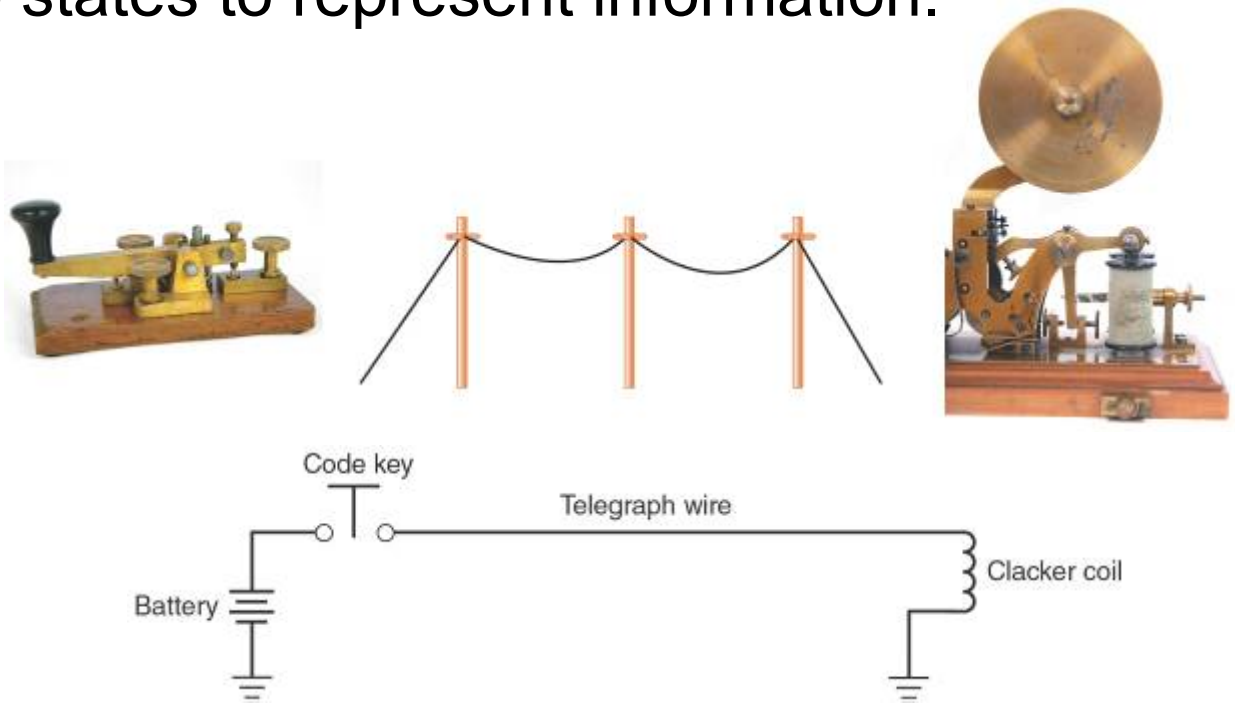
Chapter 1 Objectives

- *Selected areas covered in this chapter*:
  - Analog & digital representations.
    - How information is represented using two states.
  - Advantages/drawbacks of digital/analog techniques.
    - Analog-to-digital and digital-to-analog converters.
  - Basic characteristics of the binary number system.
    - Convert binary numbers to decimal equivalents.
  - Identify typical digital signals & a timing diagram.
  - Differences between parallel & serial transmission.
  - Major parts of a digital computer, their functions.
    - Properties of memory.
  - Distinguish among microcomputers, micro-processors, and micro-controllers.

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.



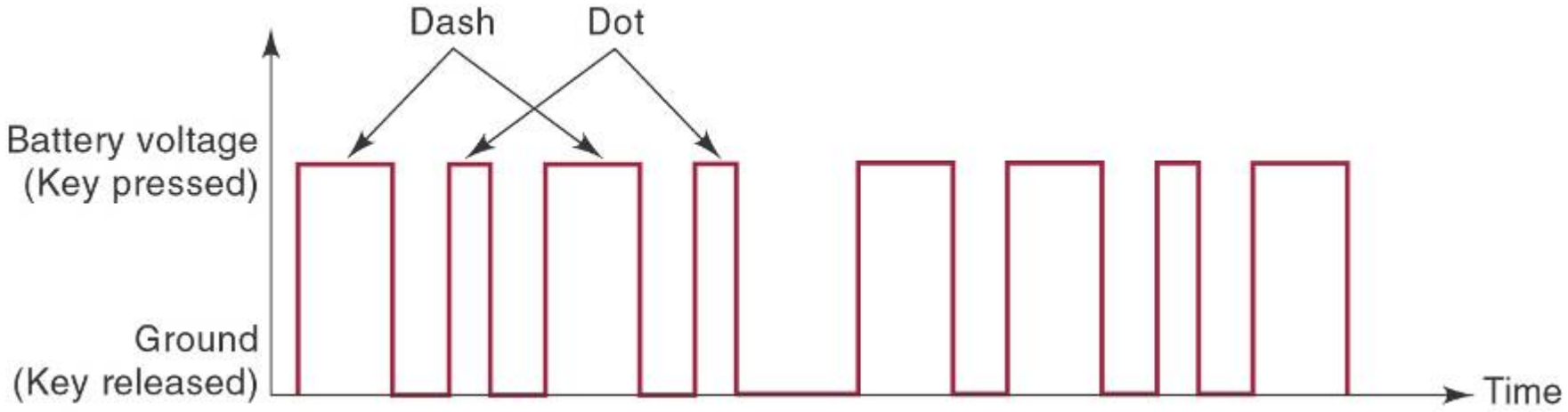
A telegraph system consisted of a battery, a code key (normally open, momentary contact switch), a telegraph wire, and an electromagnetic “clacker.”

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.

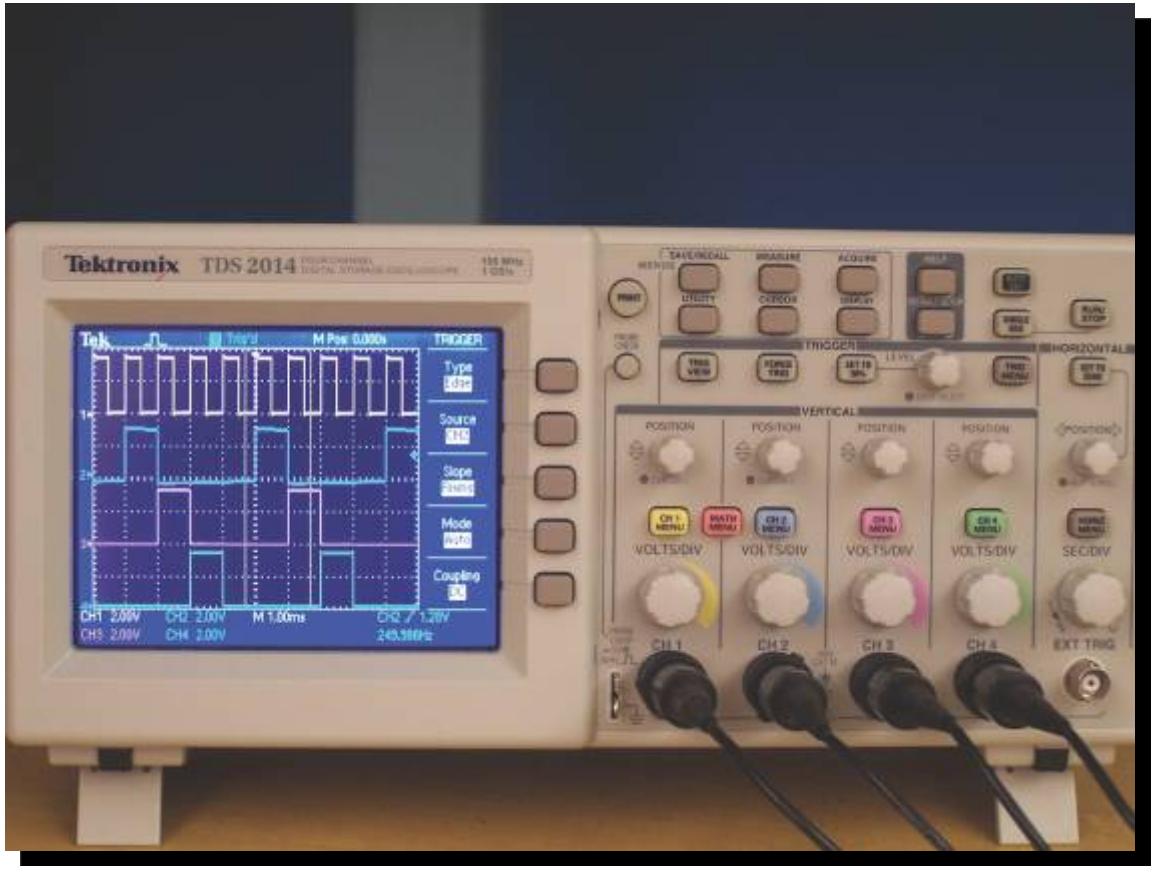
1-1 Introduction to Digital 1s and 0s

- 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 Numerical Representations

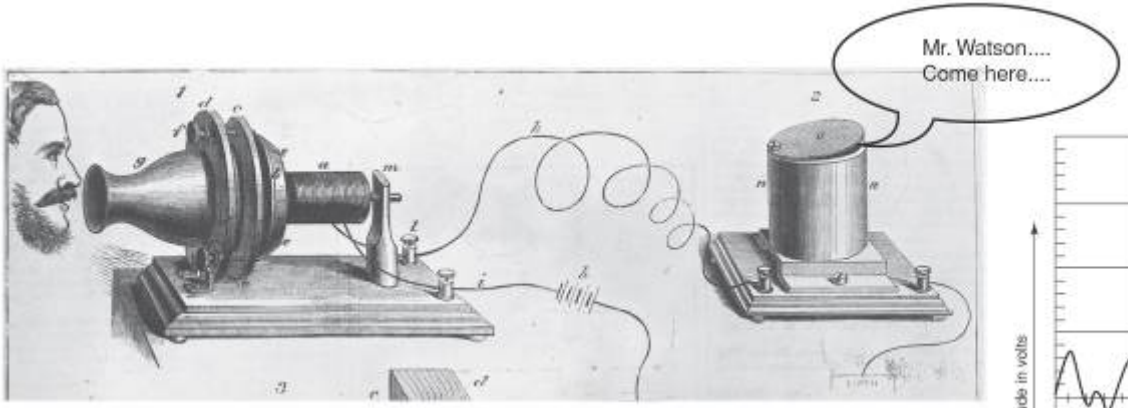
- Physical systems use quantities which must be manipulated arithmetically.
- Quantities may be represented numerically in either analog or digital form.

1-2 Numerical Representations

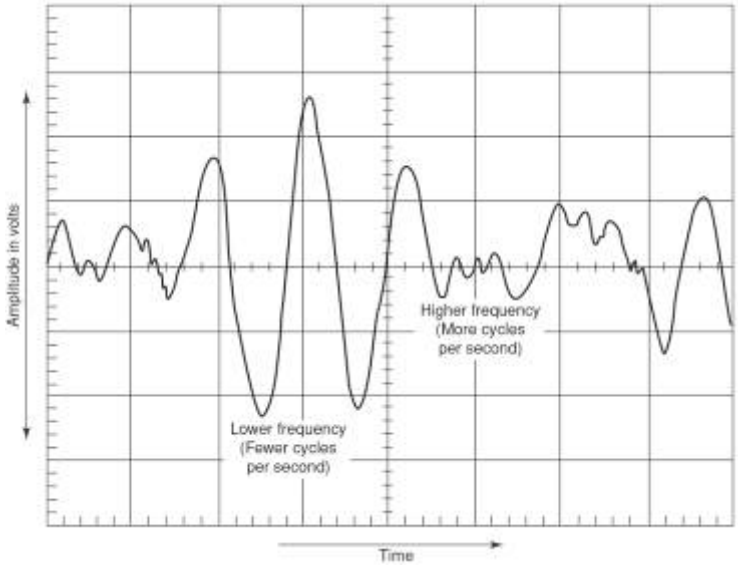
- Analog Representation—a continuously variable, proportional indicator.
  - Sound through a microphone causes voltage changes.
  - Automobile speedometer changes with speed.
  - Mercury thermometer varies over a range of values with temperature.

1-2 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.



Today, the device that converts sound energy to an analog voltage signal is known as a microphone.



1-2 Numerical Representations

- Digital Representation—varies in discrete (separate) steps.
  - 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.

1-3 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.

1-3 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.

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

1-3 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.

1-3 Digital and Analog Systems

- Party-line callers *encoded* a person's ID by the way they cranked their telephone.

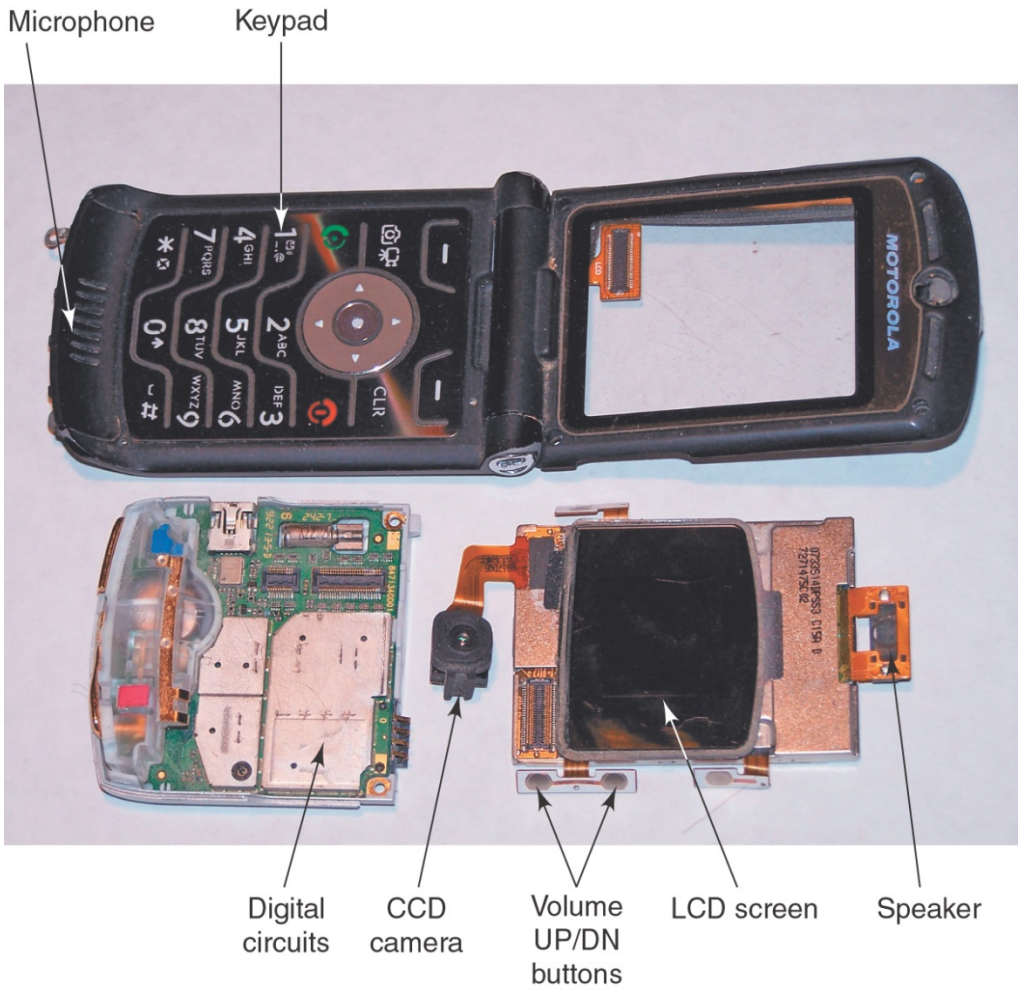
The signaling (rings) used digital representation, but voice communication was purely analog.

- The rotary-dial phone used a series of pulses, representing the ten decimal digits.

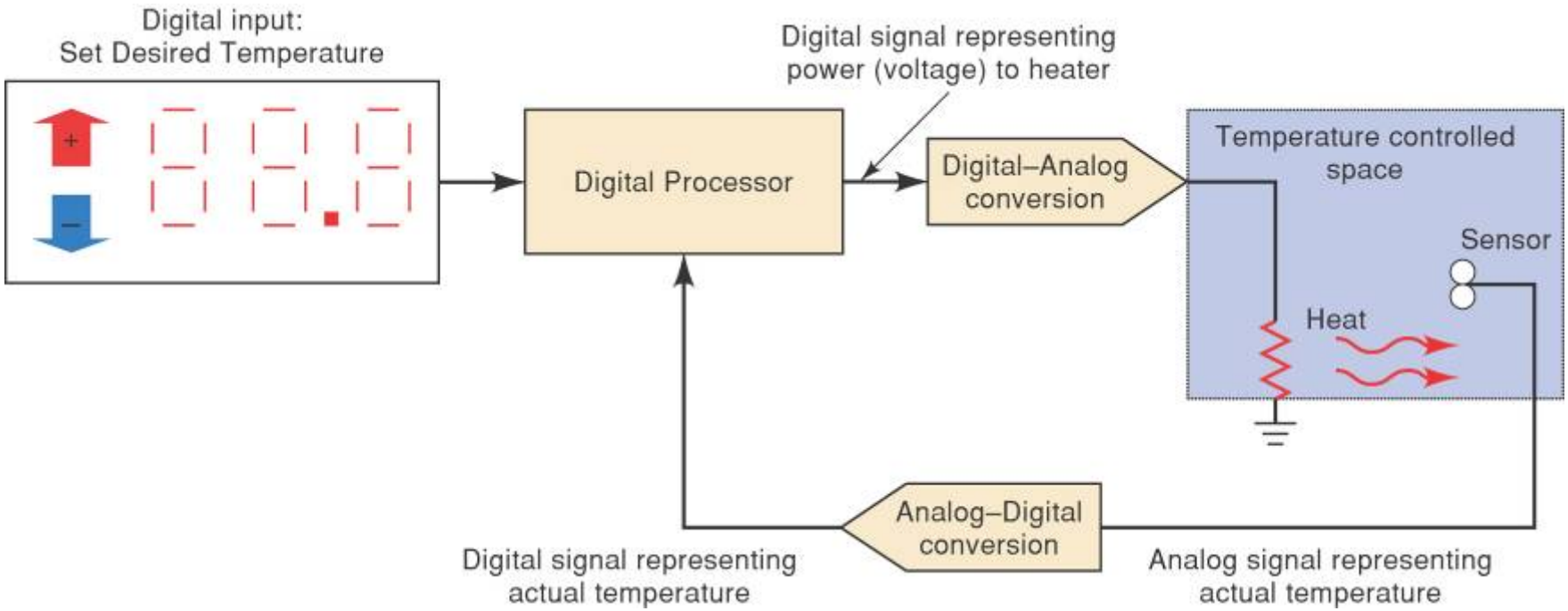
- In “touch-tone” phones, digital switching information is sent using analog tone signals.

1-3 Digital and Analog Systems

The cell phone has digital & analog components, and uses *both* types of signals.



Temperature-regulation system using an analog-to-digital converter.



1-3 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.
  - More digital circuitry can be fabricated on IC chips.

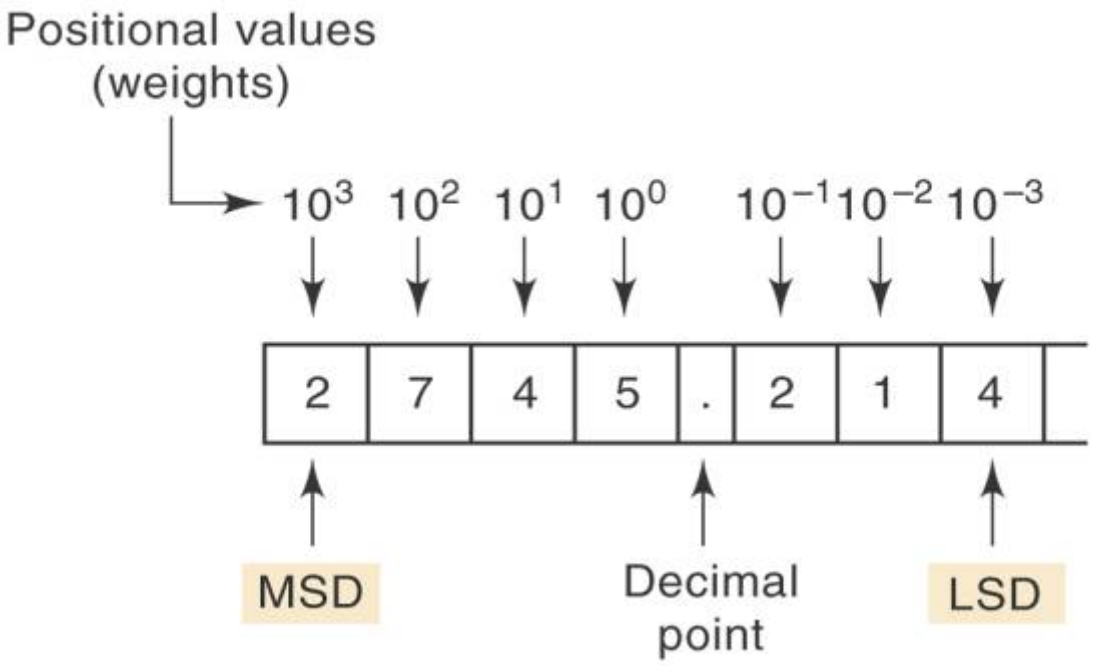
There have been remarkable recent advances in digital technology.

Advances will continue as digital technology expands and improves.

1-4 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)

- 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*).

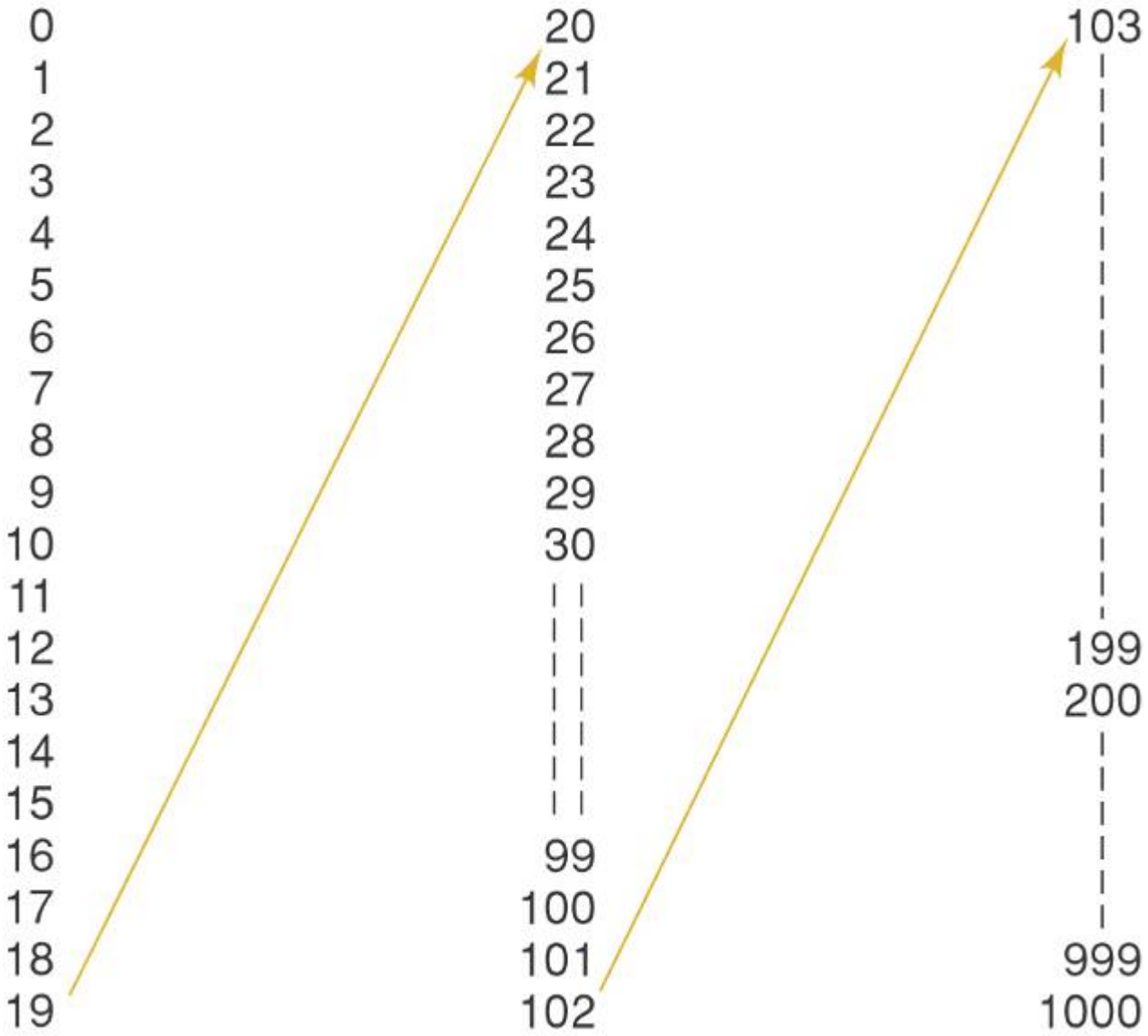


Most significant digit (MSD) & least significant digit (LSD).

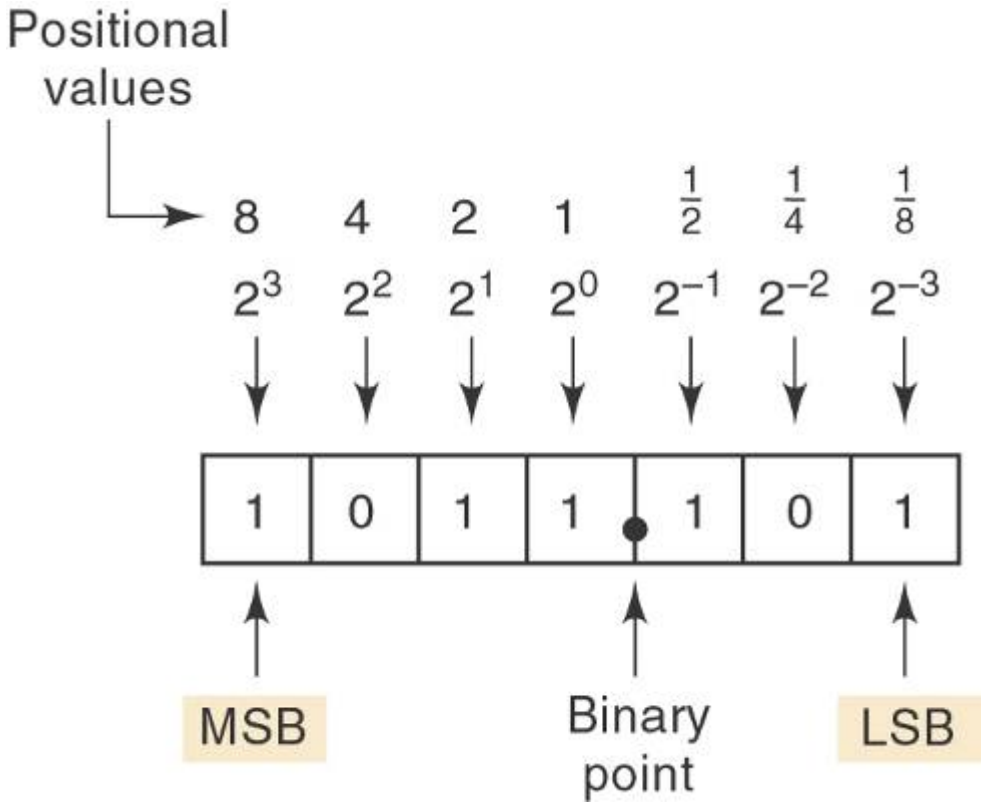
Positional value may be stated as a digit multiplied by a power of 10.

1-4 Digital Number Systems

Decimal Counting



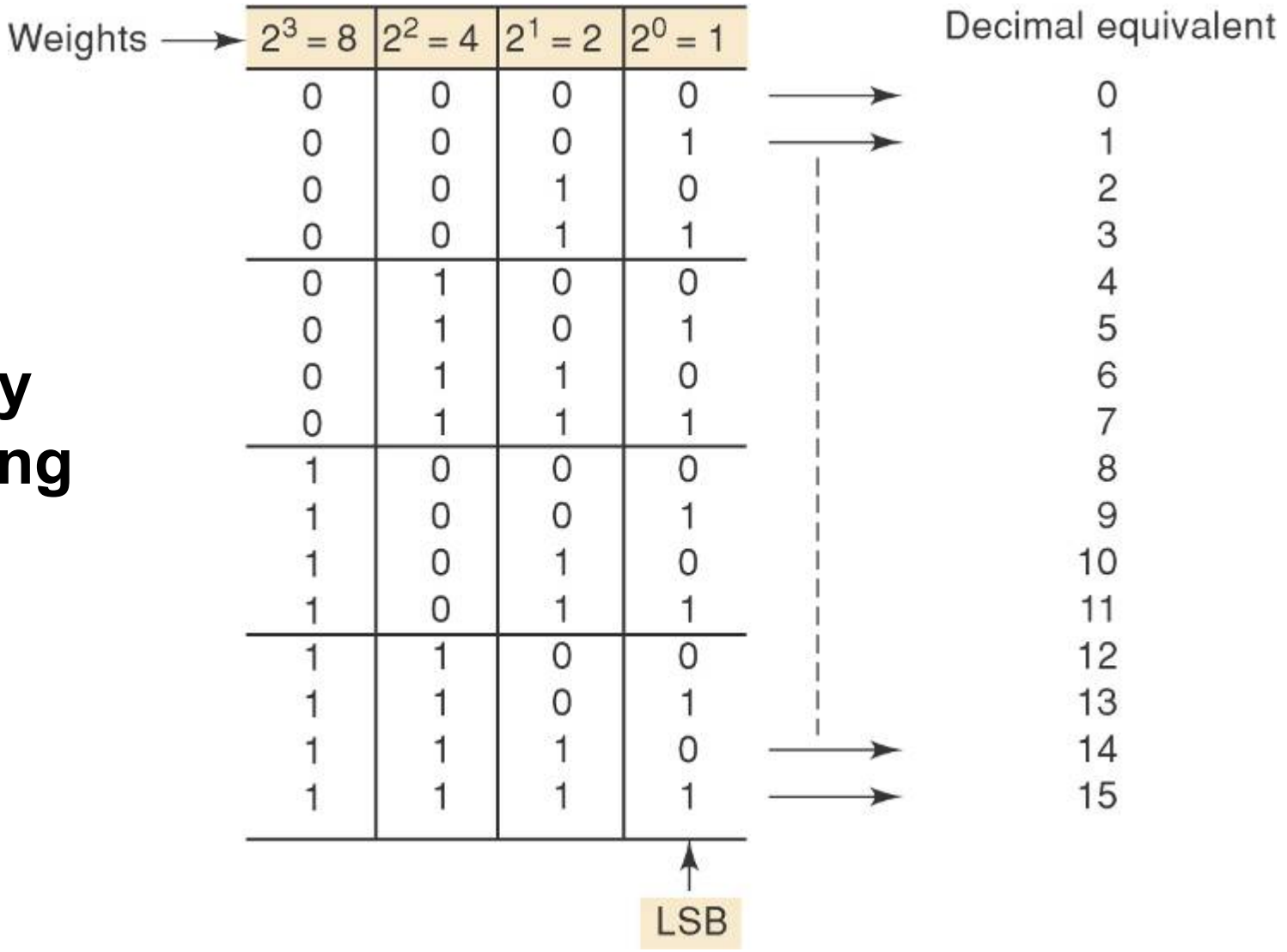
- The Binary (base 2) System
  - 2 symbols: 0,1
    - Lends itself to electronic circuit design since only two different voltage levels are required.



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

1-4 Digital Number Systems

Binary Counting

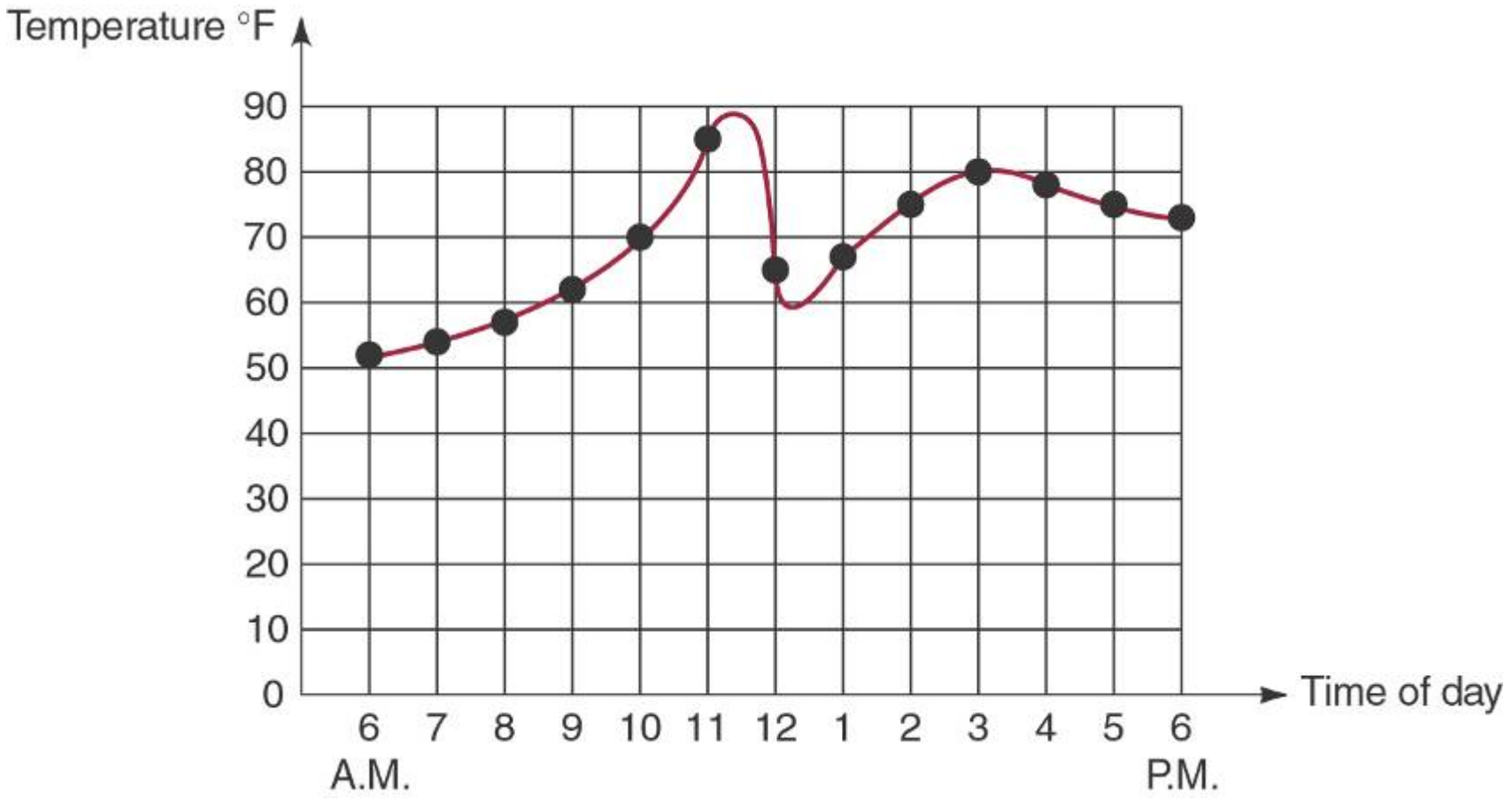


1-5 Representing Binary Quantities

- 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.

1-5 Representing Binary Quantities

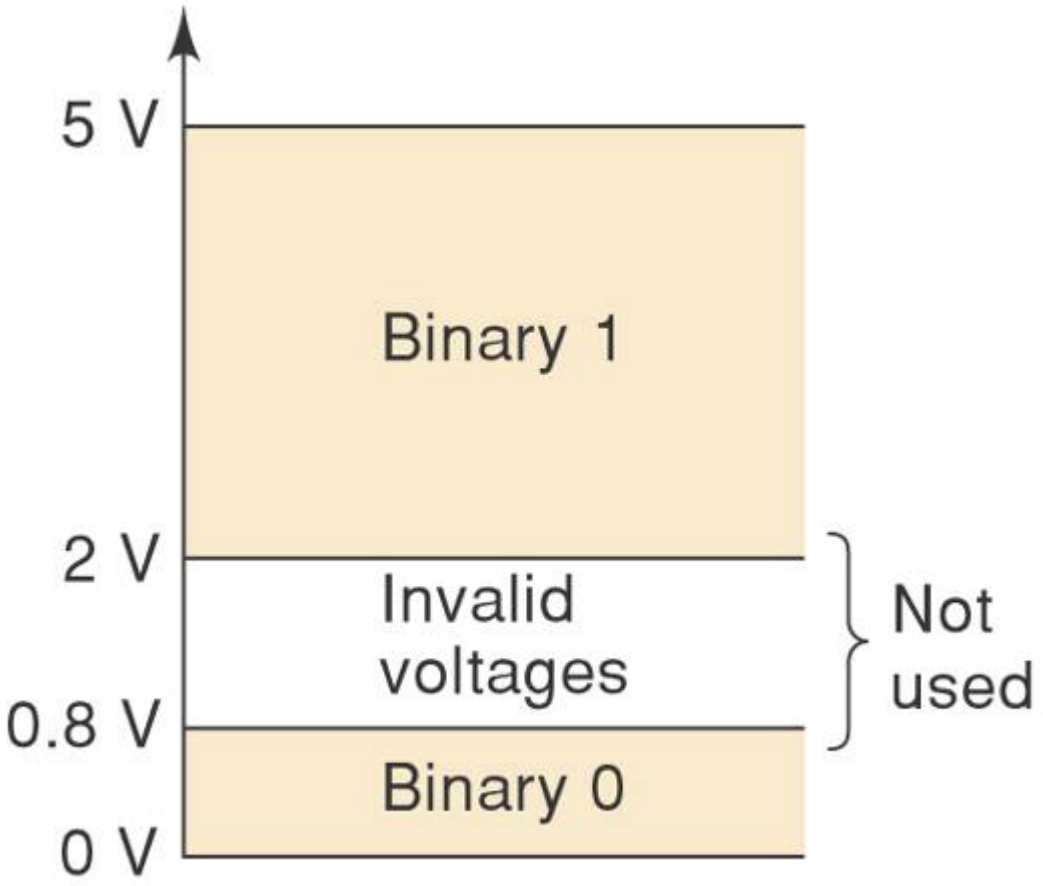
- Air temperature is an analog quantity.
  - Recorded samples are discrete integer data.



Typical representation of the two states of a digital signal.

A *higher* range of voltages represent a valid 1 and a *lower* range of voltages represent a valid 0.

HIGH and LOW are often used to describe the states of a digital system—instead of “1” and “0”

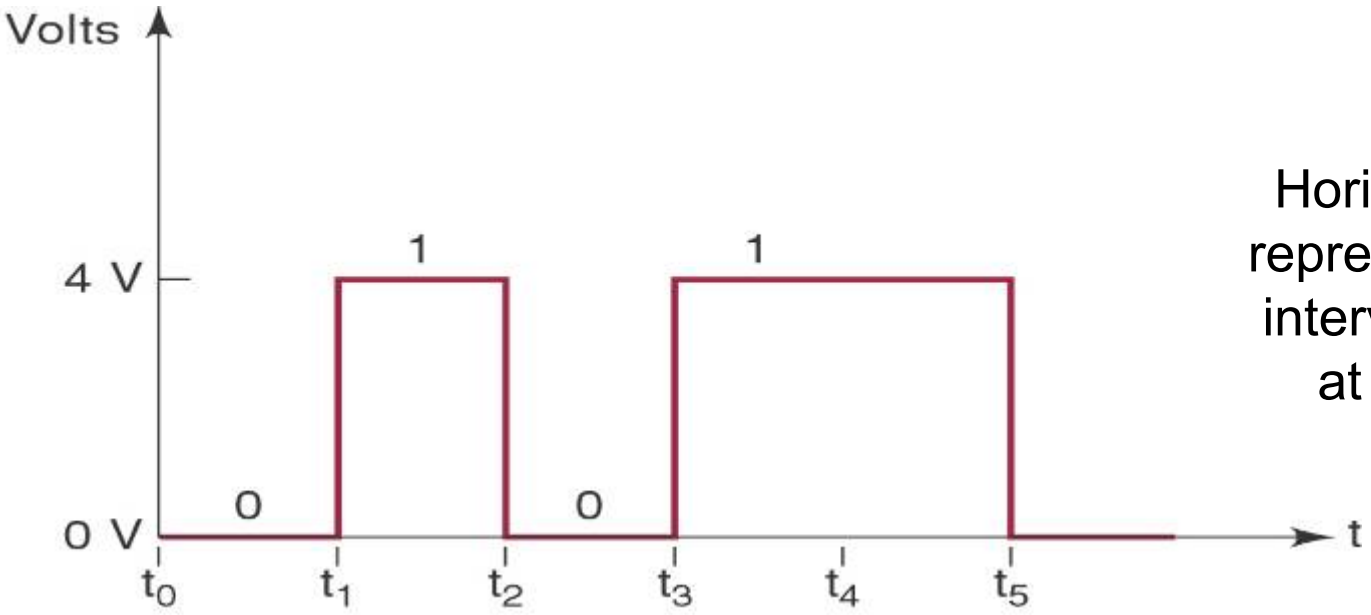


1-5 Representing Binary Quantities

- 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*)

1-5 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.

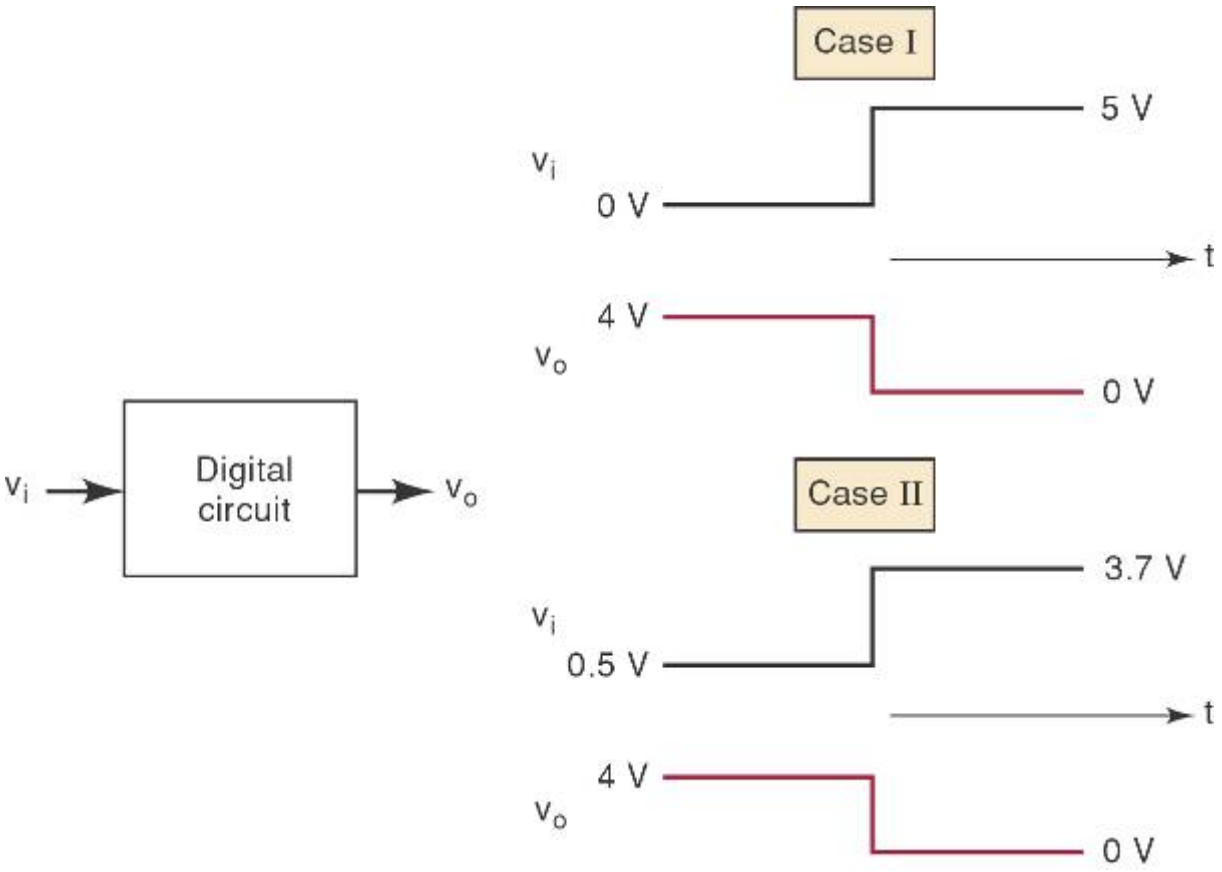


Horizontal scale represents regular intervals, starting at time zero.

1-6 Digital Circuits/Logic Circuits

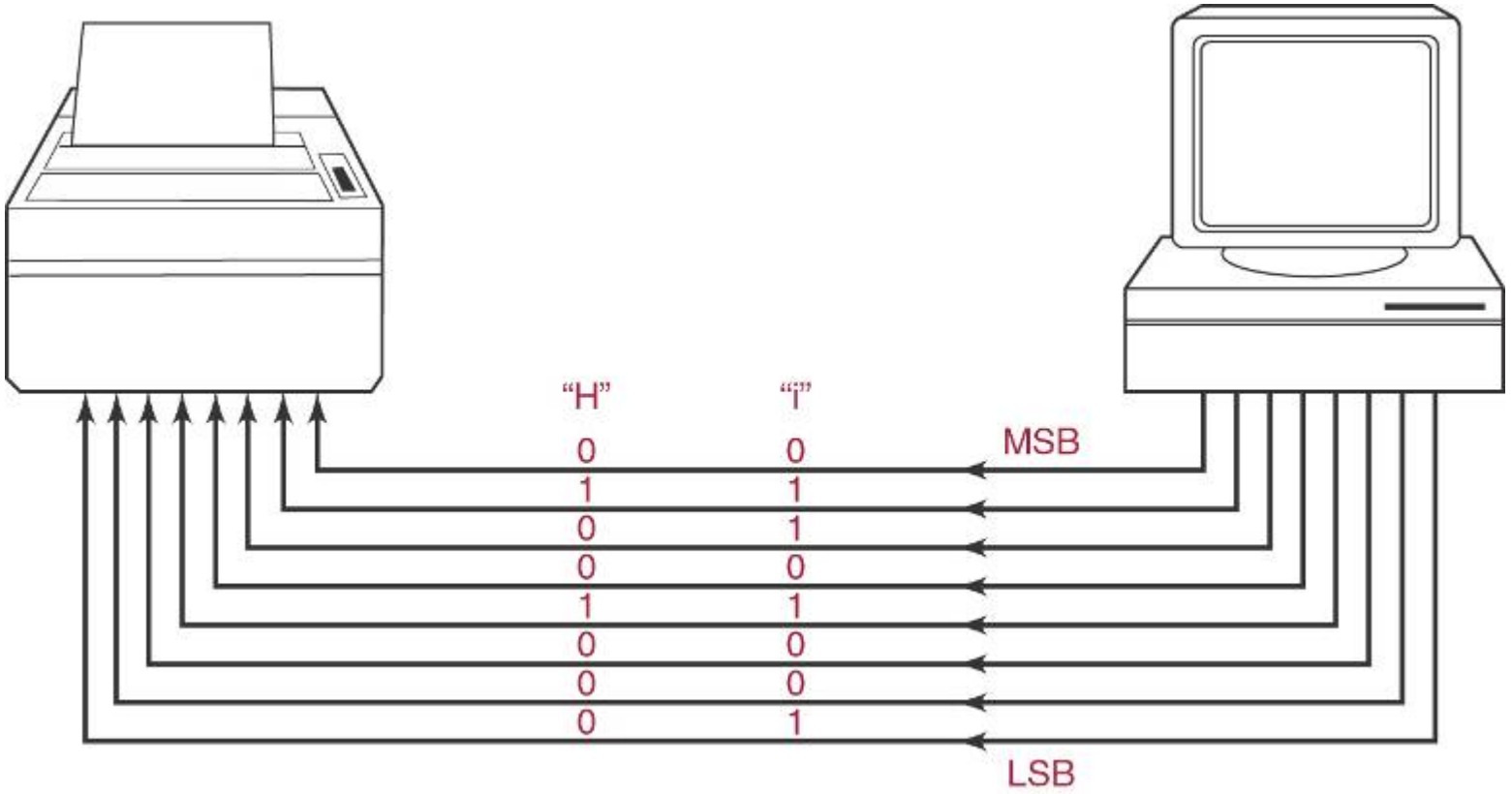
- Digital circuits - produce & respond to predefined voltage ranges.
  - The term *logic circuits* is used interchangeably.

A digital circuit responds to an input's binary level of 0 or 1—not to its actual voltage.



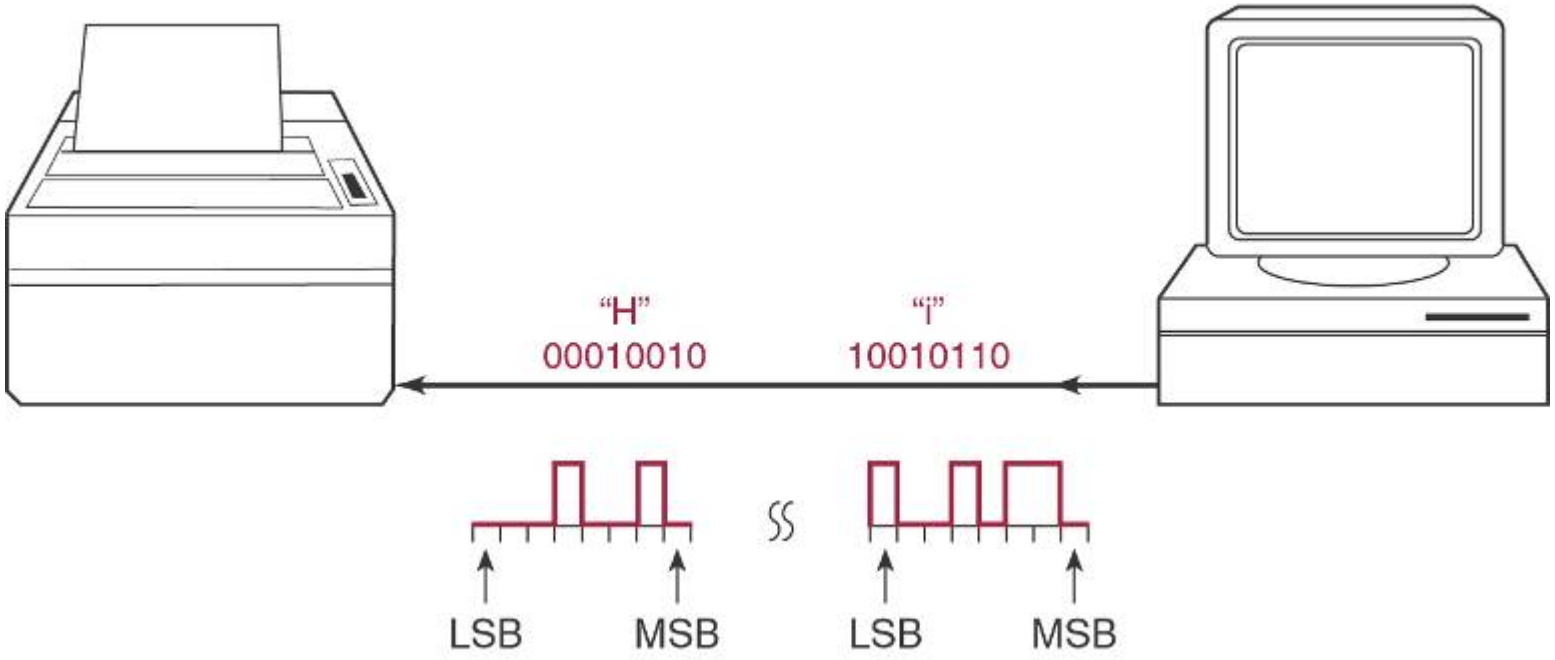
1-7 Parallel and Serial Transmission

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

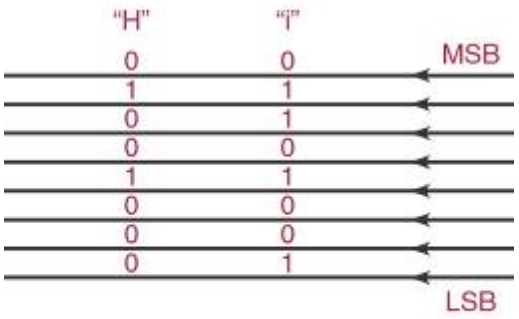


1-7 Parallel and Serial Transmission

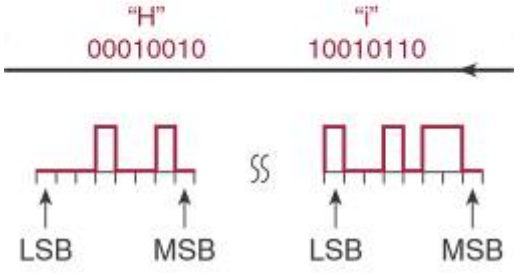
- Serial transmission – each bit in a binary number is transmitted, per some time interval.



Parallel transmission is faster but requires more paths.

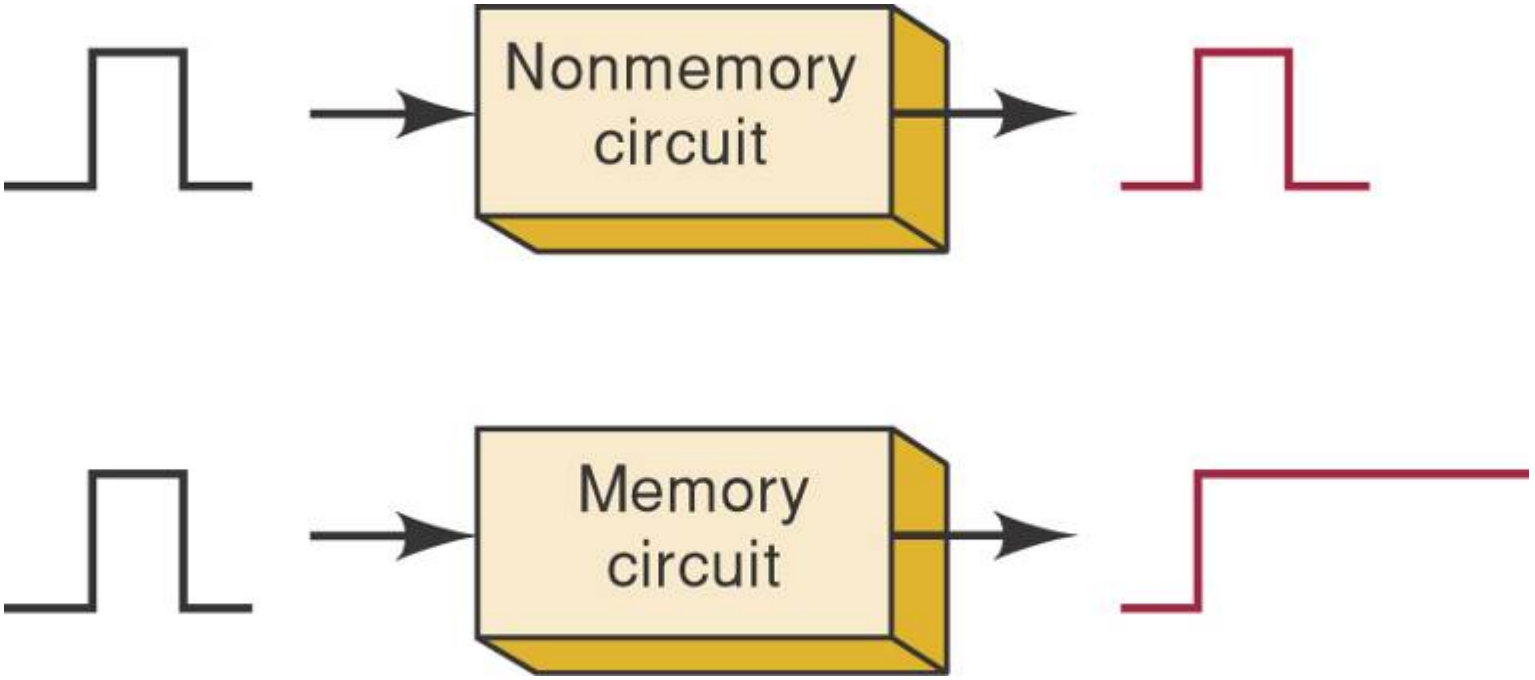


Serial is slower but requires a single path.



1-8 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.



Memory elements: magnetic, optical, electronic latching circuits.

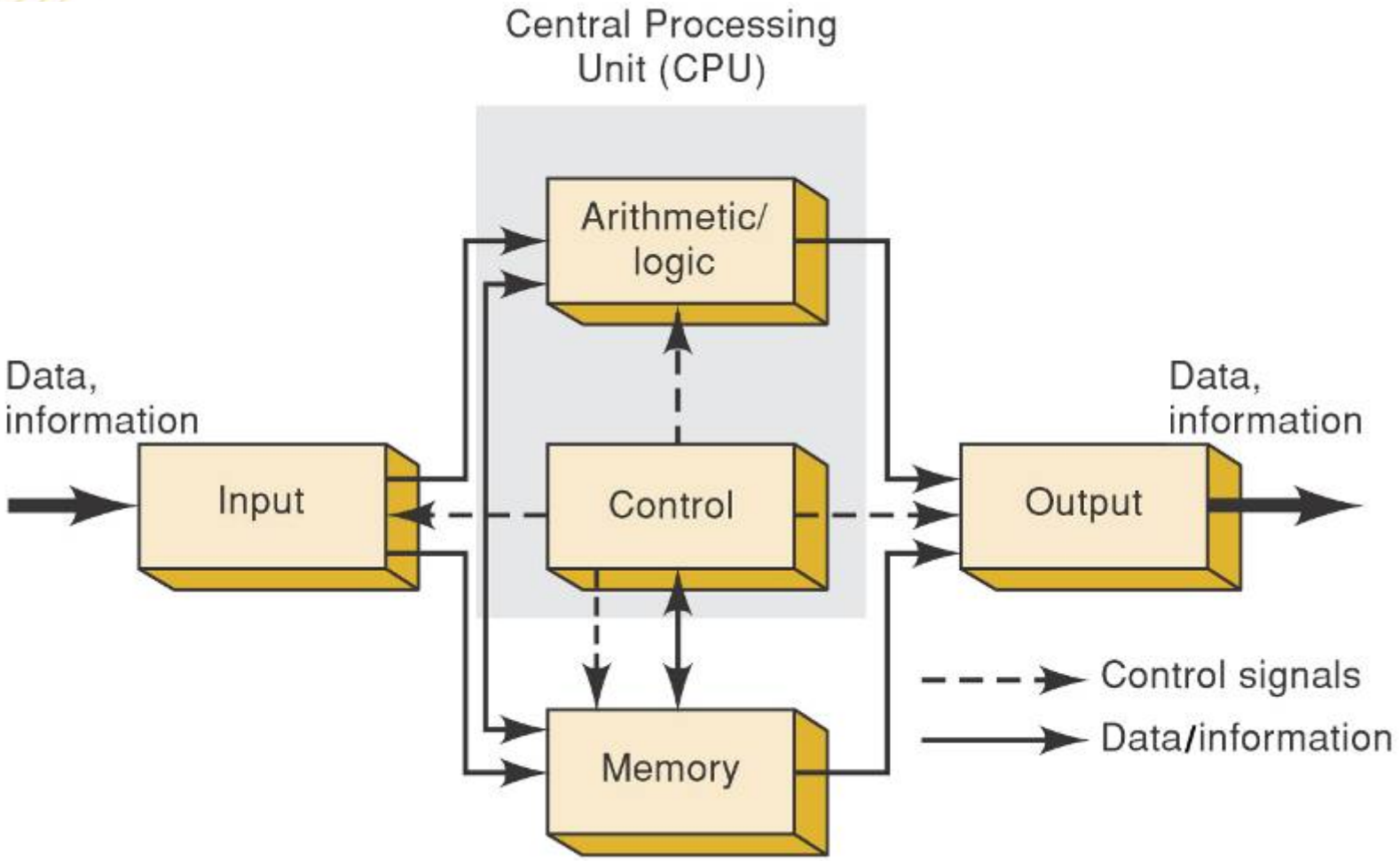
1-9 Digital Computers

- 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.

1-9 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.
  - **Arithmetic/logic unit**—arithmetic calculations and logical decisions are performed.
  - **Output unit**—presents information from the memory to the operator or process.

1-9 Digital Computers



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

1-9 Digital Computers

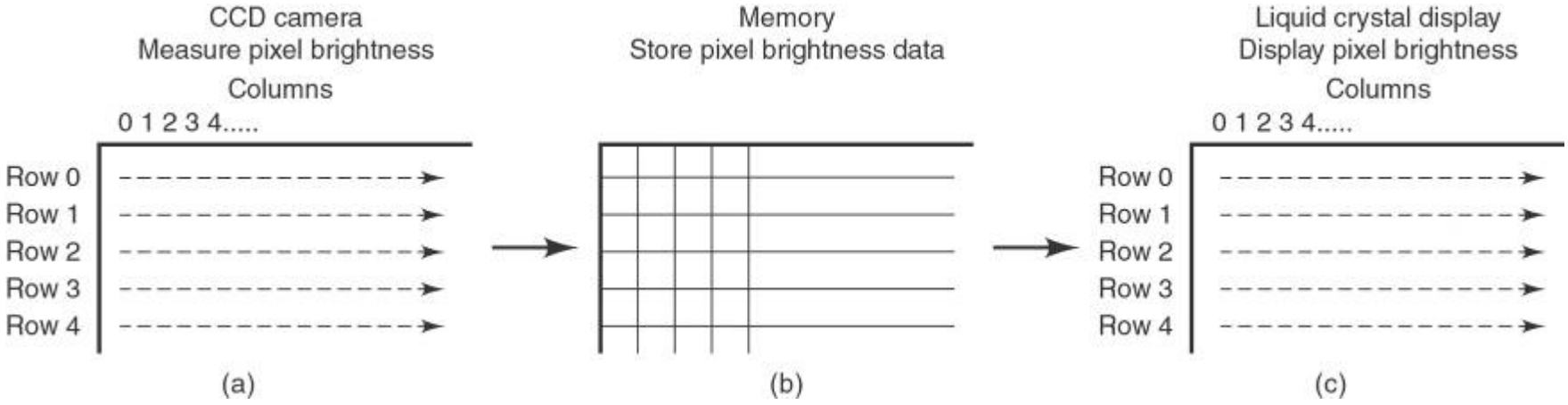
- Types of computers:
  - Microcomputer.
    - Most common (desktop PCs).
    - Has become very powerful.
  - Minicomputer (workstation).
  - Mainframe.
  - Microcontroller.
    - Designed for a specific application.
    - Dedicated or embedded controllers.
    - Used in appliances, manufacturing processes, auto ignition systems, ABS systems, and many other applications.

1-9 Digital Computers

- The basic functions of the digital subsystems of a cell phone—and all other built-in applications—are controlled by a complete microcomputer system embedded in each phone.

1-9 Digital Computers

When you take a picture, the phone convert the brightness of individual spots in the CCD to binary numbers, and stores it in memory (row x, column x).



Displaying the image on an LCD screen is the reverse process of storing an image in memory.

1-9 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**.

Digital Progress Today and Tomorrow

- 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.

END

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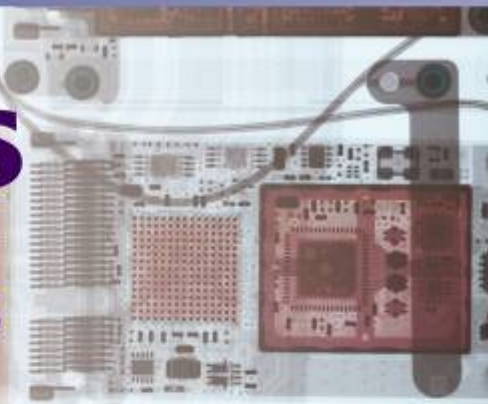

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