Digital Logic Design (EE227)

Musawar Ali

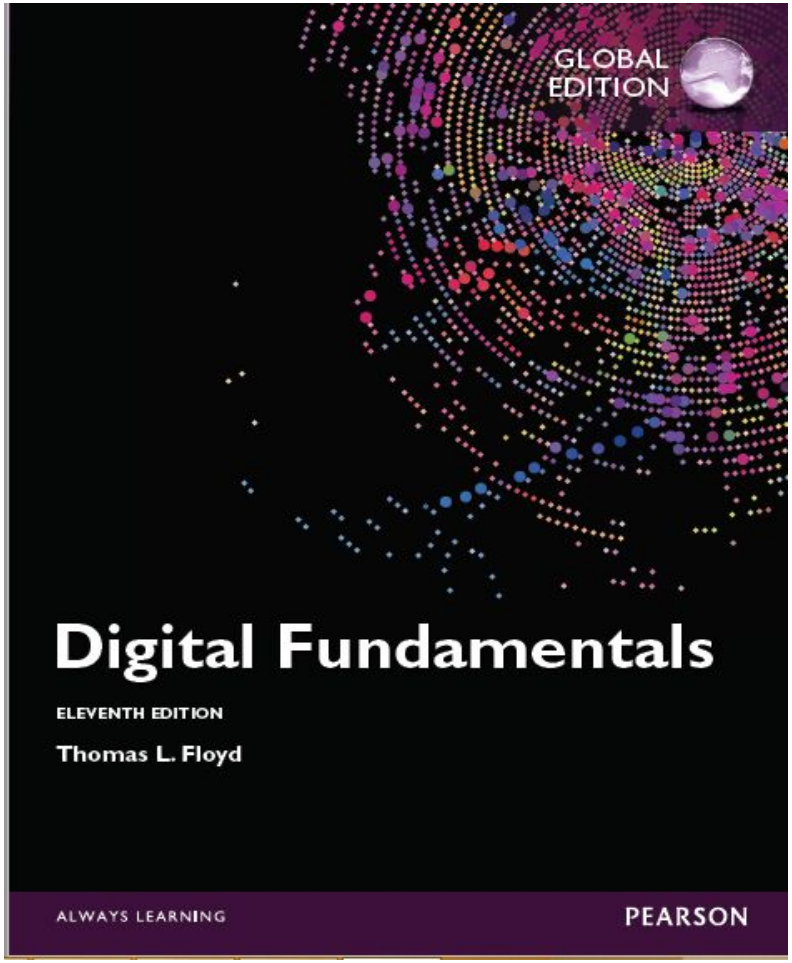
About Me

- Find me at Room 16 (Office 6 FCS)
- **Office hours:** Usually 08:00 AM – 04:00 PM
- Email me at musawar.ali@nu.edu.pk
- Feel free for any discussions.

Some Rules

- Raise your hand before asking any question and then WAIT for the permission.
- Don't talk to each other while in class.
- Never ever Miss a class.
- Be in class on Time.
- Never ever "sleep" in the class.
- Never even think about using mobile during the class.
- Never ask for permission while coming to class.
- Attendance can be taken in any time during class.
- Deadlines for quizzes and assignments would be strict, No late submissions.
- Class participation and discussions would be appreciated.

Book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Digital Fundamentals
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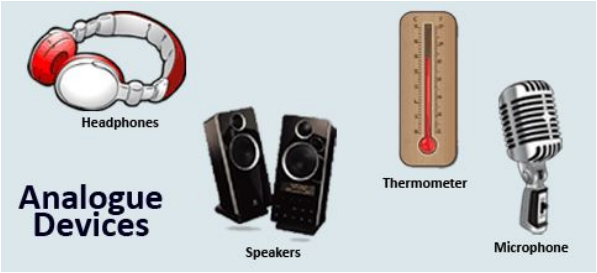
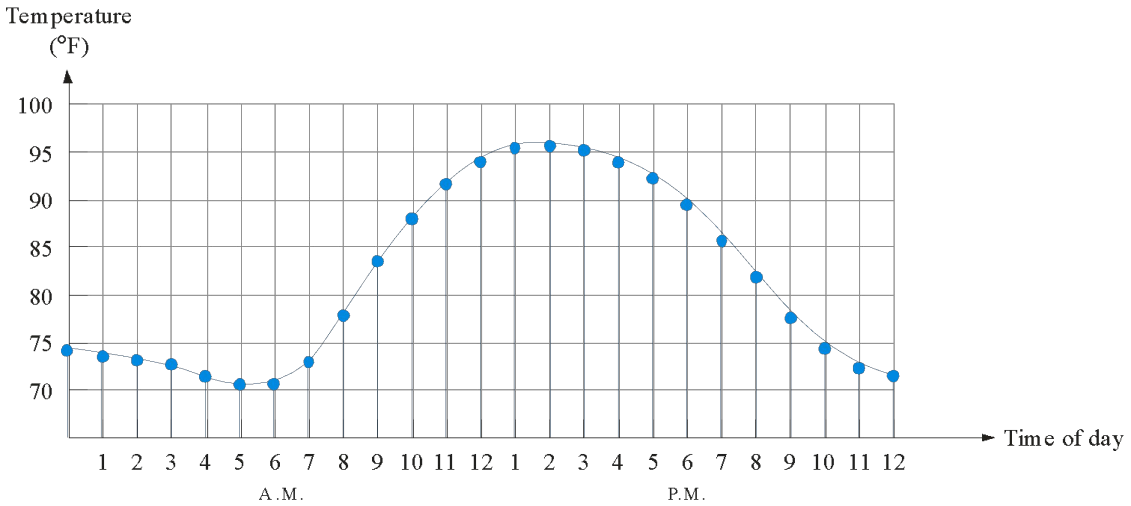
Why we study digital logic design?

Digital logic design is used to develop hardware, such as **circuit** boards and microchip processors. This hardware processes user input, system protocol, and other data in navigational systems, cell phones, or other high-tech systems.



Analog Quantities

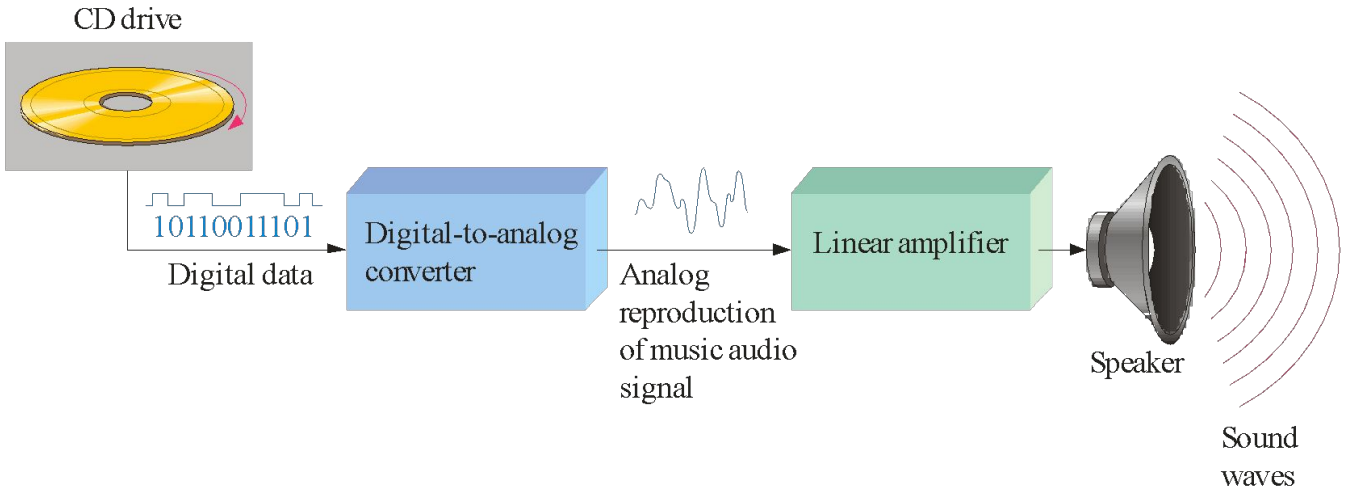
Most natural quantities that we see are **analog** and vary continuously. Analog systems can generally handle higher power than digital systems.



Digital systems can process, store, and transmit data more efficiently but can only assign discrete values to each point.

Analog and Digital Systems

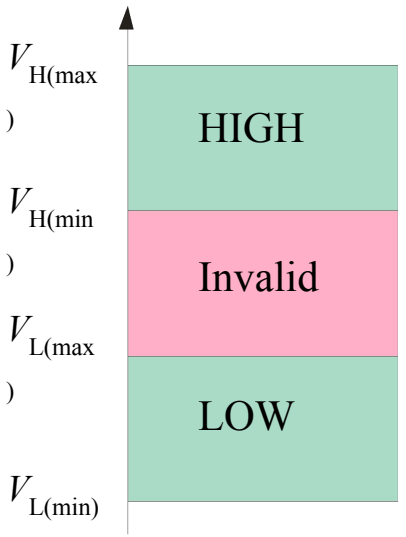
Many systems use a mix of analog and digital electronics to take advantage of each technology. A typical CD player accepts digital data from the CD drive and converts it to an analog signal for amplification.



Binary Digits and Logic Levels

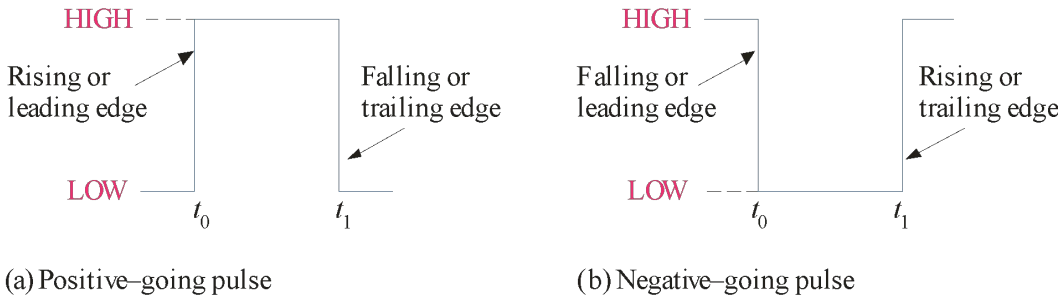
Digital electronics uses circuits that have two states, which are represented by two different voltage levels called HIGH and LOW. The voltages represent numbers in the binary system.

In binary, a single number is called a *bit* (for *b*inary dig*it*). A bit can have the value of either a 0 or a 1, depending on if the voltage is HIGH or LOW.



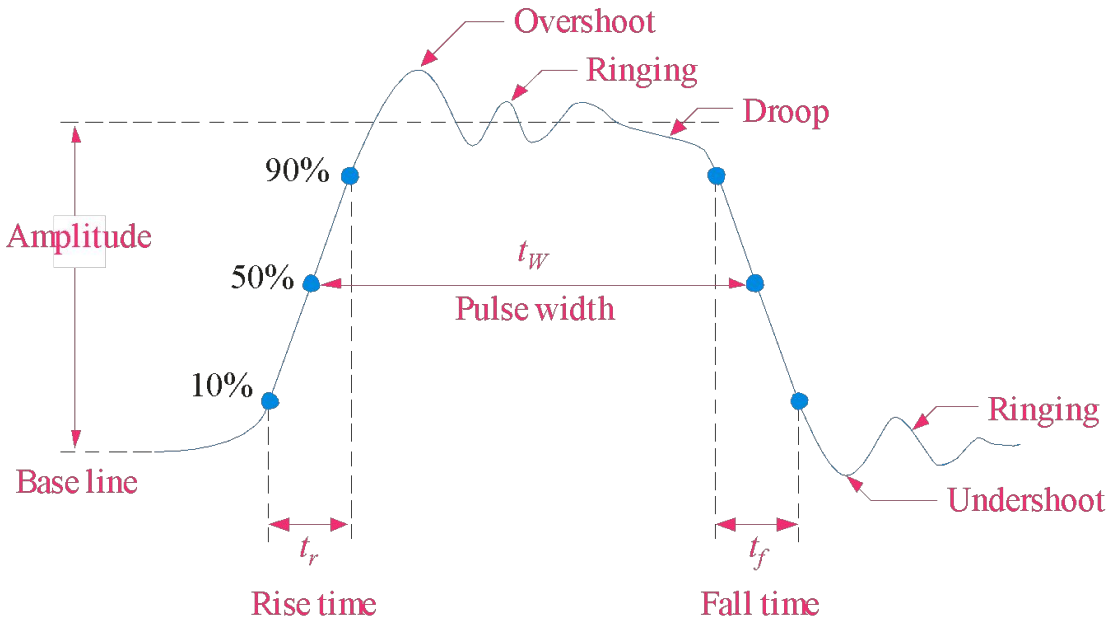
Digital Waveforms

Digital waveforms change between the LOW and HIGH levels. A positive going pulse is one that goes from a normally LOW logic level to a HIGH level and then back again. Digital waveforms are made up of a series of pulses.



Pulse Definitions

Actual pulses are not ideal but are described by the rise time, fall time, amplitude, and other characteristics.



Periodic Pulse Waveforms

Periodic pulse waveforms are composed of pulses that repeats in a fixed interval called the **period**. The **frequency** is the rate it repeats and is measured in hertz.

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

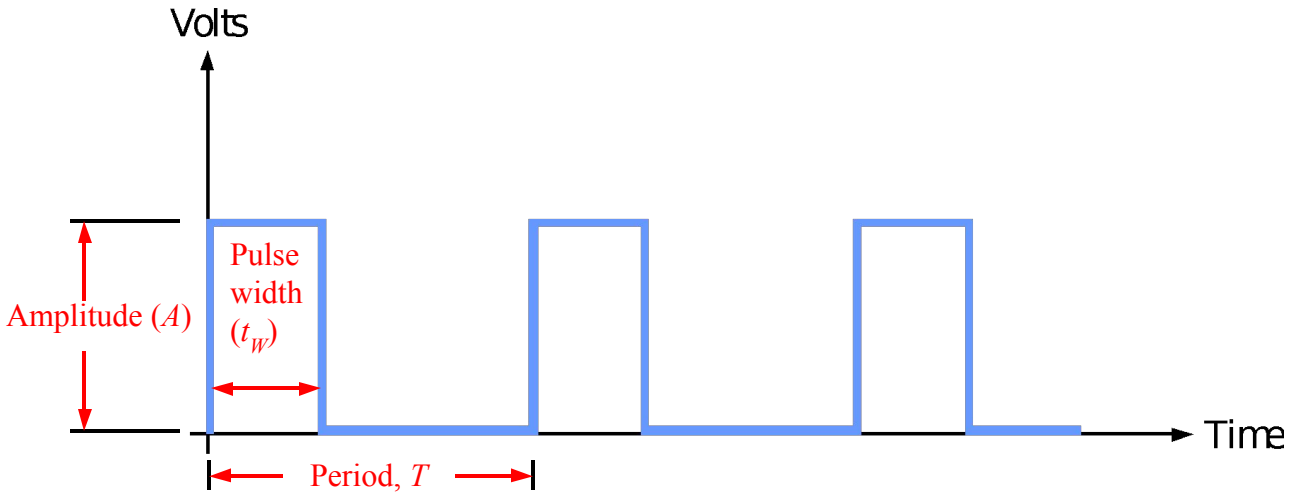
The **clock** is a basic timing signal that is an example of a periodic wave.

Example What is the period of a repetitive wave if $f = 3.2$ GHz?

Solution $T = \frac{1}{f} = \frac{1}{3.2\,\text{GHz}} =$ 313 ps

Pulse Definitions

In addition to frequency and period, repetitive pulse waveforms are described by the amplitude (A), pulse width (t_W) and duty cycle. Duty cycle is the ratio of t_W to T.



A portion of a periodic digital waveform is shown in Figure 1–10. The measurements are in milliseconds. Determine the following:

(a) period (b) frequency (c) duty cycle

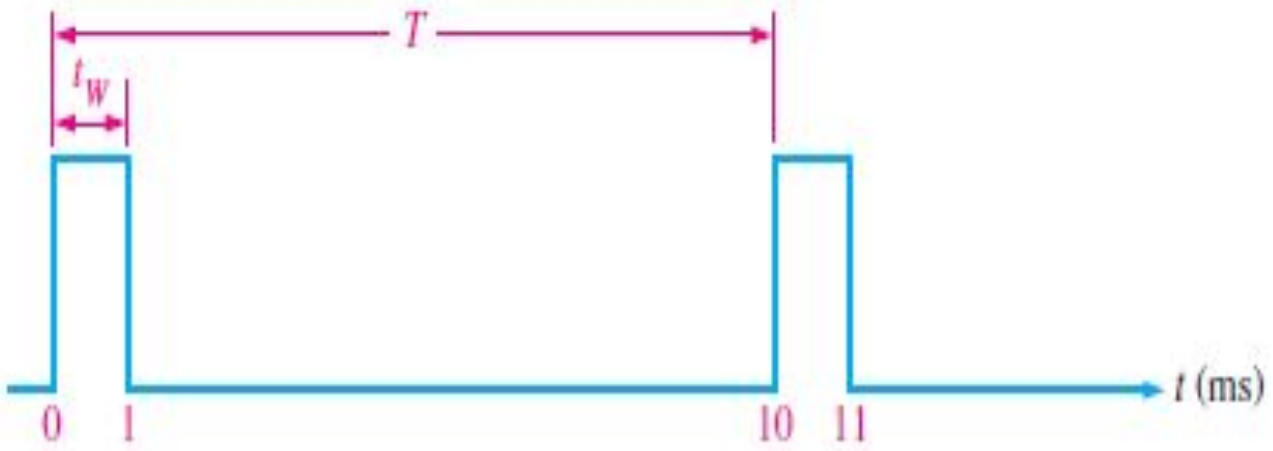


FIGURE 1–10

Example Continued….

Solution

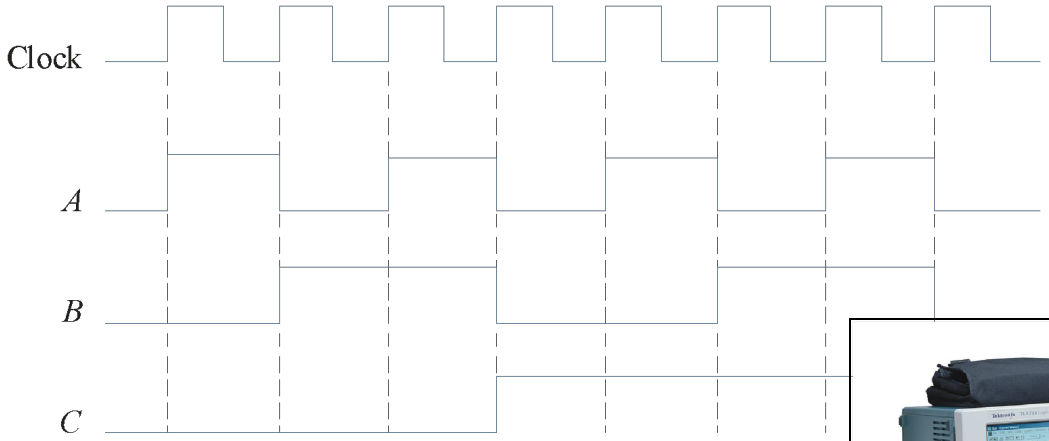
(a) The period (T) is measured from the edge of one pulse to the corresponding edge of the next pulse. In this case T is measured from leading edge to leading edge, as indicated. T equals **10 ms**.

(b) $$f = \frac{1}{T} = \frac{1}{10\text{ ms}} = \mathbf{100\ Hz}$$

(c) $$\text{Duty cycle} = \left(\frac{t_W}{T}\right)100\% = \left(\frac{1\text{ ms}}{10\text{ ms}}\right)100\% = \mathbf{10\%}$$

Timing Diagrams

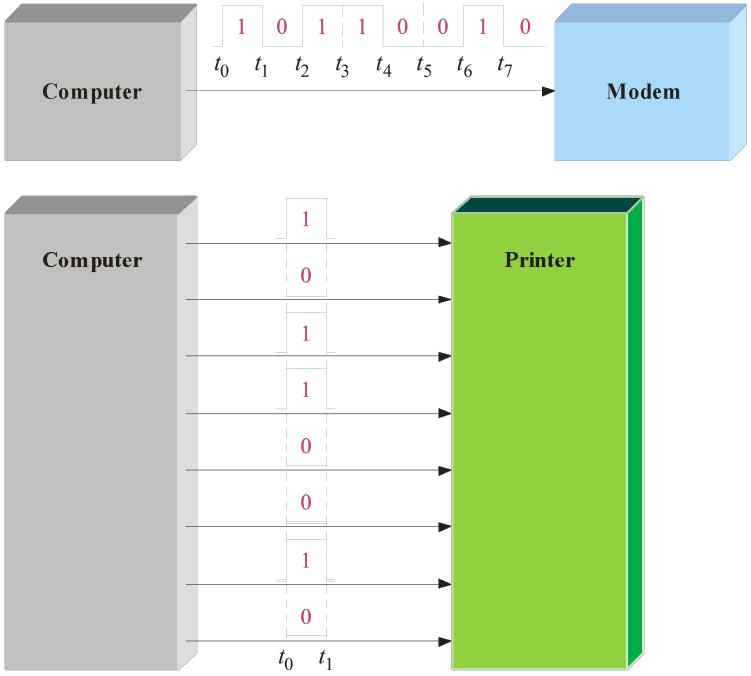
A timing diagram is used to show the relationship between two or more digital waveforms,



A diagram like this can be observed directly on a logic analyzer.

Serial and Parallel Data

Data can be transmitted by either serial transfer or parallel transfer.

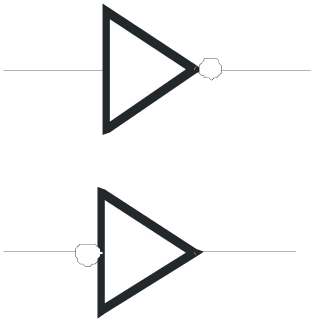


Basic Logic Functions

AND True only if ***all*** input conditions are true.

OR True only if ***one or more*** input conditions are true.

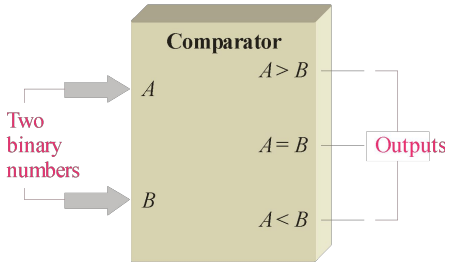
NOT Indicates the ***opposite*** condition.



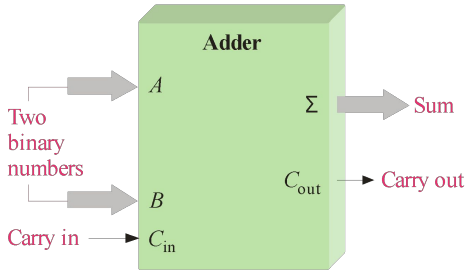
Basic System Functions

And, **or**, and **not** elements can be combined to form various logic functions. A few examples are:

The comparison function

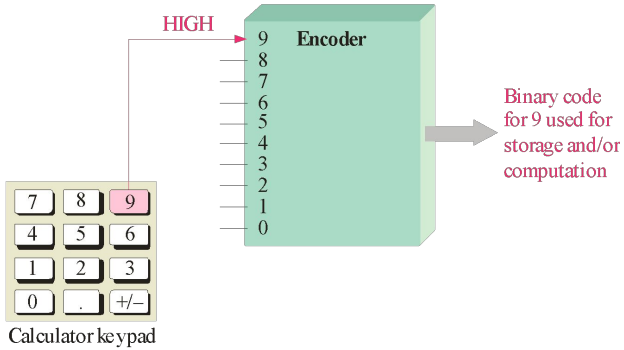


Basic arithmetic functions

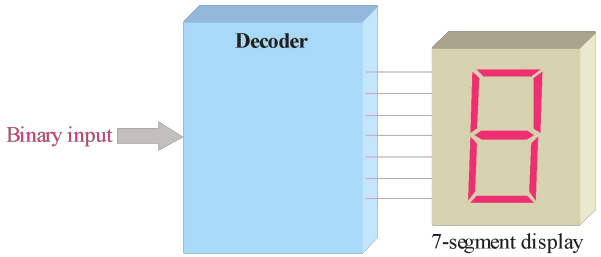


Basic System Functions

The encoding function

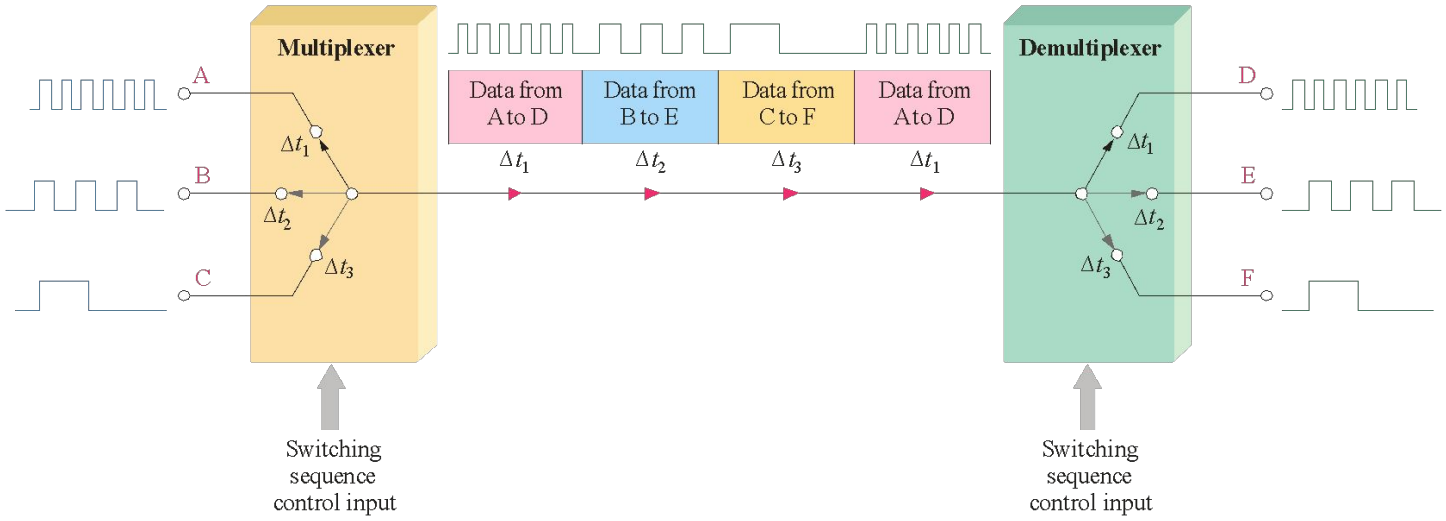


The decoding function



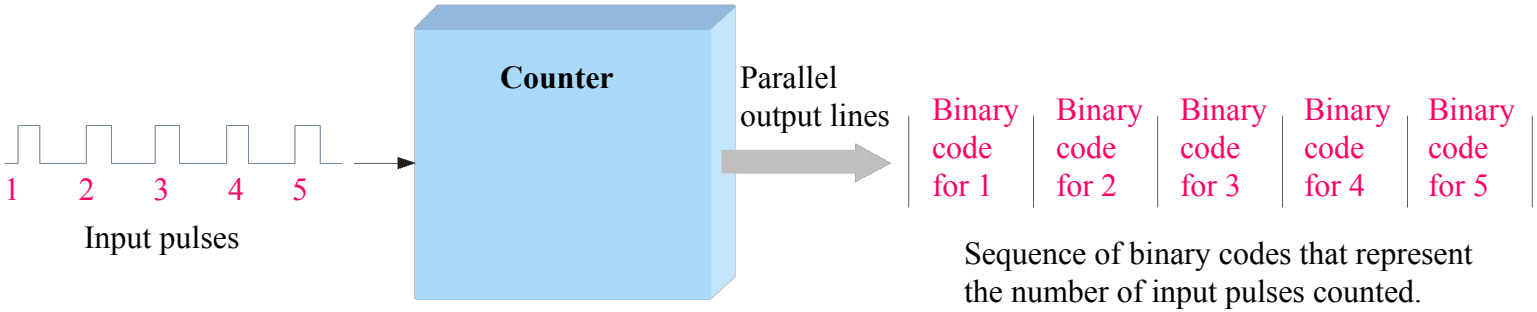
Basic System Functions

The data selection function



Basic System Functions

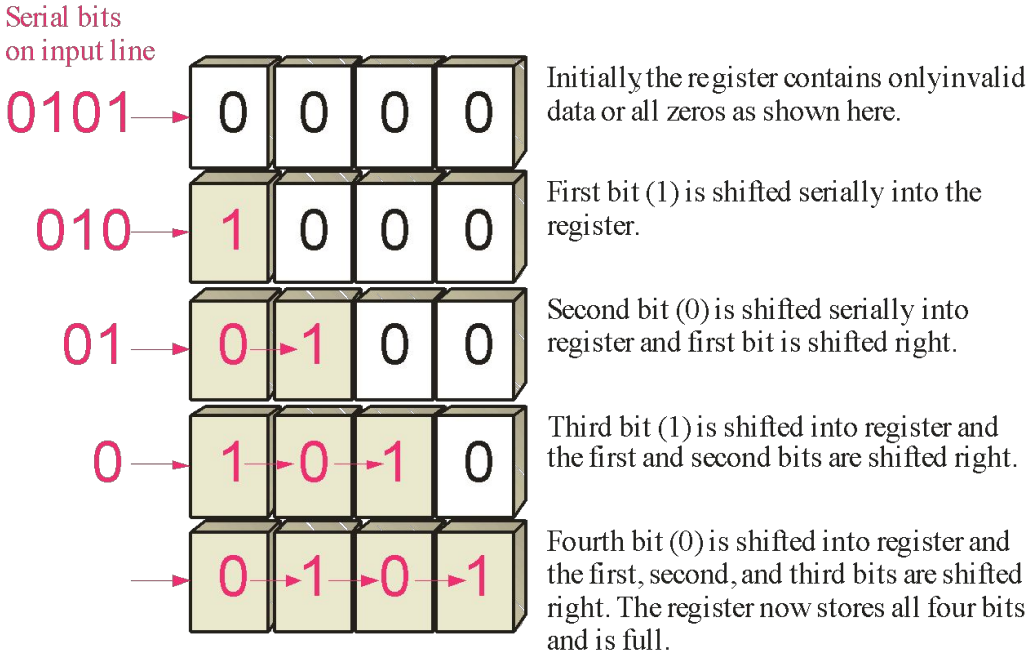
The counting function



…and other functions such as code conversion and storage.

Basic System Functions

One type of storage function is the shift register, that moves and stores data each time it is clocked.



Analog	Being continuous or having continuous values.
Digital	Related to digits or discrete quantities; having a set of discrete values.
Binary	Having two values or states; describes a number system that has a base of two and utilizes 1 and 0 as its digits.
Bit	A binary digit, which can be a 1 or a 0.
Pulse	A sudden change from one level to another, followed after a time, called the pulse width, by a sudden change back to the original level.

Clock	A basic timing signal in a digital system; a periodic waveform used to synchronize actions.
Gate	A logic circuit that performs a basic logic operations such as AND or OR.
NOT	A basic logic function that performs inversion.
AND	A basic logic operation in which a true (HIGH) output occurs only when all input conditions are true (HIGH).
OR	A basic logic operation in which a true (HIGH) output occurs when when one or more of the input conditions are true (HIGH).

1. Compared to analog systems, digital systems
   a. are less prone to noise
   b. can represent an infinite number of values
   c. can handle much higher power
   d. all of the above

2. The number of values that can be assigned to a bit are

   a. one

   b. two

   c. three

   d. ten

3. The time measurement between the 50% point on the leading edge of a pulse to the 50% point on the trailing edge of the pulse is called the

a. rise time

b. fall time

c. period

d. pulse width

4. The time measurement between the 90% point on the trailing edge of a pulse to the 10% point on the trailing edge of the pulse is called the

a. rise time

b. fall time

c. period

d. pulse width

5. The reciprocal of the frequency of a clock signal is the

   a. rise time

   b. fall time

   c. period

   d. pulse width

6. If the period of a clock signal is 500 ps, the frequency is

   a. 20 MHz

   b. 200 MHz

   c. 2 GHz

   d. 20 GHz

7. AND, OR, and NOT gates can be used to form

   a. storage devices

   b. comparators

   c. data selectors

   d. all of the above

8. A shift register is an example of a

   a. storage device

   b. comparator

   c. data selector

   d. counter

9. A device that is used to switch one of several input lines to a single output line is called a

a. comparator

b. decoder

c. counter

d. multiplexer

10. For most digital work, an oscilloscope should be coupled to the signal using

a. ac coupling

b. dc coupling

c. GND coupling

d. none of the above

Quiz

Answers:

1. a	6. c
2. b	7. d
3. d	8. a
4. b	9. d
5. c	10. b