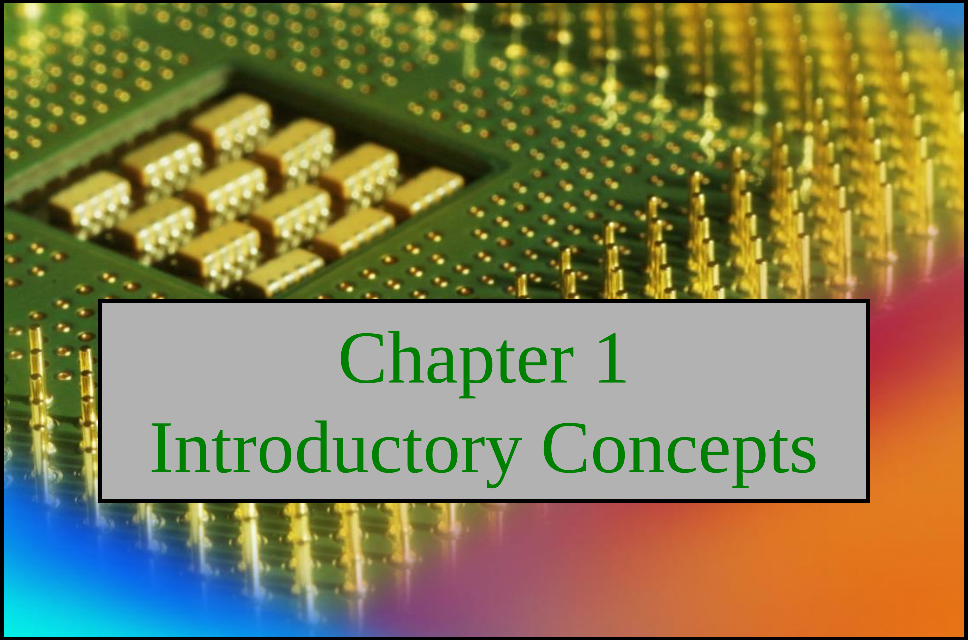
EE-227
Digital Logic Design

Spring-2019



Chapter 1
Introductory Concepts

Course Instructor: Engr. Khalid Iqbal Soomro

CHAPTER OBJECTIVES

- Explain the basic differences between digital & analog quantities
- Show how voltage levels are used to represent digital quantities
- Describe various parameters of a pulse waveform such as rise time, fall time, pulse width, frequency, period, and duty cycle
- Explain the basic logic functions of NOT, AND, and OR
- Describe several types of logic operations and explain their application in an example system
- Identify fixed-function digital integrated circuits according to their complexity and the type of circuit packaging
- Identify pin numbers on integrated circuit packages
- Recognize various instruments and understand how they are used in measurement and troubleshooting digital circuits and systems

Introduction

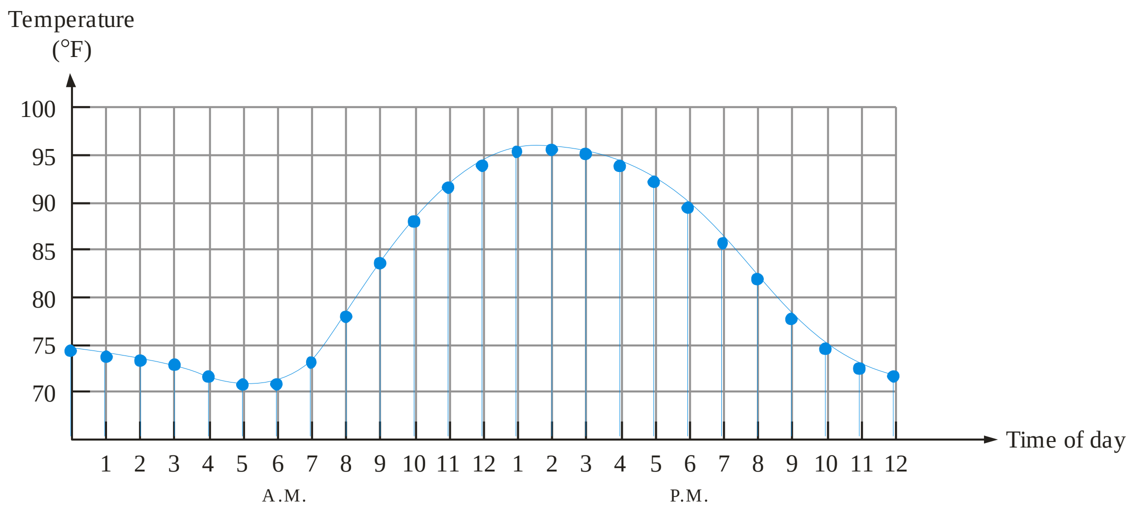
The term *digital* is derived from the way operations are performed, by counting digits. For many years, applications of digital electronics were confined to computer systems. Today, digital technology is applied in a wide range of areas in addition to computers.

Such applications as television, communications systems, radar, navigation and guidance systems, military systems, medical instrumentation, industrial process control, and consumer electronics use digital techniques.

Over the years digital technology has progressed from vacuum-tube circuits to discrete transistors to complex integrated circuits, many of which contain millions of transistors, and many of which are programmable.

Analog Quantities

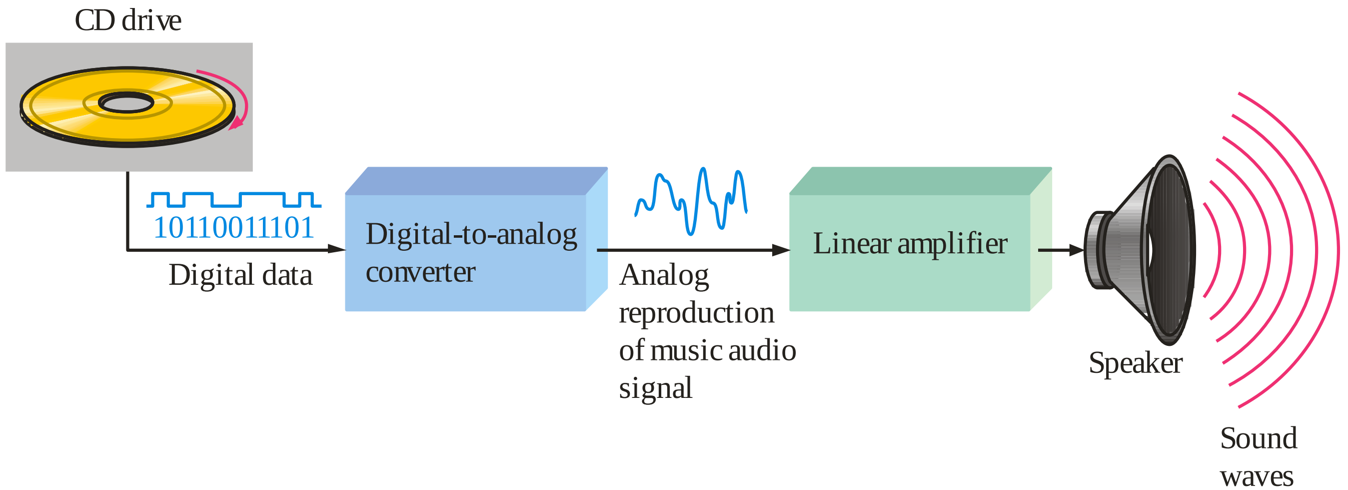
Most natural quantities that we see are **analog** and vary continuously. Analog systems can generally handle higher power than digital systems. Example: Temperature, Time…



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

Analog and Digital Systems

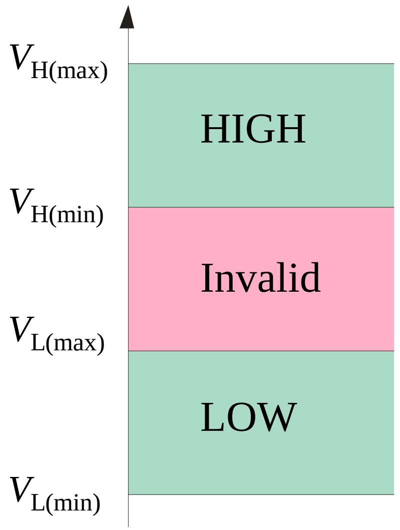
Many systems use a mix of analog and digital electronics to take advantage of each technology. A typical CD player accepts digital data from the CD drive and converts it to an analog signal for amplification.



Binary Digits and Logic Levels

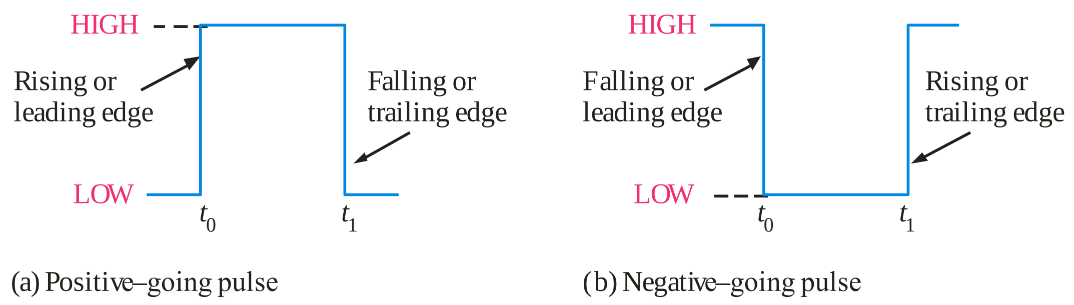
Digital electronics uses circuits that have two states, which are represented by two different voltage levels called HIGH and LOW. The voltages represent numbers in the binary system.

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.



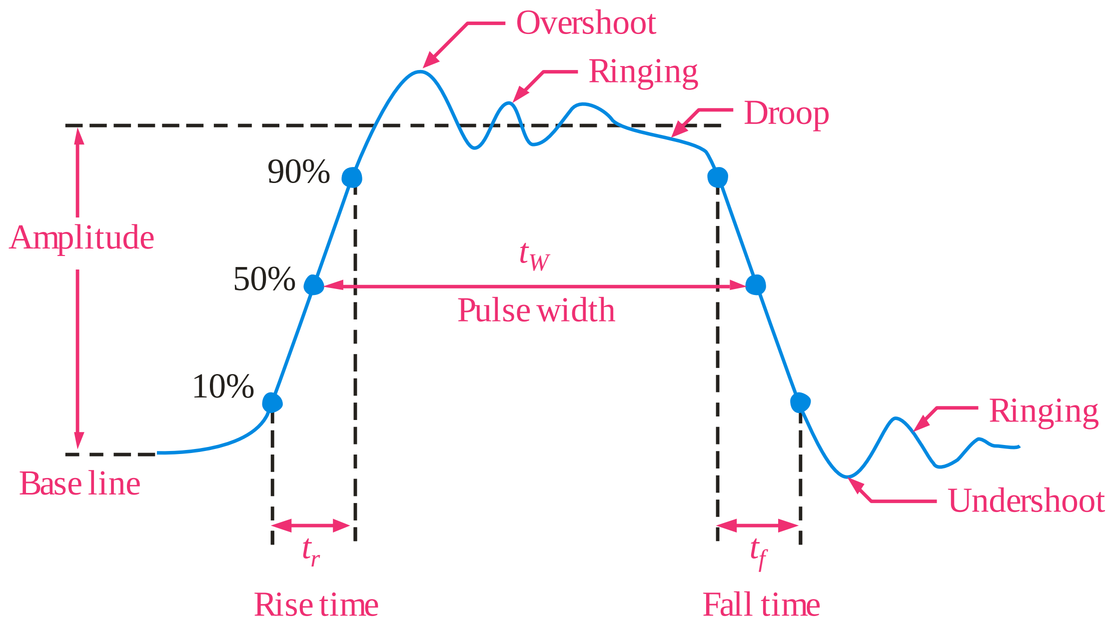
Digital Waveforms

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.

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

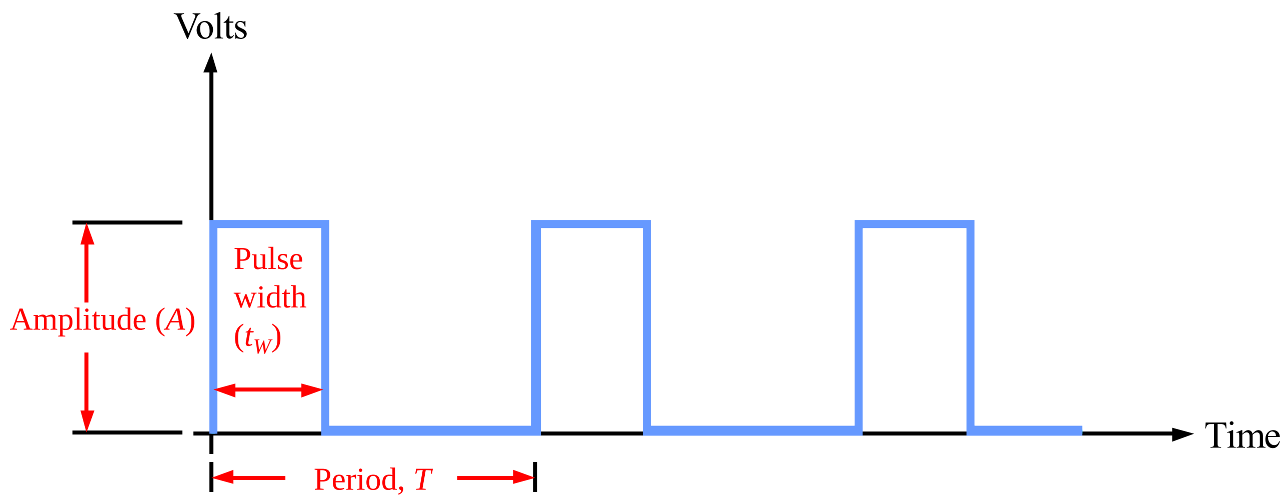
The **clock** is a basic timing signal that is an example of a periodic wave.

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

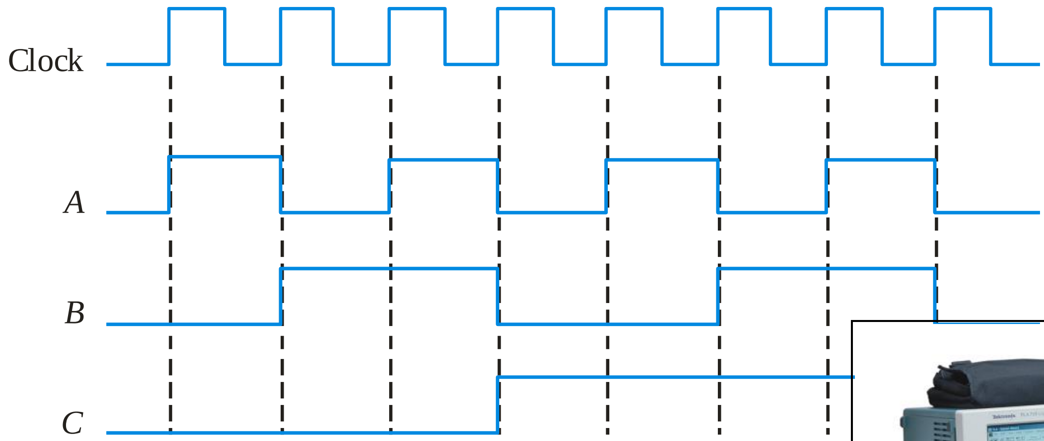
Pulse Definitions

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.

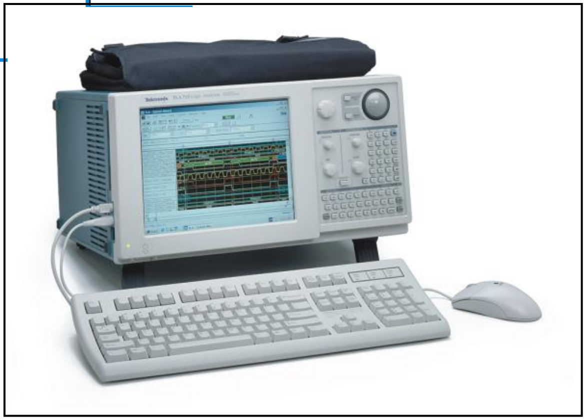


Timing Diagrams

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

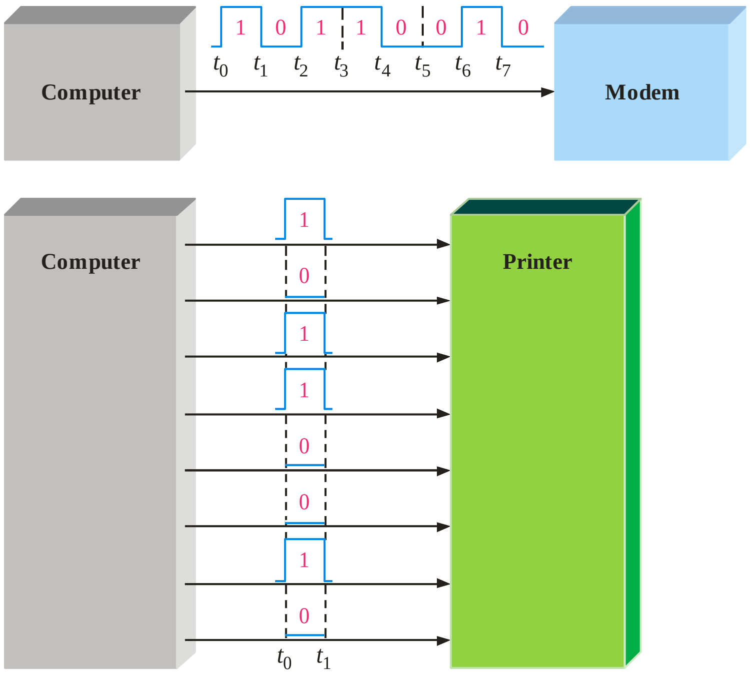


A diagram like this can be observed directly on a logic analyzer.



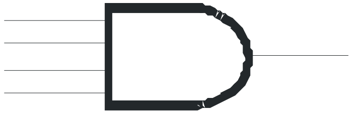
Serial and Parallel Data

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

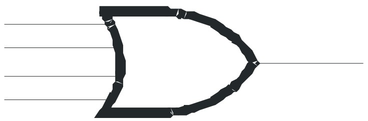


Basic Logic Functions

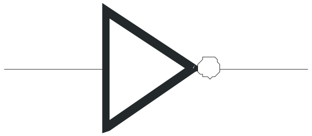
AND True only if *all* input conditions are true.

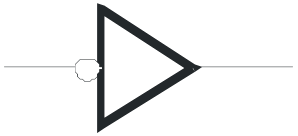


OR True only if *one or more* input conditions are true.



NOT Indicates the *opposite* condition.

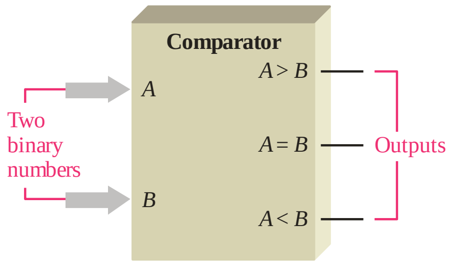




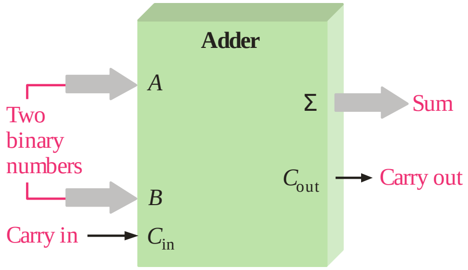
Basic System Functions

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

The comparison function

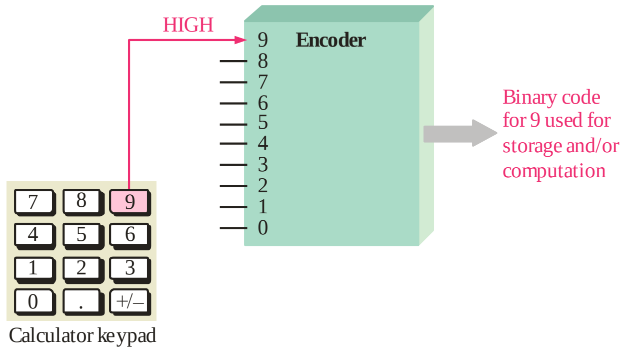


Basic arithmetic functions

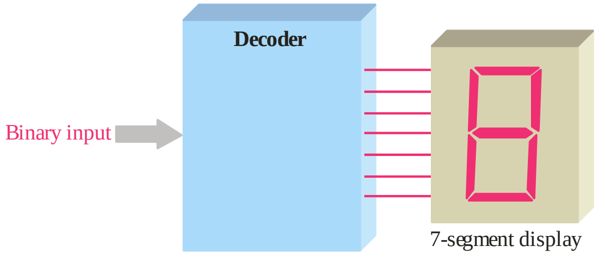


Basic System Functions

The encoding function

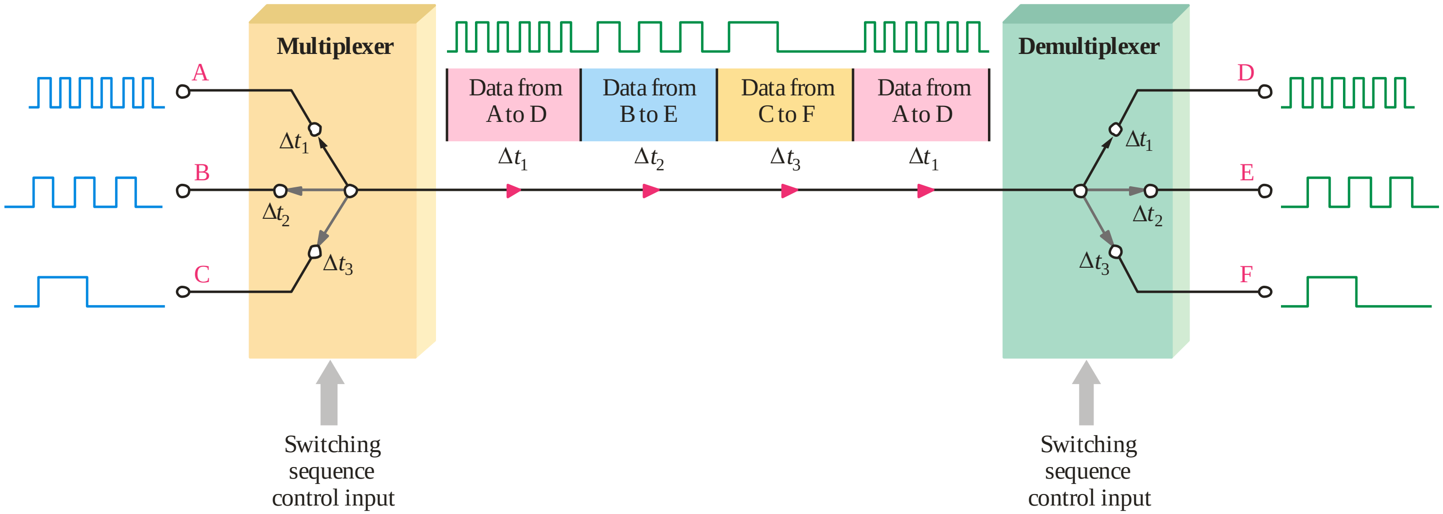


The decoding function



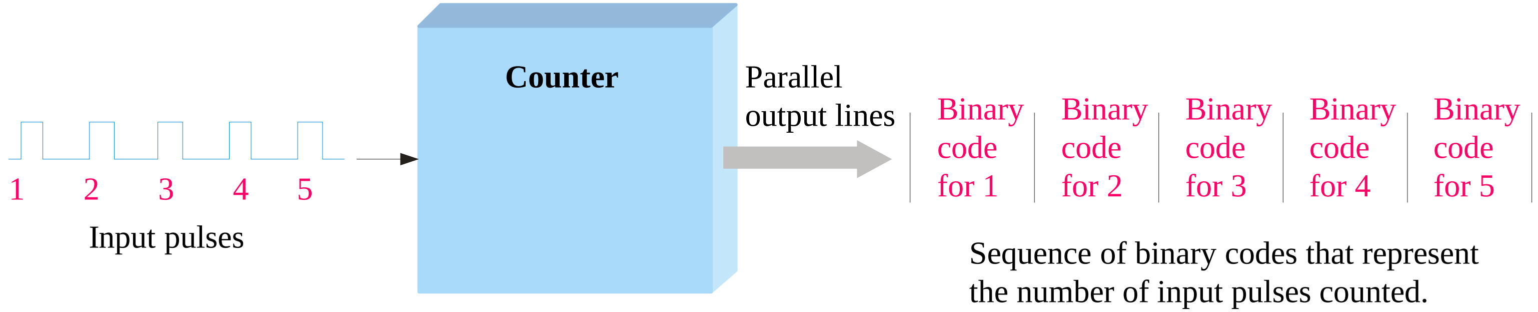
Basic System Functions

The data selection function



Basic System Functions

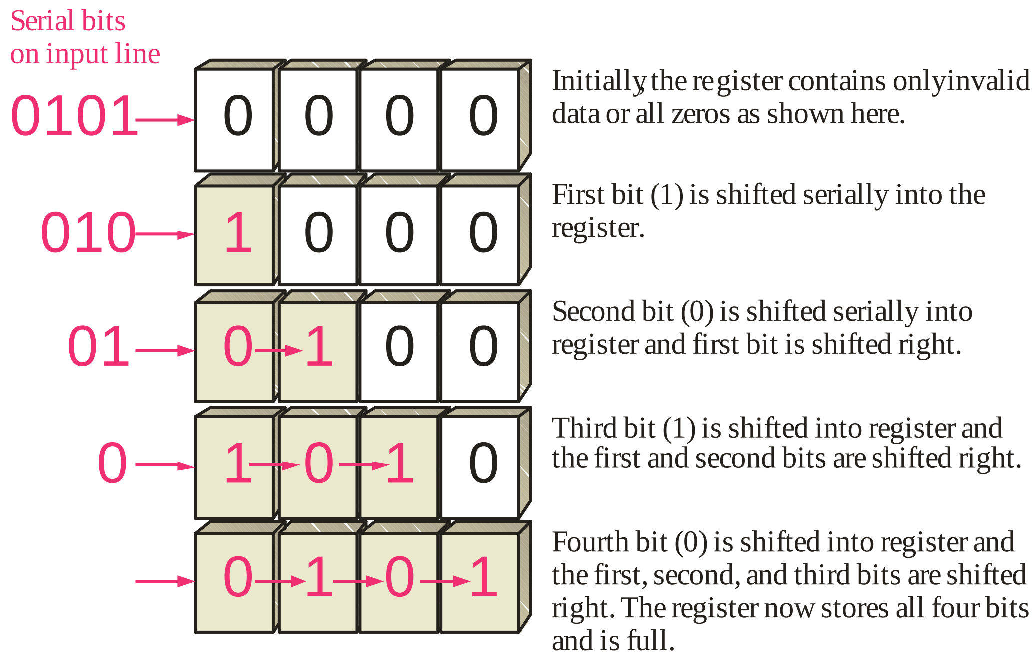
The counting function



…and other functions such as code conversion and storage.

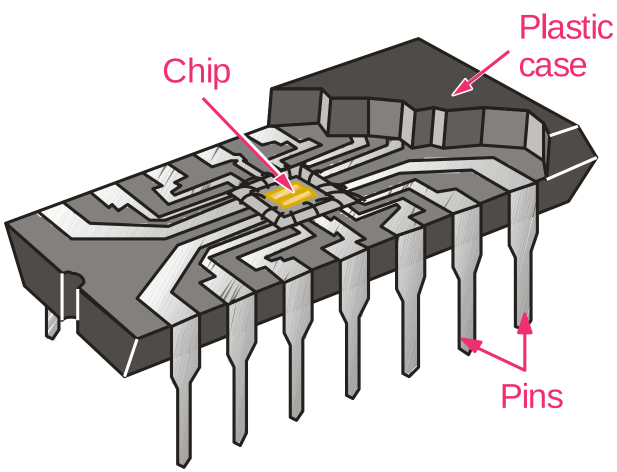
Basic System Functions

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



Integrated Circuits

Cutaway view of DIP (Dual-In-line Pins) chip:



The TTL series, available as DIPs are popular for laboratory experiments with logic.

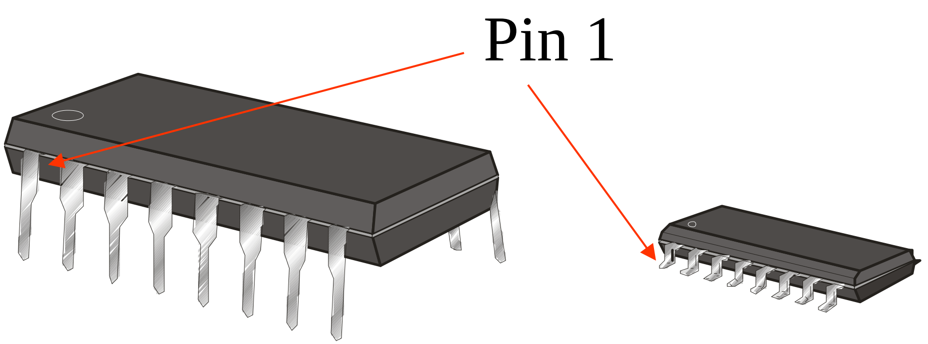
Integrated Circuits

An example of laboratory prototyping is shown. The circuit is wired using DIP chips and tested.

In this case, testing can be done by a computer connected to the system.

Integrated Circuits

DIP chips and surface mount chips

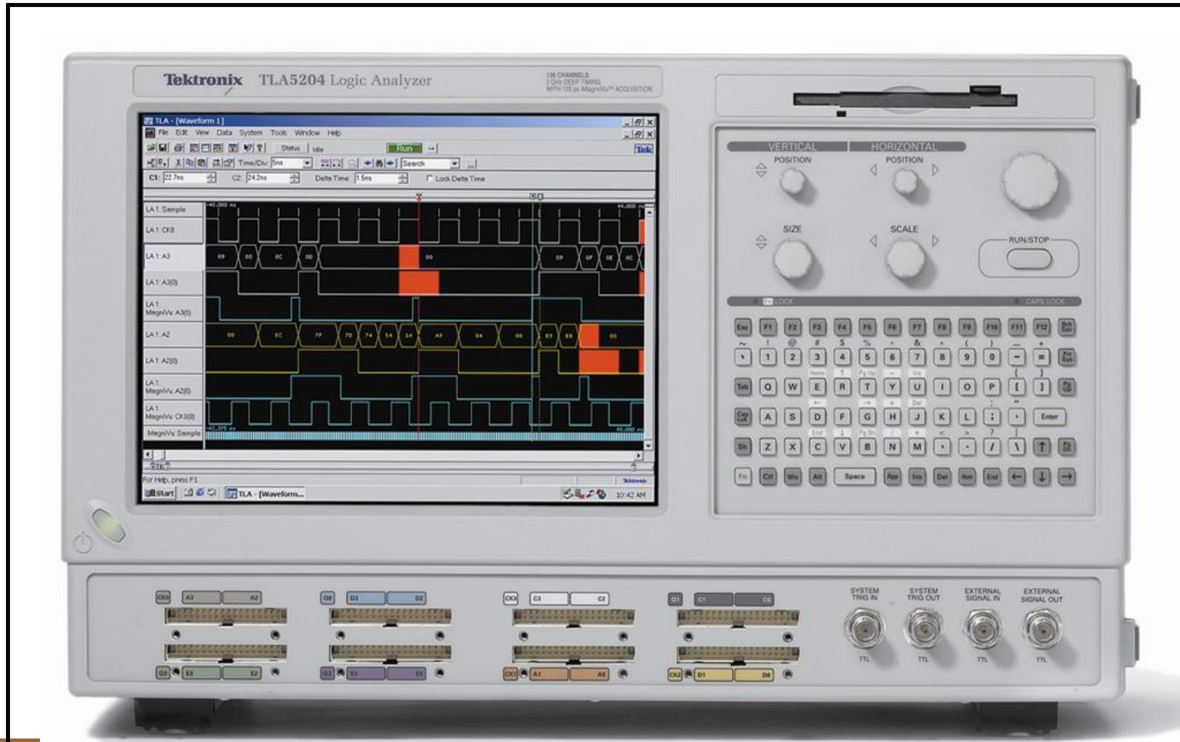


Dual in-line package

Small outline IC (SOIC)

Test and Measurement Instruments

The logic analyzer can display multiple channels of digital information or show data in tabular form.



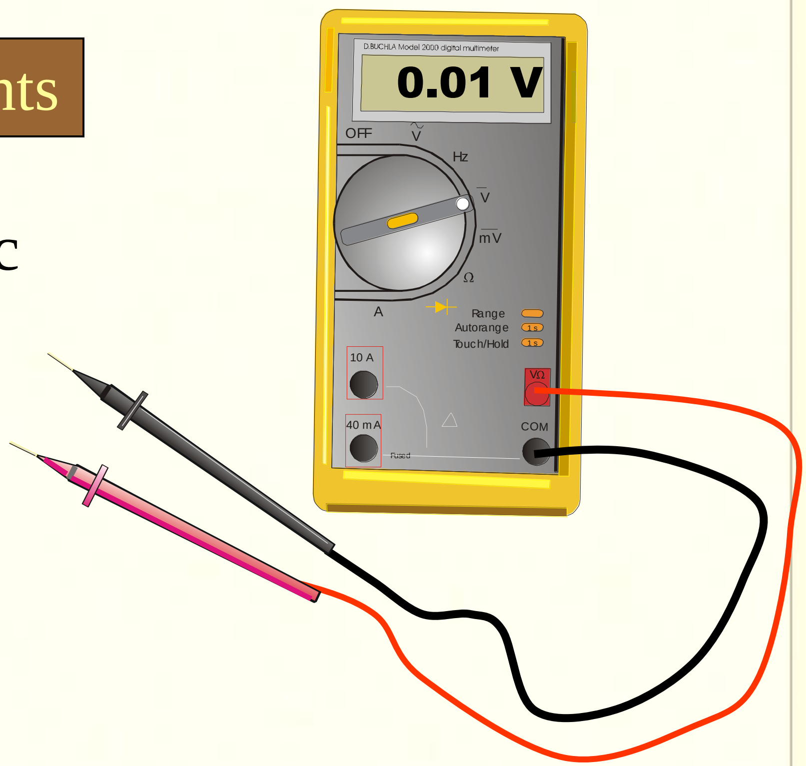
Test and Measurement Instruments

The DMM can make three basic electrical measurements.

Voltage

Resistance

Current



In digital work, DMMs are useful for checking power supply voltages, verifying resistors, testing continuity, and occasionally making other measurements.

Selected Key Terms

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.

Selected Key Terms

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).

Selected Key Terms

Fixed-function logic A category of digital integrated circuits having functions that cannot be altered.

Programmable logic A category of digital integrated circuits capable of being programmed to perform specified functions.

Quiz

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

Quiz

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

    a. one

    b. two

    c. three

    d. ten

Quiz

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.

Quiz

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

Quiz

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

   a. rise time

   b. fall time

   c. period

   d. pulse width

Quiz

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

Quiz

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

    a. storage devices

    b. comparators

    c. data selectors

    d. all of the above

Quiz

8. A shift register is an example of a

   a. storage device

   b. comparator

   c. data selector

   d. counter

Quiz

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

Quiz

Answers:

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