DIGITAL LOGIC DESIGN EE(1005)

LECTURE-1,2,3

Introduction to Digital Logic Design

WHAT IS THIS COURSE ALL ABOUT?

- The fundamental of Digital Logic
  - Binary numbers and relate number systems
  - Digital circuit building block (Logic Gates)
  - Boolean Algebra and Logic simplification

- How to design
  - Combinational logic circuits
  - Sequential logic circuits

Week	Course Contents/Topics	Chapter
01	Introduction. Digital Electronics. Digital Principles. Analog Vs. Digital. Basic Logic operations.	1
02	Number Systems. Binary to Decimal. Decimal to Binary conversion. Hexadecimal Number system. BCD code. The Byte, Nibble and Word.	2
03	Logic Gates, AND OR & NOT Gates, NOR NAND XOR Gates.	3
04	Boolean Algebra and logic simplification. DeMorgan's Theorems. Boolean analysis of Logic circuits. Truth Tables. The Karnaugh Map.	4
05	Basic Combinational circuits. Implementing Combinational Logic. Using NAND and NOR Gates.	5
06	**Mid Term 1**	
07 & 08	Basic Adders. Parallel Binary Adders. Ripple v/s Look-Ahead carry adders. Comparators. Decoders. Encoders. Multiplexers. Demultiplexers.	6
09 & 10	Latches. Edge-Triggered Flip-Flops. Flip-Flop Operating Characteristics. Flip-Flop applications.	7
11	Asynchronous Counters. Synchronous Counters. Cascaded Counters. Counter Decoding.	8
12	**Mid Term 2**	
13 & 14	Basic Shift Register Operations. Serial In/Serial Out Shift Registers. Serial In/Parallel Out and Parallel In/Parallel Out Shift Registers. Bidirectional Shift Registers.	9
15 & 16	Memory Basics, the Random-Access Memory. The Read-only Memory. Programmable ROM. The Flash Memory. Memory Expansion. Special Types of Memories. Magnetic & Optical Storage.	10

BOOKS

Text Book (1)	**Title**	Digital Fundamentals
	Author	Thomas L. Floyd
	Publisher	Pearson Education , 10th or 11th Edition
Text Book (2)	**Title**	Digital Design
	Author	M. Morris Mano, Michael Ciletti
	Publisher	Pearson Education , 4th Edition
Ref. Book (1)	**Title**	Digital Principles and Applications
	Author	Donald P Leach, Albert Paul Malvino, Goutam Saha
	Publisher	McGraw Hill Companies, 6th Edition
Ref. Book (2)	**Title**	Digital Systems Principles and Applications
	Author	Ronald J. Tocci, Neal S. Widmer, Gregory L. Moss
	Publisher	Pearson Education, 10th Edition

GRADING POLICY

Midterm	30%
Class Quizzes	10%
Assignments/Project/Viva	10%
Final Exam	50%
Total	100%

Chapter No:01 Introductory Concept

- Explain the basic differences between digital and 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

DIGITAL TECHNOLOGY

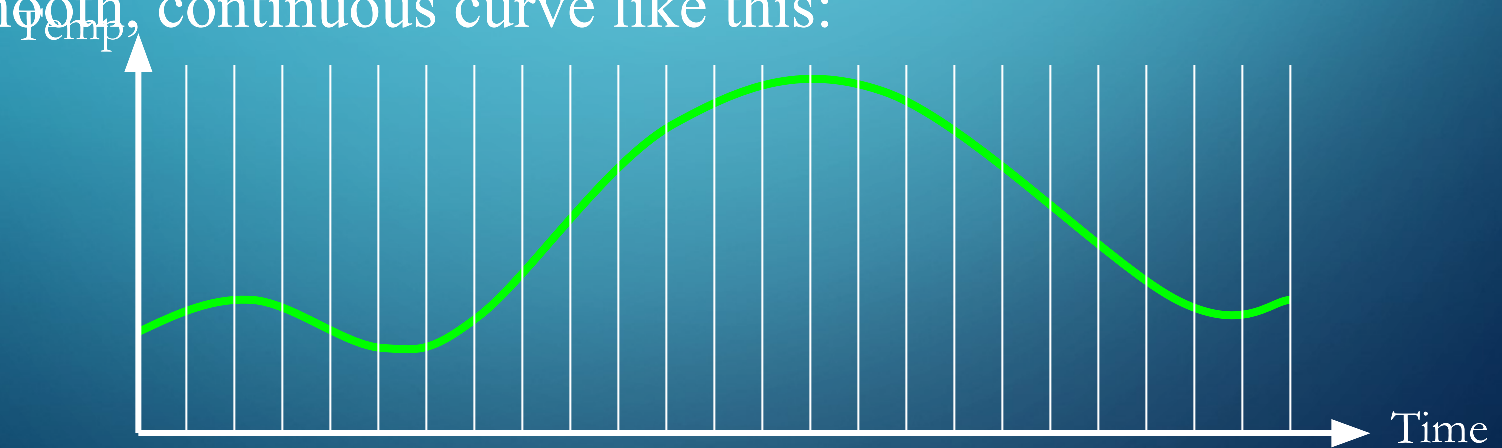
- *The term digital is derived from the way computer perform operations by counting digits.*
- *Today, digital tech is applied in a wide range of areas.*
- *The tech has progressed from vacuum-tube to discrete transistors to complex ICs.*

DIGITAL AND ANALOG QUANTITIES

- *Two categories of electronic circuits:*
  - *Analog*
  - *Digital*
- *Analog quantity = continuous values*
- *Digital quantity = a discrete set of values*

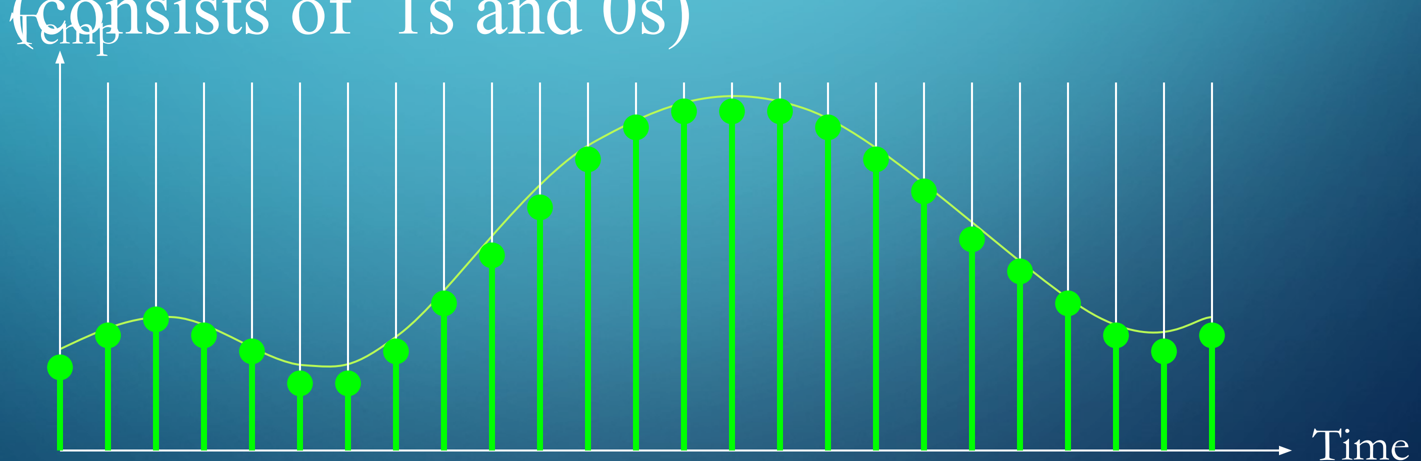
ANALOG QUANTITY

- Most things in nature analog form
  - Temperature, pressure, distance, etc
- Smooth, continuous curve like this:



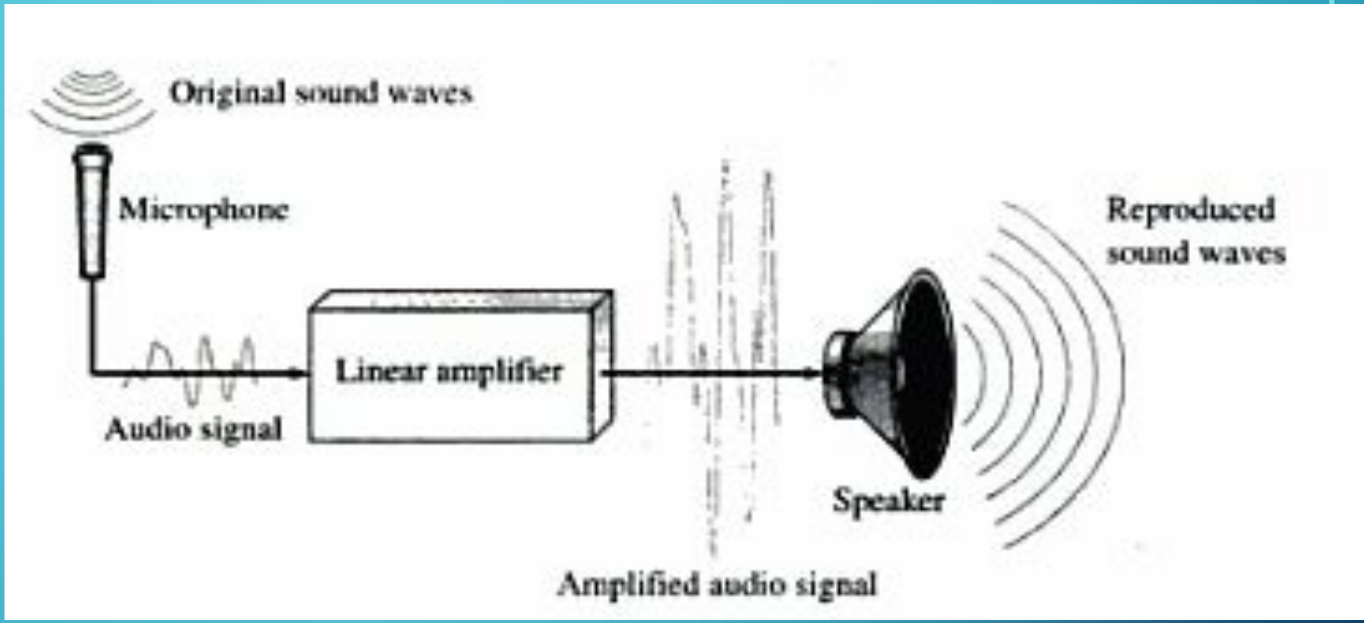
DIGITAL QUANTITY

- Sampled-value representation (quantization)
- Each dot can be digitized as a digital code (consists of 1s and 0s)



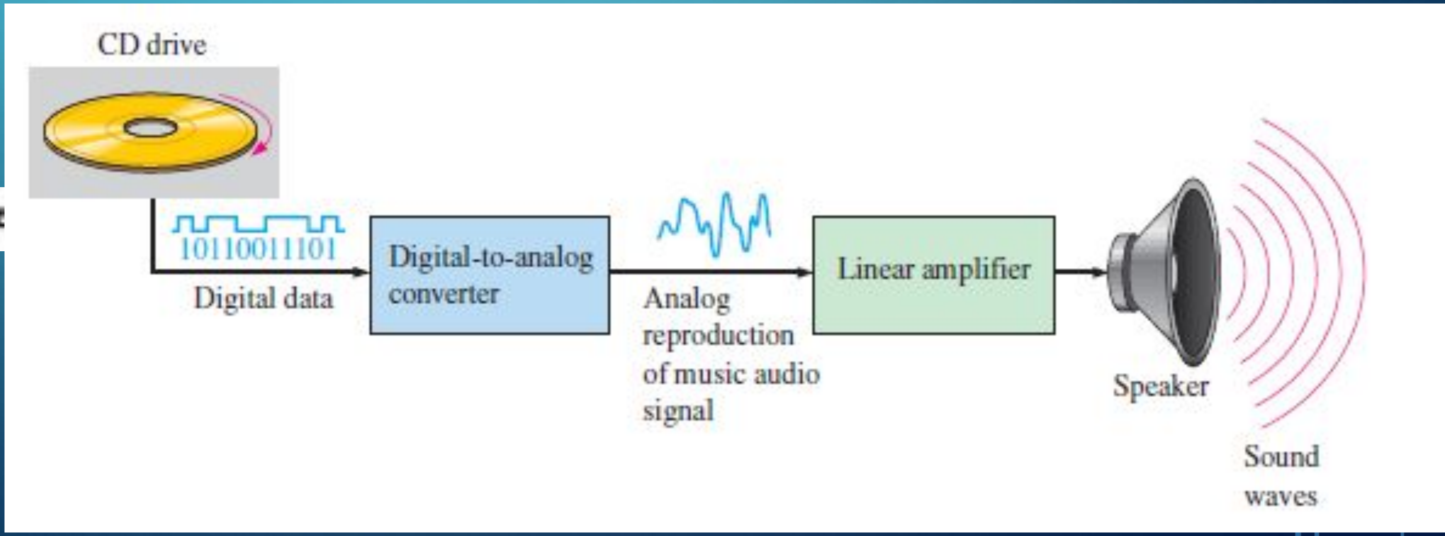
An Analog Electronic System

A basic audio public address system



A System Using Digital and Analog Methods

Basic principle of a CD playe



DIGITAL ADVANTAGES

- Digital data can be processed and transmitted more efficiently and reliably than analog data.
- Digital data has a great advantage when storage is necessary.
- Music when converted to digital form can be stored more compactly and reproduced with great accuracy and clarity than analog.
- Noise doesn’t effect digital data.

DIGITAL MUSIC

- The media is very compact but higher-density (and counting):
  - CDs
  - Memory cards

- No more bulky and noise media like cassette tape

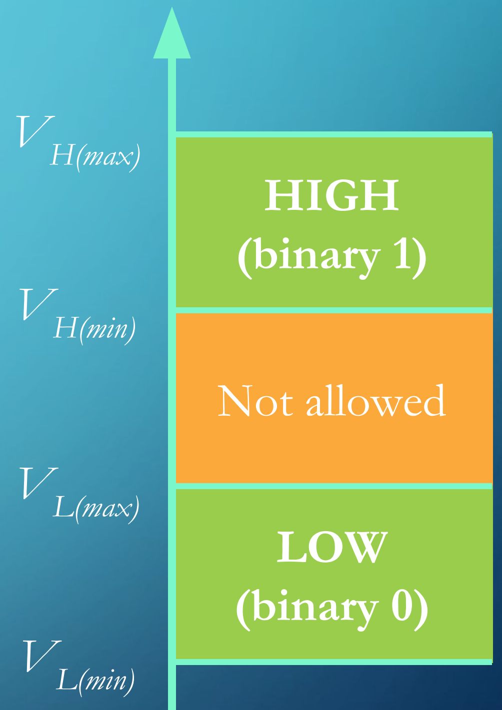
Binary Digits, Logic Levels, & Digital Waveforms

BINARY DIGITS

- Binary system (either 0 or 1)
  - Bit (comes from *binary digit*)
- Digital circuits:
  - 1 represents HIGH voltage
  - 0 represents LOW voltage
- Groups of bits (combinations of 0s and 1s) are called <u>codes</u>
  - Being used to represent numbers, letters, symbols, (i.e. ASCII code), instructions, and etc.

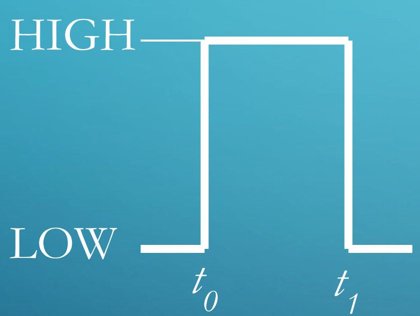
LOGIC LEVELS

- The voltages used to represent a 1 and 0 are called <u>logic levels</u>.
  - Ideally, there is only HIGH (1) and LOW (0).
  - Practically, there must be thresholds to determine which one is HIGH or LOW or neither of them.
- CMOS
  - (2V to 3.3V □ HIGH)
  - (0V. To 0.8V □ LOW)

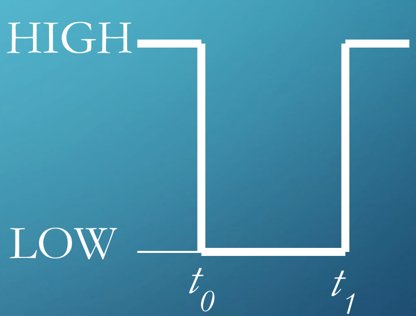


DIGITAL WAVEFORMS

- Voltage levels that are changing back and forth between HIGH and LOW
- (Ideal) pulse



Positive-going pulse

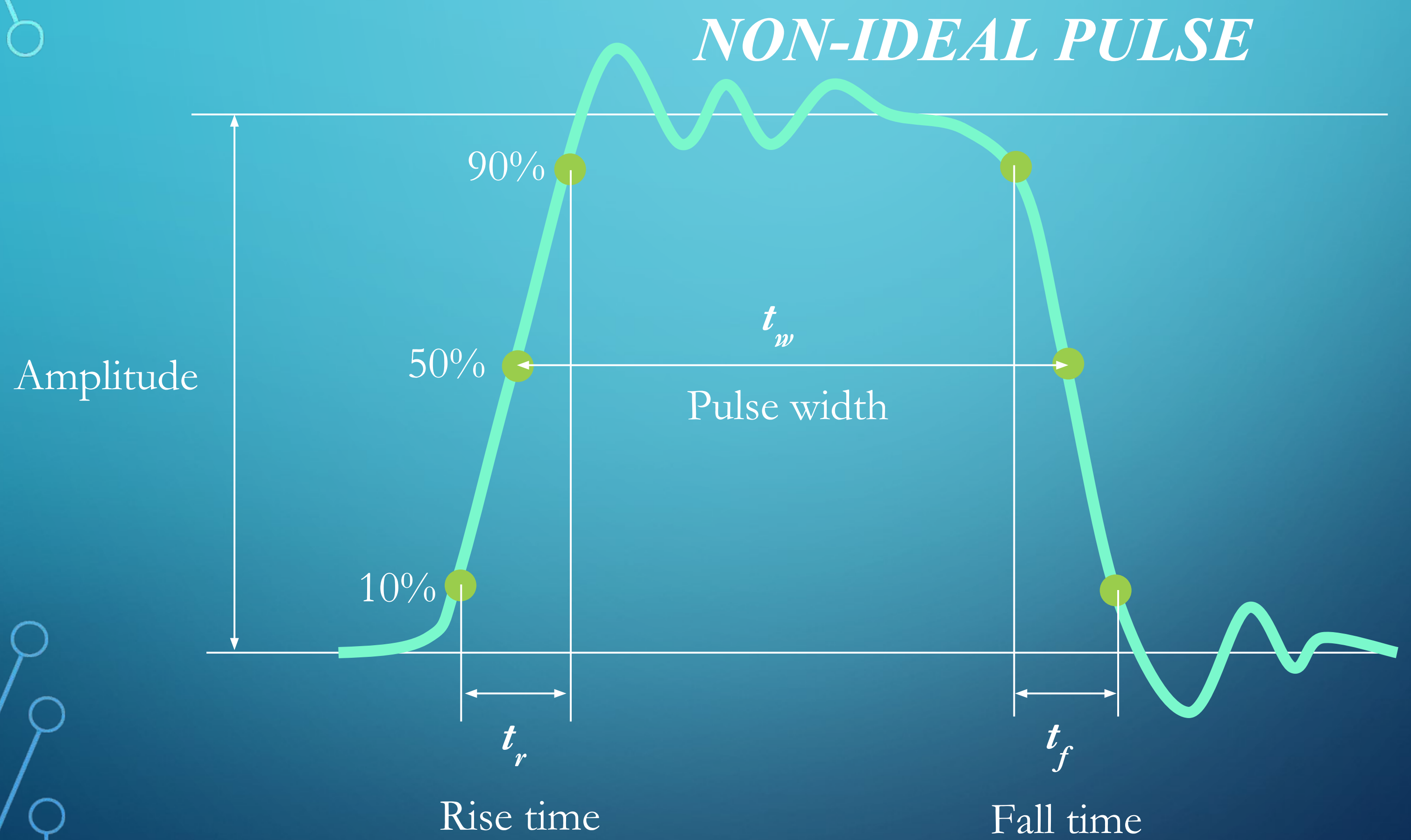


Negative-going pulse

- At t_0 □ leading edge, at t_1 □ trailing edge

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.

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

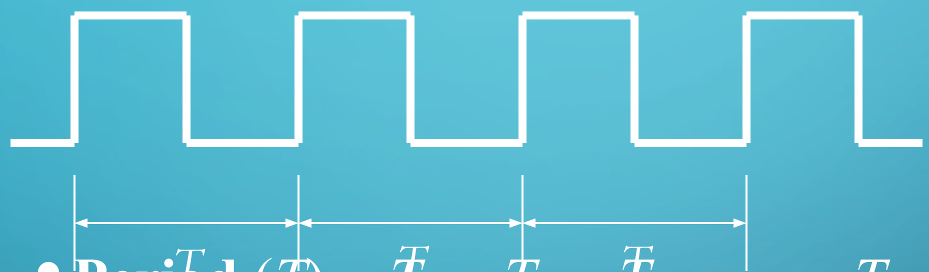
The **clock** is a basic timing signal that is an example of a periodic wave.

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

WAVEFORM CHARACTERISTICS

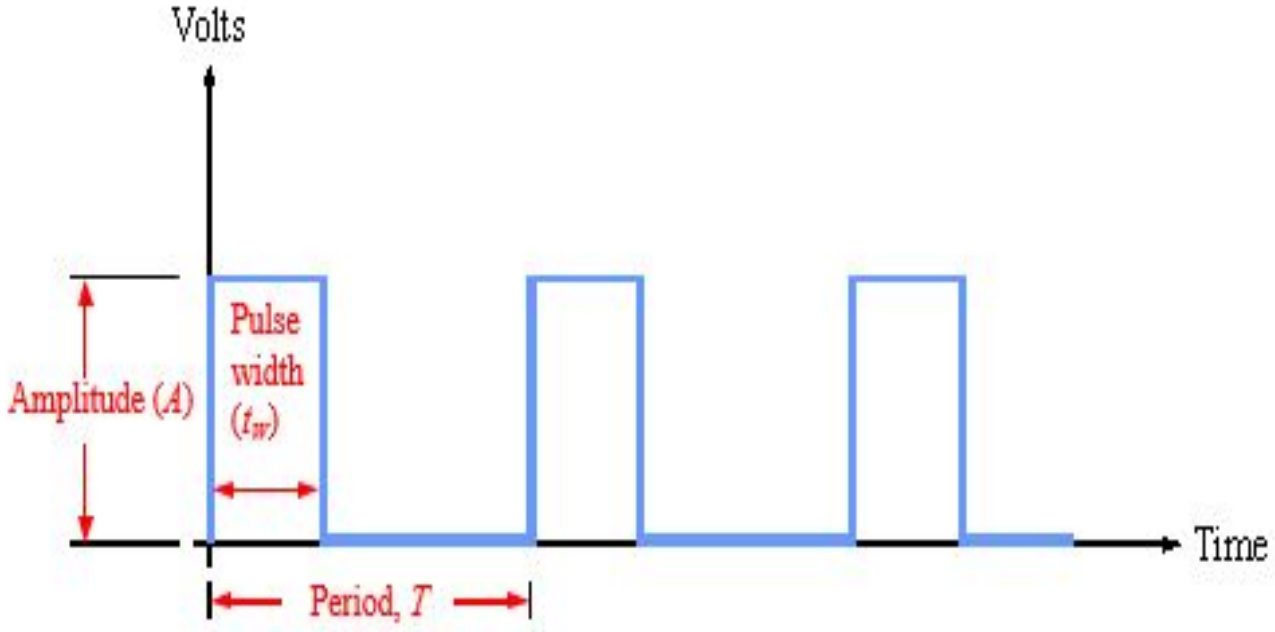
- Waveforms = series of pulses (called pulse train)
  - Periodic



    - **Period** (T) = $T_1 = T_2 = T_3 = \ldots = T_n$
    - **Frequency** (f) = $1/T$
  - Nonperiodic

Pulse Definitions

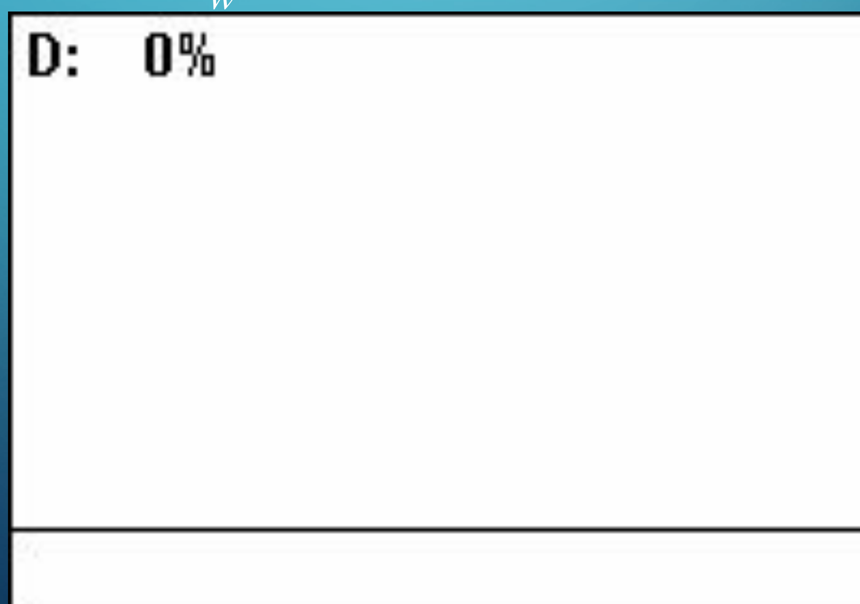
In addition to frequency and period, repetitive pulse waveforms are described by the amplitude (A), pulse width (t_W) and duty cycle. Duty cycle is the ratio of t_W to T.



DUTY CYCLE

- Ratio of the pulse width (t_w) to the period (T)

$$\text{Duty cycle} = (\, t_w \,/\, T \,) \times 100\%$$



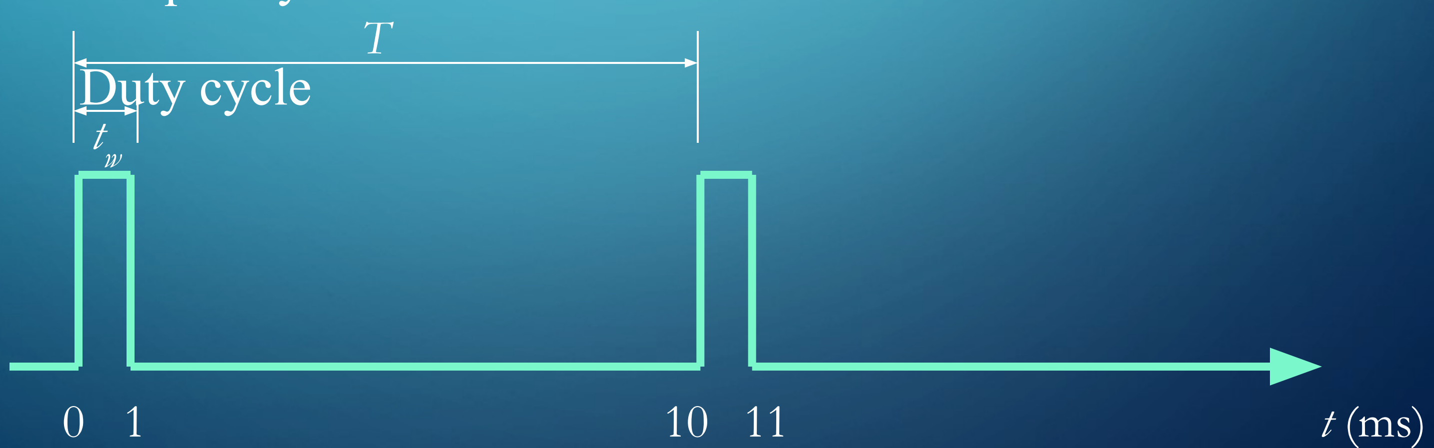
EXAMPLE

- From a portion of a periodic waveform (as shown) determine:

a) Period

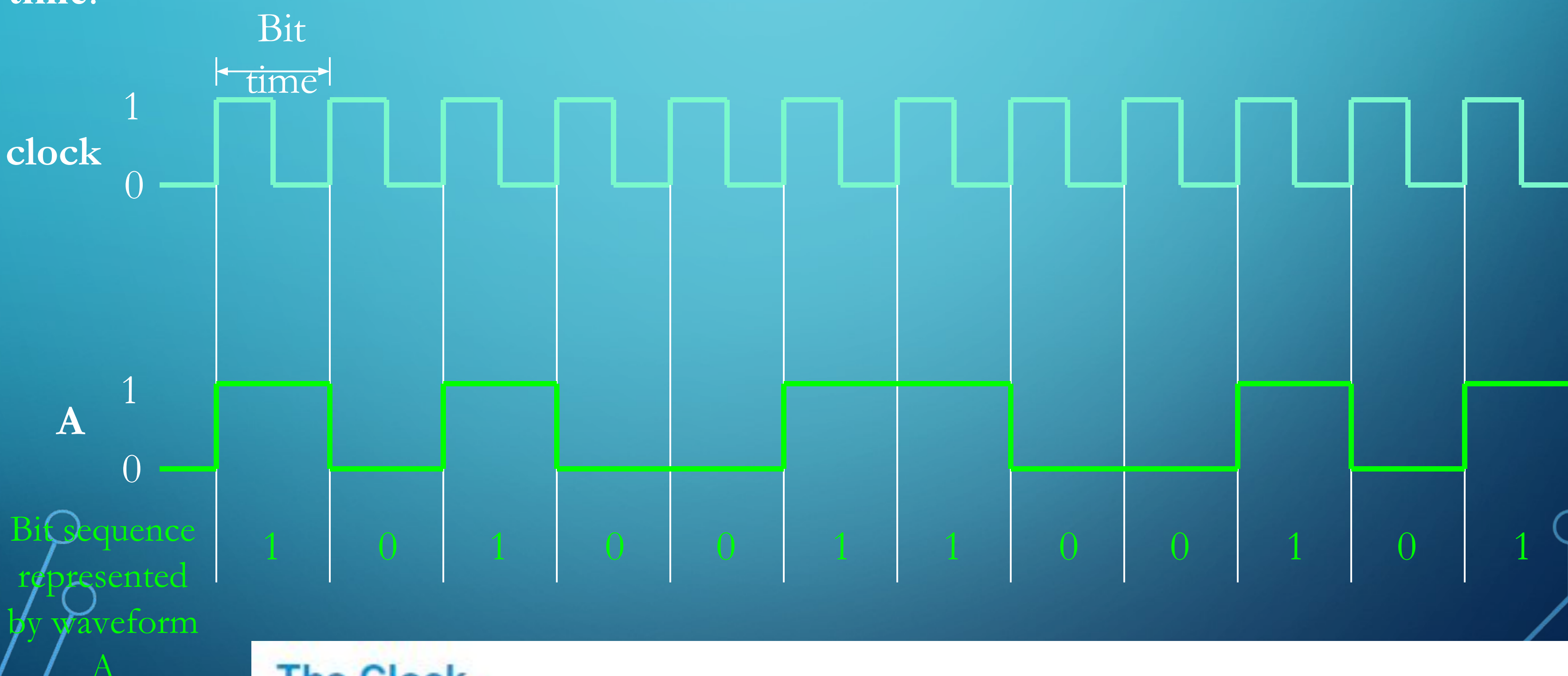
b) Frequency

c) Duty cycle



A DIGITAL WAVEFORM CARRIES BINARY INFORMATION

Binary information that is handled by digital systems appears as waveforms that represent sequences of bits. When the waveform is HIGH, a binary 1 is present; when the waveform is LOW, a binary 0 is present. Each bit in a sequence occupies a defined time interval called a **bit time**.

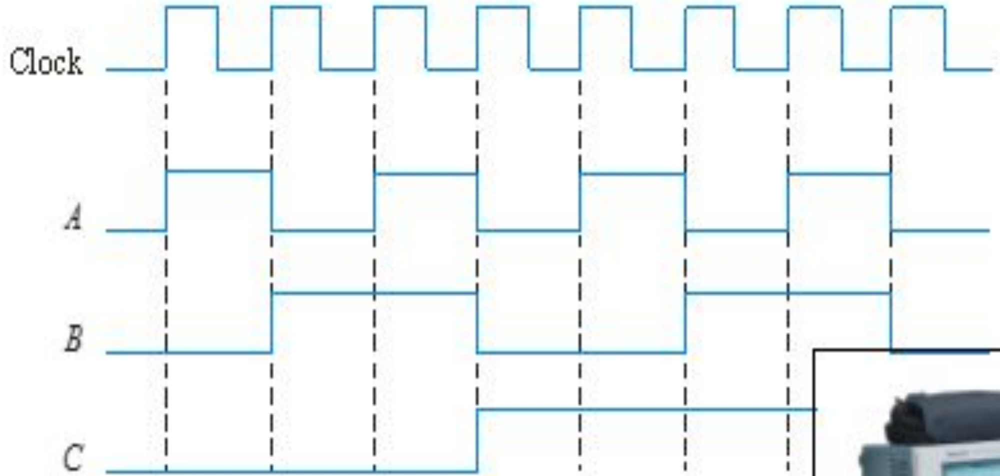


The Clock

In digital systems, all waveforms are synchronized with a basic timing waveform called the **clock**. The clock is a periodic waveform in which each interval between pulses (the period) equals the time for one bit.

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.

DATA TRANSFER

- **Data** refers to groups of bits that convey some type of information. Binary data, which are represented by digital waveforms, must be transferred from one device to another within a digital system or from one system to another in order to accomplish a given purpose.
- Binary data are transferred in two ways:
  - Serial – bits are sent one bit at a time
  - Parallel – all the bits in a group are sent out on separate lines at the same time (one line for each bit)

InfoNote : Universal Serial Bus (USB) is a serial bus standard for device interfacing. It was originally developed for the personal computer but has become widely used on many types of handheld and mobile devices. USB is expected to replace other serial and parallel ports. USB operated at 12 Mbps (million bits per second) when first introduced in 1995, but it now provides transmission speeds of up to 5 Gbps.

PARALLEL TRANSMISSION

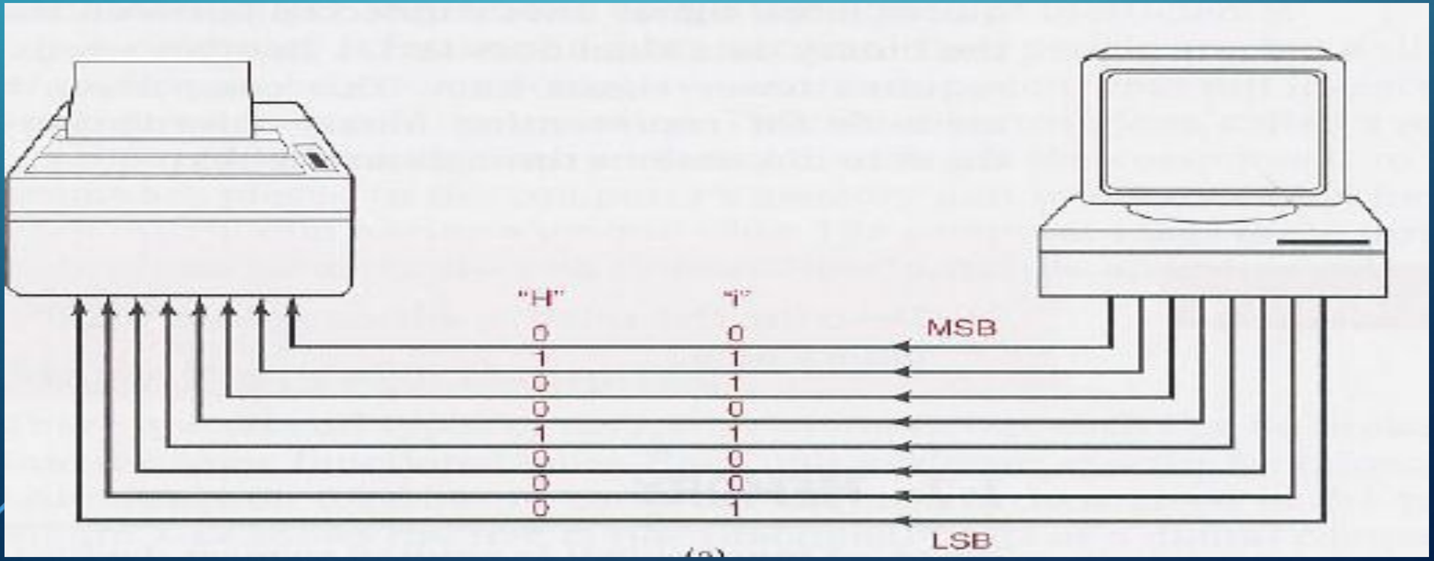
All the bits in a group are sent out on separate lines at the same time. There is one line for each bit.

Advantage:

Parallel is Faster (b/c all bits are transmitted simultaneously)

Disadvantage:

More lines are required



SERIES TRANSMISSION

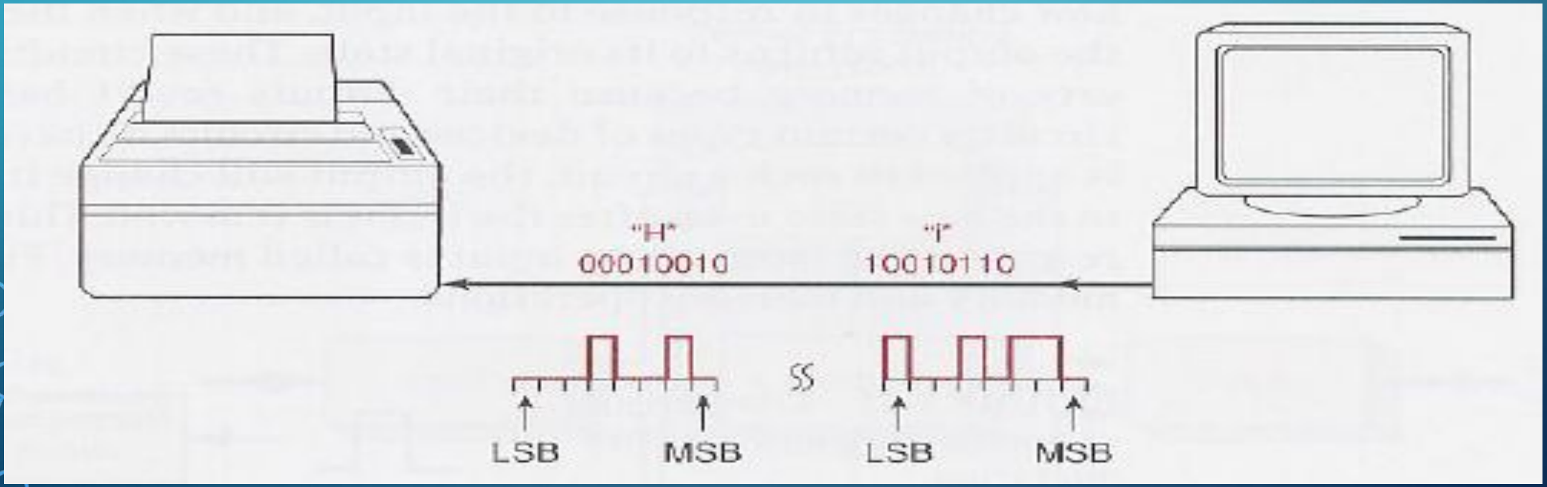
One bit sent at a time along a single conductor. To transfer eight bits in series, it takes eight time intervals.

Advantage:

Only one line is required.

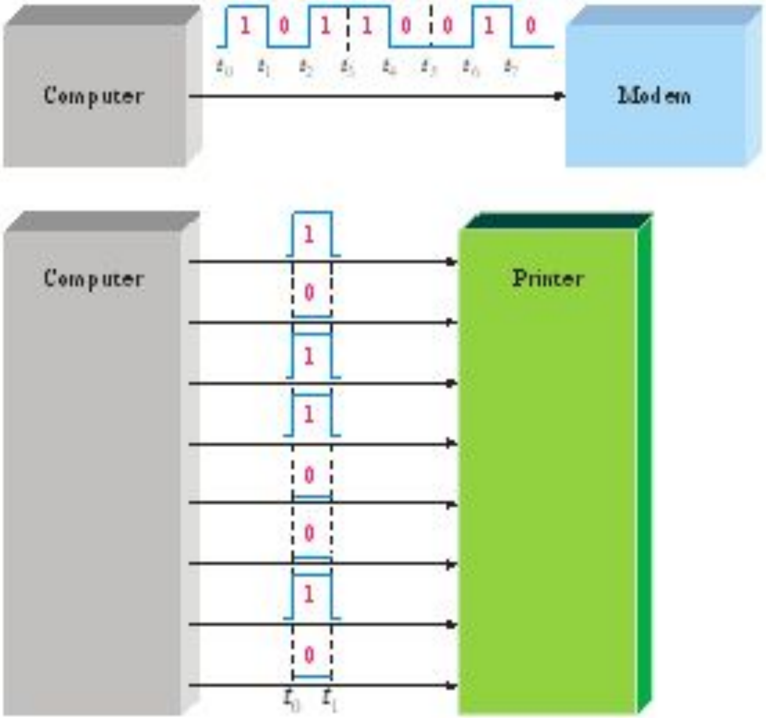
Disadvantage:

It takes longer time to transfer the data.



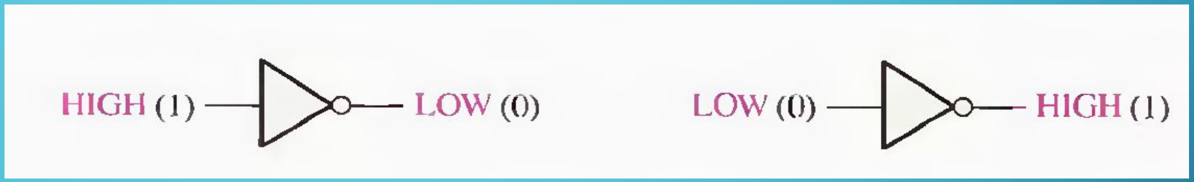
Serial and Parallel Data

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

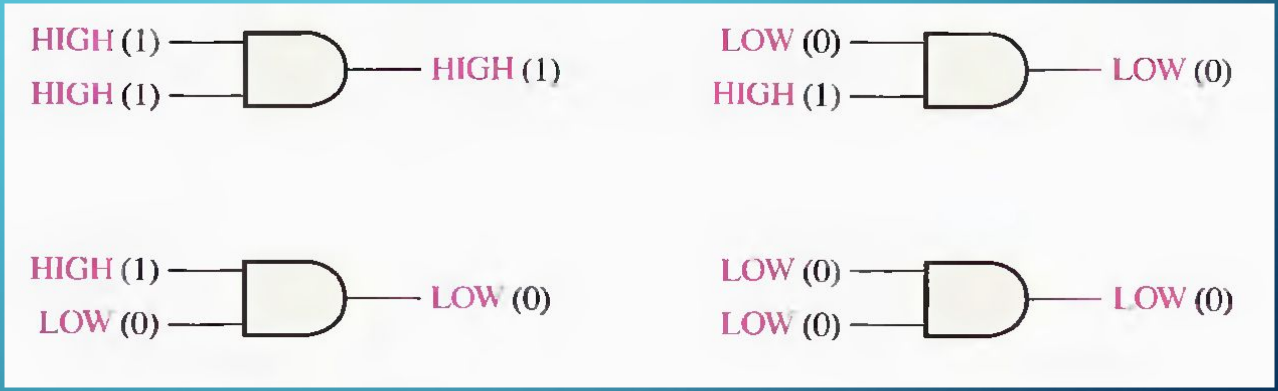


BASIC LOGIC OPERATIONS

NOT operation



AND operation



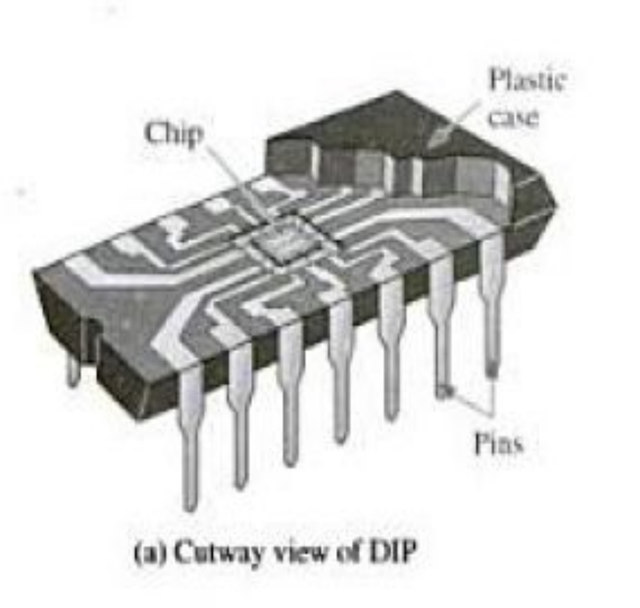
OR operation

Digital Integrated Circuits

A monolithic integrated circuit (ICs)is an electronic circuit that is constructed entirely on a single chip of silicon. All components that make up the circuit—transistor , diodes, resistors and capacitors –are an integral part of that single chip.

The most common IC s fabrication technologies are :

- ***CMOS*** *(complementary metal -oxide semiconductor)*
- ***TTL*** *(transistor - transistor logic)*
- ***NMOS*** *(N – channel metal -oxide semiconductor)*
- ***ECL*** *(emitter- coupled logic)*



(a) Cutway view of DIP


(b) Dual in-line package (DIP)