Lecture 2-

Second stage

Medical Physical Department

Digital Electronics

Lecture 1: Introduction of Logic Gates

Dr. Feral Ibrahim Althefery

Introduction of Logic Gates

1. Introduction

The individual memory cells used in computers are bitable in operation (pendulous between 1 and 0) and capable of storing a single binary bit. Therefore, it is most practical to use the binary number system that uses only two basic symbols 0 and 1 to represent numbers.

Binary logic is used to describe, in mathematical way, the manipulation and processing of binary information. Binary logic consists of binary variables and logic operations. The binary variables are letters of the

alphabet such as X, A, D . . . etc. Each variable has two possible values, 0 or 1. The basic logic operations are the three operations OR, AND, and NOT.

2. Gates

A **gate** is simply an electronic circuit which operates on one or more input signals to perform the logic operation and produce an output signal.

Logic gates are the most basic logic circuits. These are the **fundamental building blocks** from which all other logic circuits and digital systems are constructed. In Boolean algebra there are **only three basic operations**: **OR**, **AND**, and **NOT**, called logic operations. Logic **gates** can be **constructed** from **diodes, transistors, and resistors** connected so that the circuit output is the result of a basic logic operation (OR, AND, NOT) performed on the inputs.

A Digital Logic Gate is an electronic circuit which makes logical decisions based on the combination of digital signals present on its inputs.

Digital logic gates can have more than one inputs, but generally only have one digital output. Individual logic gates can be connected or cascaded together to form a logic gate function with any desired number of inputs, or to form **combinational** and **sequential** type circuits, or to produce different logic gate functions from standard gates.

Commercially available digital logic gates are available in two basic families or forms, **TTL** which stands for *Transistor-Transistor Logic* such as the 7400 series, and **CMOS** which stands for *Complementary Metal-Oxide-Silicon* which is the 4000 series of chips as shows in figure 1.

This notation of TTL or CMOS refers to the logic technology used to manufacture the integrated circuit, (IC) or a "chip" as it is more commonly called.

Generally speaking, **TTL** logic IC's use Negative-Positive-Negative NPN and Positive-Negative-Positive PNP type Bipolar **J**unction Transistors while **CMOS** logic IC's use complementary MOSFET or JFET type Field Effect Transistors for both their input and output circuitry as shows in figure 2.

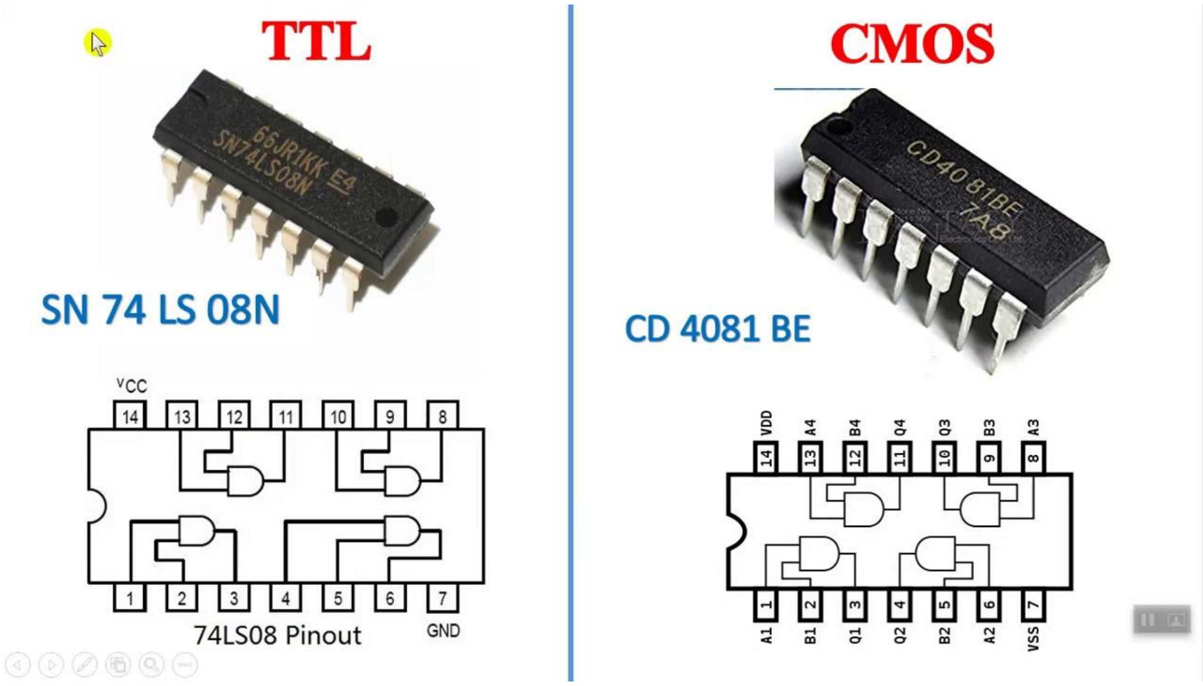


Fig. 1 CMOS and TTL

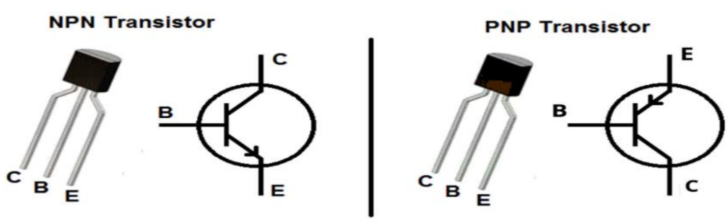


Fig. 2 NPN and PNP Transistor

3. Boolean Logic

Named after English mathematician George Boole (1815 – 1864). Boolean algebra uses symbols to represent a logical expression that has one of two possible values: True/False (1/0; ON/OFF; High/Low).

The main purpose of these logical expressions is to describe the relationship between a logic circuit's output (the decision) and its inputs (the circumstances), both of which are binary values.

Boolean constants and variables are allowed to have only two possible values, 0 or 1. A Boolean variable is a quantity that may, at different times, be equal to either 0 or 1.

Boolean **0 and 1** do not represent actual numbers but instead represent the **state of a voltage variable**, or what is called its "**logic level**". A voltage in a digital circuit is said to be at the logic **0 level** or the logic **1 level**, depending on its actual numerical value (e.g. **low** or **high**). The **inputs** are considered **logic variables** whose logic **levels** at any time **determine** the **output levels.** We use **letter symbols** to represent **logic variables**. For example, the letter A might represent a certain digital circuit input or output, and at any time either A = 0 or A = 1.

4. Truth table

A truth table is a two-dimensional array where there is one column for each input and one column for each output (a circuit may have more than one output). Since we are dealing with binary values, each input can be either 0 or 1.The number of truth table possibilities are 2^n, where n is the number of input variable. For example, if n=3 the number of possibilities are $2^3=8$.

The values in the output column are determined from applying the corresponding input values to the functional operator. For example, in the following truth table:

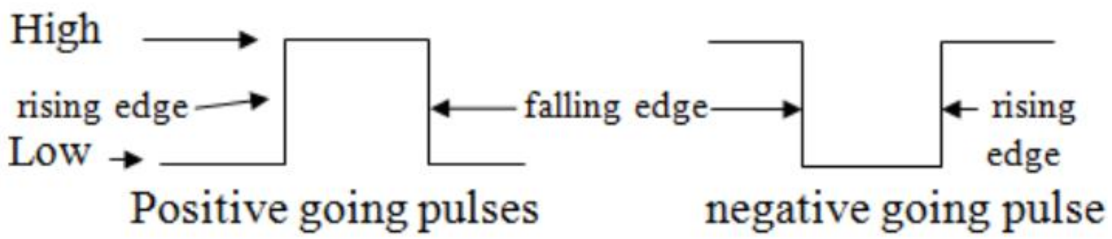
Input		Output
X	Y	F
0	0	0
0	1	1
1	0	0
1	1	1

There are 2 input variables, X and Y, and one output variable, F. So there are 4 combinations.

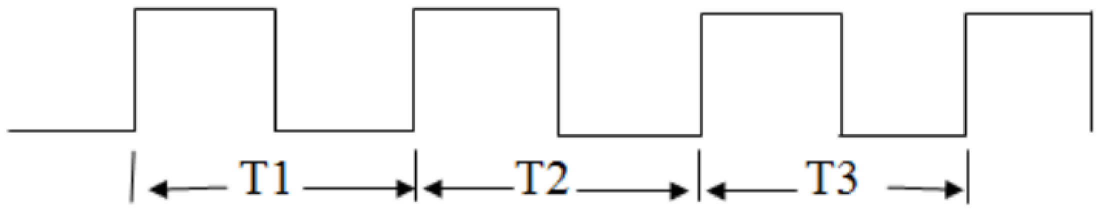
The output F = 1 when either X and Y are both 1 or X=0 and Y =1, while the value of F is 0 for the other possibilities. Using truth tables is one method to formally describe the operation of a circuit or function.

5. Pulse waveform

Pulses are very important in digital circuits and systems because voltage level are normally changing back and front between High (logic 1) and Low (logic 0) states.



Pulses can be classified as either periodic or non periodic, as shown in fig (3).



(a)Periodic waveform

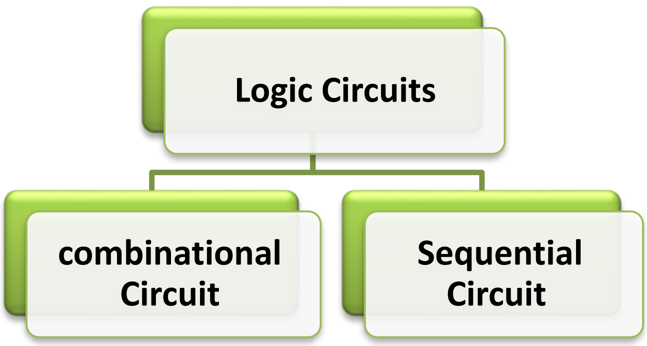
(b) Non- periodic waveform

Fig (3) Periodic and Non- periodic waveforms

A **timing diagram** is a graphical method of showing the exact output behavior of a logic circuit for every possible of input condition. It is used to describe the operation of digital devices because its visual characteristics are much easier to understand than explanation using words.

6. Logic Circuits

In digital system, logic circuits generally fall into two categories, both combinational and sequential circuits are the most widely used circuits. These are two broad categories of circuits defined in digital electronics where one type of circuit is independent of time and the other is dependent on time.



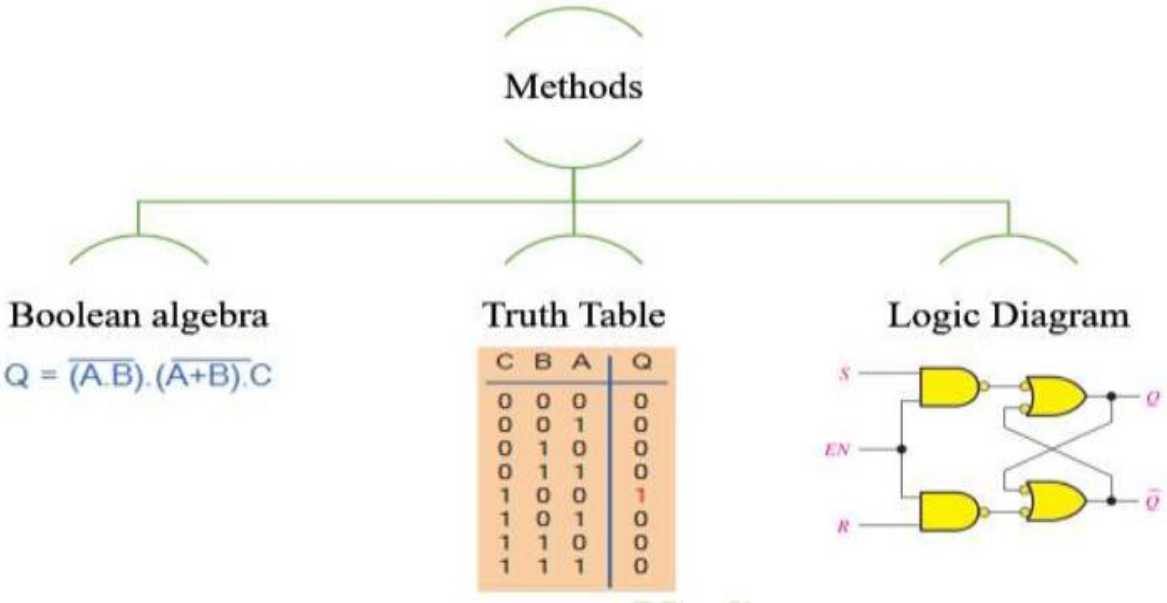
Following are the important differences between combinational and sequential circuit:

Basis for Comparison	Combinational Circuits	Sequential Circuits
Basic	The output is discovered by the present state of the inputs.	Both the present input and past state output are used to identify the output.
Storage capability	Does not store data.	Can store a small amount of data.

Application	Used in adders, Subtractor.	Used in flip-flop and latches.
Clock	Circuits do not rely on the clock.	Clock is utilized for performing triggering functions.
Feedback	No requirement of the feedback.	Feedback is required.

- **Function of a Combinational Logic Circuit**

The three main methods of specifying the function of a combinational logic circuit are:



7. Some Types of Logical Gates

- AND Gate
- OR Gate
- NOT Gate
- NANAD Gate
- NOR Gate
- XOR Gate
- XNOR Gate

`