Practical exercise 2

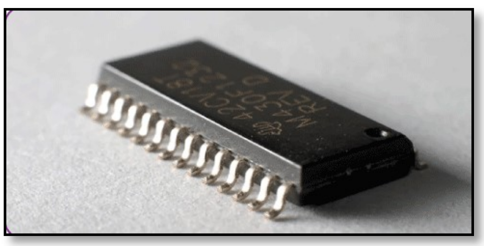
Aim: Study of Basic Gates Ics (7400, 7404, 7408, 7486, 7432) and verification of Truth tables by monitoring the output of Ics on Bread Board.

Apparatus: Bread board, switches IC 7408, 100ohm resistor, output pin, input pin, battery etc.

Objective: To become familiar with the digital electronic lab apparatus like ICs and learn about functionality of each of the IC.

Theory:

What is IC ?:



Before the discovery of ICs, the basic method of making circuits was to select the components like diodes, transistors, resistors, inductors and capacitors and connect them by shouldering. But due to size and power consumption issues, it was necessary to develop a small size circuit with less power consumption, reliability and shockproof.

After the invention of the semiconductors and transistors, things were quite simplified to a particular extent, but the development of integrated circuits changed electronics technology's face. Jack Kilby from Texas Instruments and Bob Noyce from Intel are the official creators of integrated circuits, and they did it independently.

An integrated circuit sometimes called a cheap, microchip and microelectronic circuit, is a semiconductor wafer on which thousands or millions of tiny resistors, capacitors, diodes and transistors are fabricated. An IC can function as an amplifier ,oscillator, timer ,counter, logic gate, computer memory, microcontroller or microprocessor.

An IC is the fundamental building block of all model electronic devices. As the name suggests, it's an integrated system of multiple miniaturized and interconnect components embedded into a thin substrate of semiconductor material (usually silicon crystal)

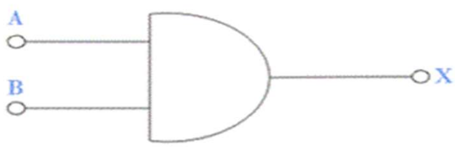
[1] AND Gate: IC 7408

An AND gate is a logic gate having two or more inputs and a single output. An AND gate operates on logical multiplication rules. In this gate, if either of the inputs is low (0), then the output is also low. If all of the inputs are high (1), then the output will also be high. An AND gate can have any number of inputs, although 2 input and 3 input AND gates are the most common.

There are many integrated circuits that work on this logic which we will revisit later on. Let us first get a better understanding of how the output of an AND Gate output behaves with respect to its inputs.

In other words, an AND gate is a digital device that produces high output only when all inputs are high and produces low output under all other inputs conditions. A high digital signal means logically 1 and a low digital signal means logically 0.

The symbol for a two-input AND gate is logically represented as:



Where A and B represent the input of the gate and X represents the output. A, B, and X can either be 0 (low) or 1 (high) logically.

The logical operation of AND gate hence can be represented as:

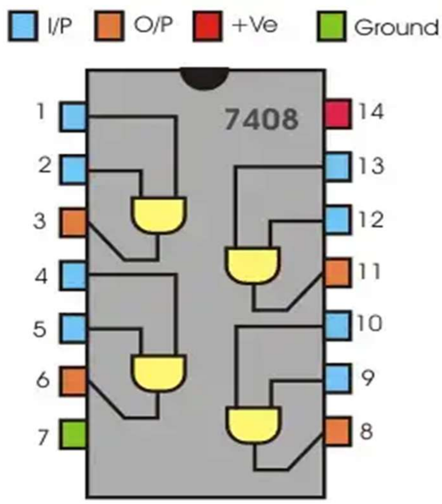
$$AB = X$$

All multiplication combinations of A and B can be represented in tabular form in truth table. Truth tables list the output of a particular digital logic circuit for all the possible combinations of its inputs. The truth table of a 2 input AND **gate** can be represented as:

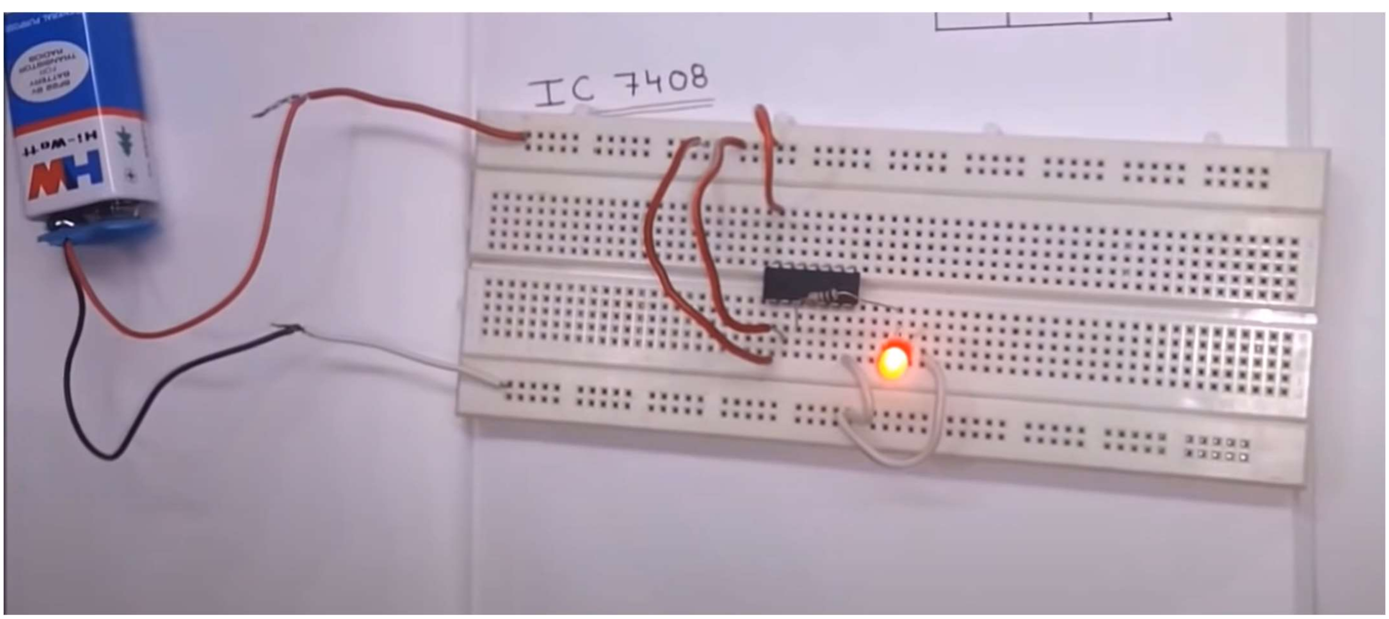
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

For AND Gate IC number is 7408. 7408 is 2- input IC where four gates are present together.

Let us have a look at the internal diagram of 7408.



Circuit connection of IC 7408:

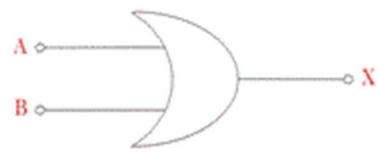


[2] OR Gate: IC 7432

An **OR gate** is a logic gate that performs logical OR operation. A logical OR operation has a high output (1) if one or both the inputs to the gate are high (1). If neither input is high, a low output (0) results. Just like an And gate, an OR gate may have any number of input probes but only one output probe.

The function of a logical OR gate effectively finds the maximum between two binary digits, just as the complementary AND function finds the minimum.

The logical symbol of 2 input OR gate is shown below:



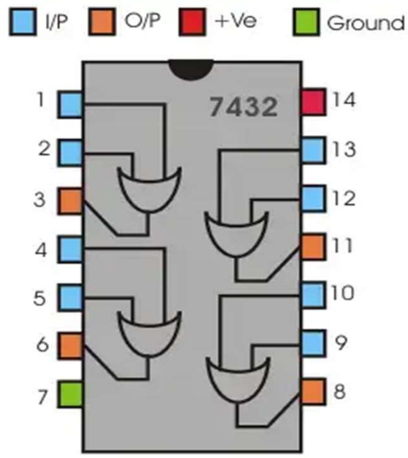
Truth tables list the output of a particular digital logic circuit for all the possible combinations of its inputs. The truth table of a 2 input OR gate can be **represented as:**

Inputs		Output
A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

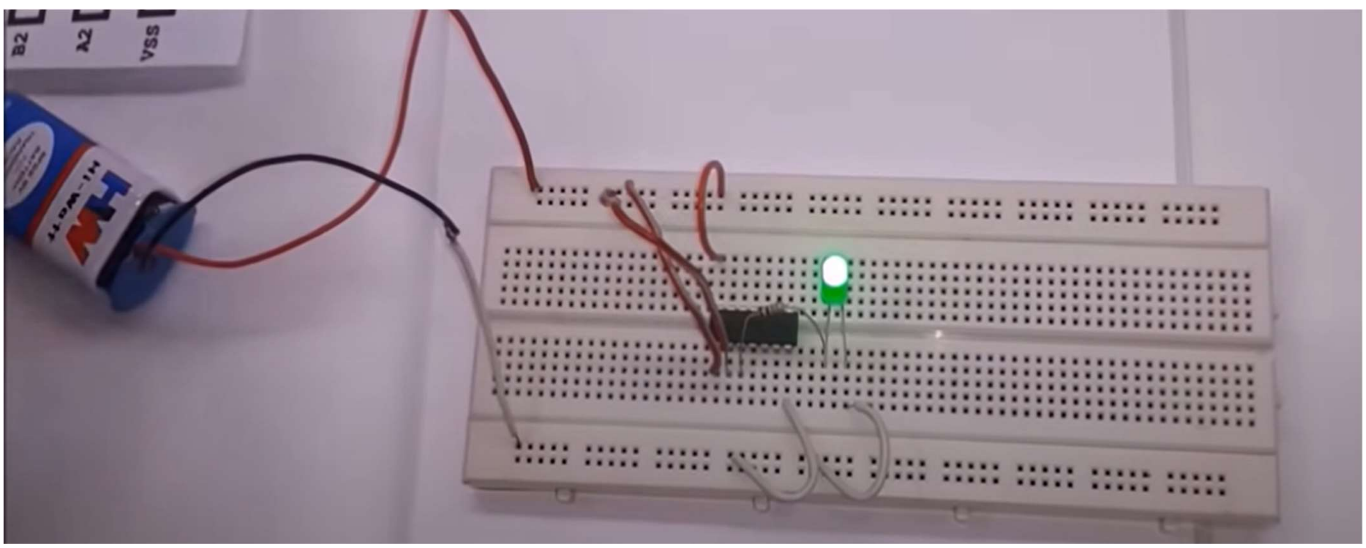
In this IC, pin 1 and 2 are the inputs of the first gate where the output is from pin number 3. Again pin numbers 4 and 5 are the inputs of the second gate whose output is in pin 6. Pin 10 and 9 are the inputs of the fourth gate whose output is at pn 8. The input of the last gate or fourth gate is pin 13 and 12 and pin 11 is its output.

For AND Gate IC number is 7432:

Pin 7 is ground and pin 14 is +vcc supply where again +Vcc supply where again +SVdC is the normal and maximum supply. One thing must be maintained at +SVDC. If the i/p voltage would be more than this it may cause damage to the IC.

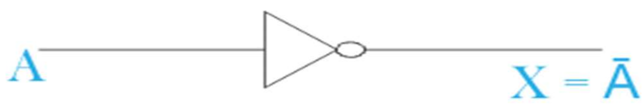


Circuit connection of IC 7432**:**



[3] NOT Gate: IC 7404

A **NOT gate** is a logic gate that inverts the digital input signal. For this reason, a NOT gate is sometimes is referred to as an inverter (not to be confused with a power inverter). A NOT gate always has high (logical 1) output when its input is low (logical 0). Conversely, a **logical NOT gate** always has low (logical 0) output when the input is high (logical 1). The logical symbol for a NOT gate is shown below:

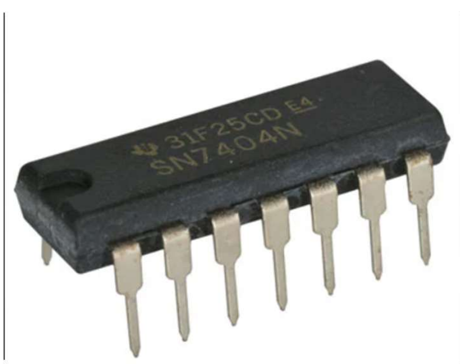


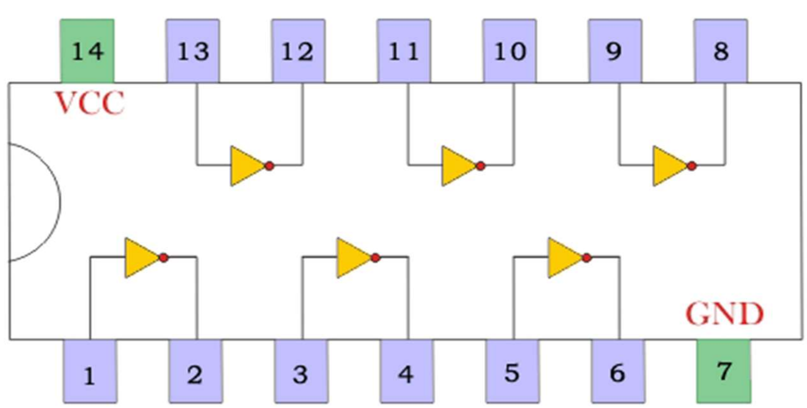
If the input binary variable of a NOT gate is considered as A, then the output binary variable of the gate will be Ā. As the symbol of not operation is (–) bar. If the value of A is 1.
then Ā = 0 and in the opposite if the value of A is then Ā = 1.

Truth tables list the output of a particular digital logic circuit for all the possible combinations of its inputs. The truth table of a **NOT gate** can be represented as:

A	X = Ā
0	1
1	0

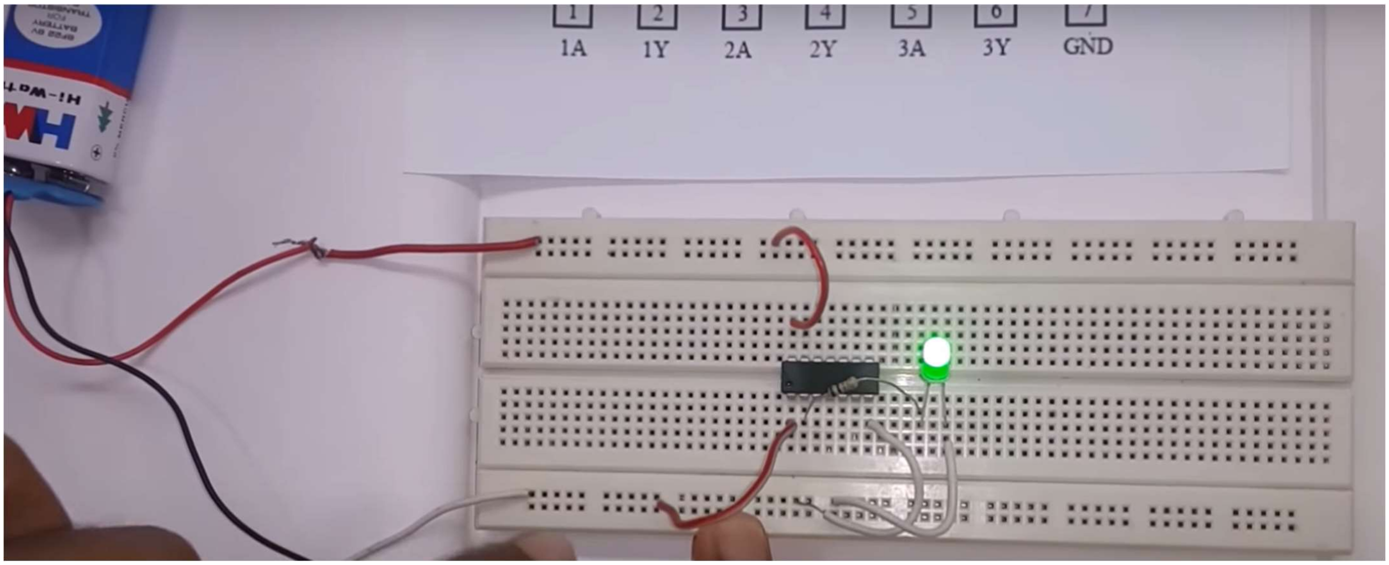
The IC available at the market for **NOT gate** is IC 7404. One 7404 IC contains a total of six transistors inverter or simply six **NOT gate**.





7404 Six Inverter

Circuit connection of IC 7404**:**



[4] NOR Gate: IC 7402

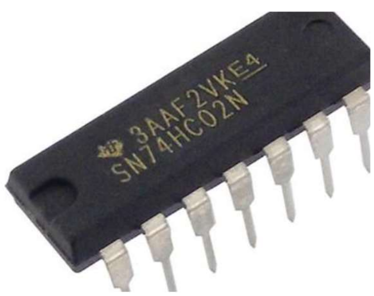
A NOR gate ("not OR gate") is a logic gate that produces a high output (1) only if all its inputs are false, and low output (0) otherwise. Hence the NOR gate is the inverse of an OR gate, and its circuit is produced by connecting an OR gate to a NOT gate. Just like an OR gate, a NOR gate may have any number of input probes but only one output probe.
A NOT gate followed by an OR gate makes a NOR gate. The basic logic construction of the NOR gate is shown below:

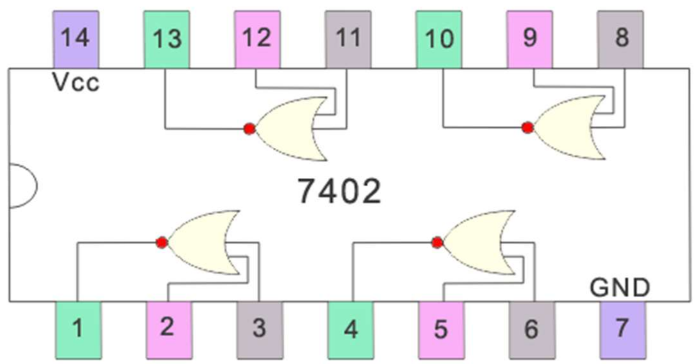
We know that the output of an OR gate is 0 only when all inputs of the OR gate are 0. Hence in the case of the NOR gate, the output is 1 only when all inputs are 0. In all other cases, that is for all other combinations of inputs the output is 0.

Truth tables list the output of a particular digital logic circuit for all the possible combinations of its inputs. The truth table of a 2 input NOR gate can be represented as:

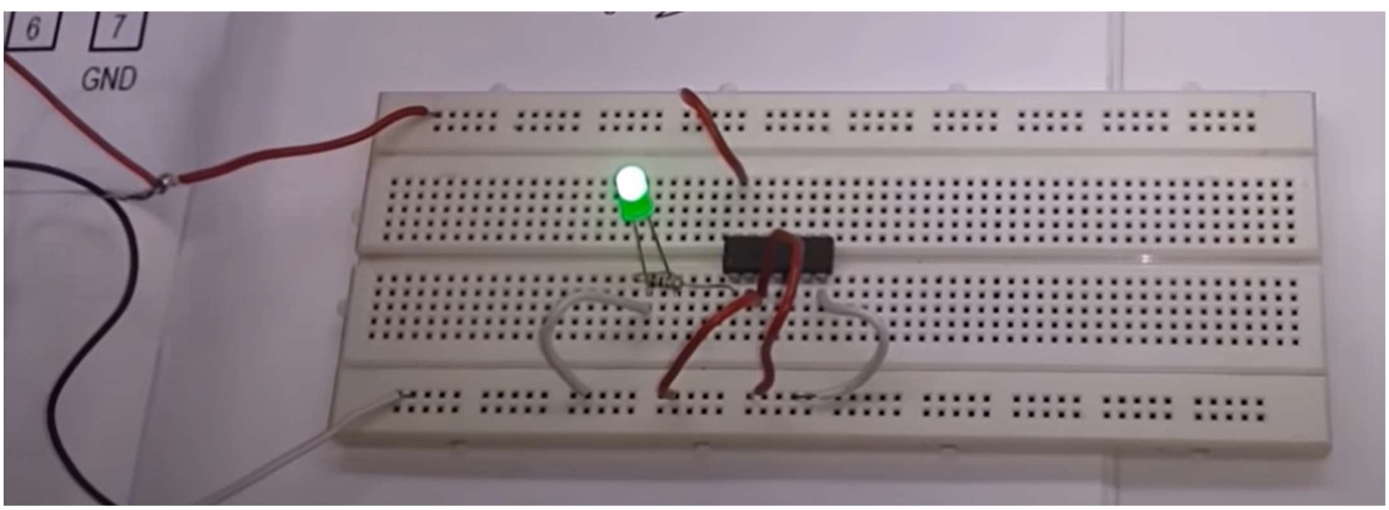
Inputs		Output
A	B	$X = \overline{A + B}$
0	0	1
0	1	0
1	0	0
1	1	0

IC 7402 contains four two inputs NOR gates.





Circuit connection of IC 7402**:**

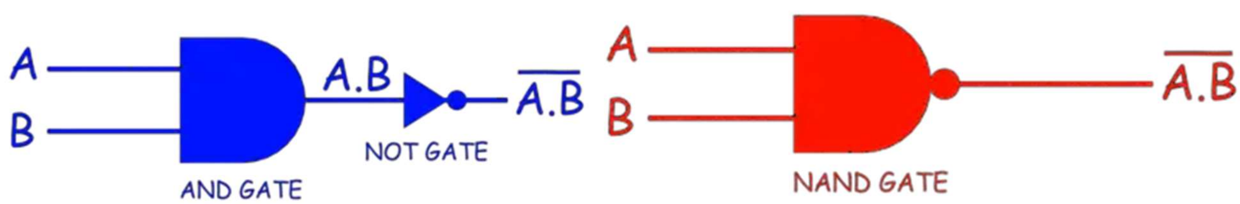


[5] NAND Gate: IC7400

A **NAND gate** ("not AND gate") is a logic gate that produces a low output (0) only if all its inputs are true, and high output (1) otherwise. Hence the NAND gate is the inverse of an AND gate, and its circuit is produced by connecting an AND gate to a NOT gate. Just like an AND gate, a NAND gate may have any number of input probes but only one output probe.

The NAND gate performs the logical NAND operation. NAND gates are known as universal gates (along with NOR gates), which means they are a type of logic gate which can implement any Boolean function without the need to use any other gate type.

The basic logical construction of the **NAND gate** is shown below (you can see it is an AND gate followed by a NOT gate):



The **symbol of a NAND gate** is similar to the AND gate, but a bubble is drawn at the output point of the AND gate**.**

NAND gate means "not AND gate", hence the output of this gate is just reverse of that of a similar AND gate.

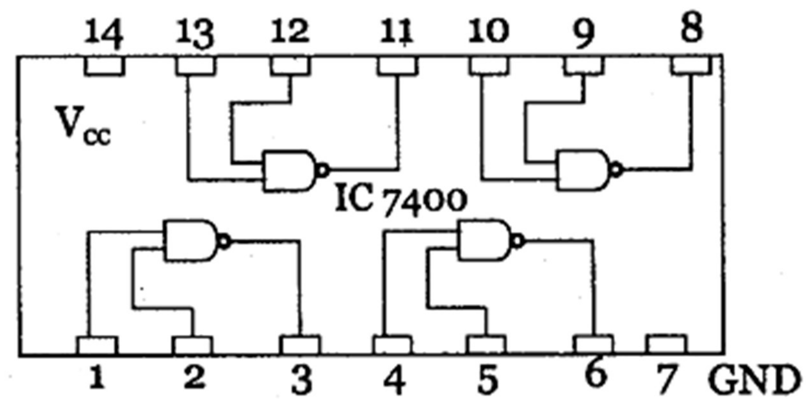
We know that the output of the AND gate is only high or 1 when all the inputs are high or 1. In all other cases, the output of the AND gate is low or 0.

In the NAND, the fact is the opposite, here, the output is only logical 0 when and only when all inputs of the gate are 1s, and in all other cases, the output of the NAND gate is high or 1.

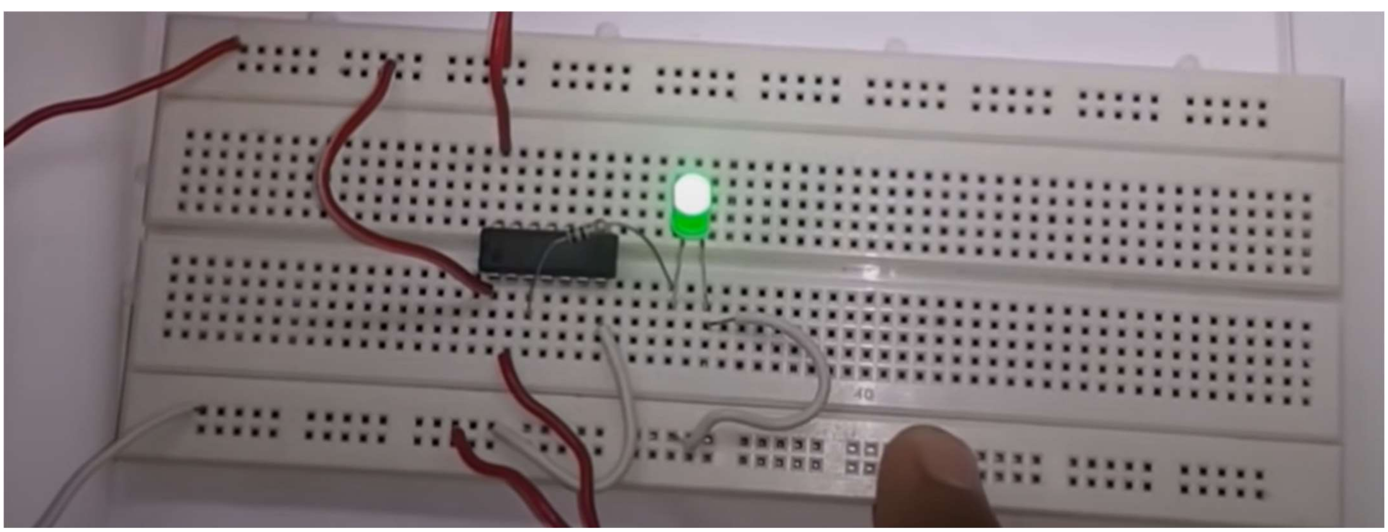
Hence, the truth table of a 2 input NAND gate can be represented as:

Inputs		Output
A	B	$X = \overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

IC 7400 contains four two inputs NAND gates.



Circuit connection of IC 7400**:**



[6] EX-OR Gate: IC 7486

Two special logic circuits that occur quite often in digital systems are the exclusive-OR and exclusive-NOR circuits.

The circuit of an exclusive-OR gate is shown in fig 1 .

As obvious, there are two inputs and one output. The exclusive-OR operation is denoted by $\oplus$.

Hence the expression for the output of the circuit is given as :

$A \oplus B = A\bar{B} + \bar{A}B$

The truth table for two input EX-OR gate is shown in Table 1 .

A	B	$Z=A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

Table 1

The output expression for two input EX-OR gate, in short, is given as

$$Z = A \oplus B = A\bar{B} + \bar{A}B$$

This circuit is also called an inequality comparator or detector because it produces output only when the two inputs are different.

The main characteristic property of an EX-OR gate is that it can perform modulo-2 addition. It should be noted that the same EX-OR truth table applies when adding two binary digits (bits). A 2-input EX-OR circuit is therefore sometimes called a modulo-2 adder or a half adder. The name half adder refers to the fact that possible carry-bit, resulting from an addition of two preceding bits, has not been taken into account. The name Exclusive-OR is derived from the fact that its output is a 1, only when exclusively one f its input is a 1 (it excludes the condition when both the inputs are 1).

Fig 5 shows the pinout diagram of an IC7486 which is a quad 2-input EX-OR gate.

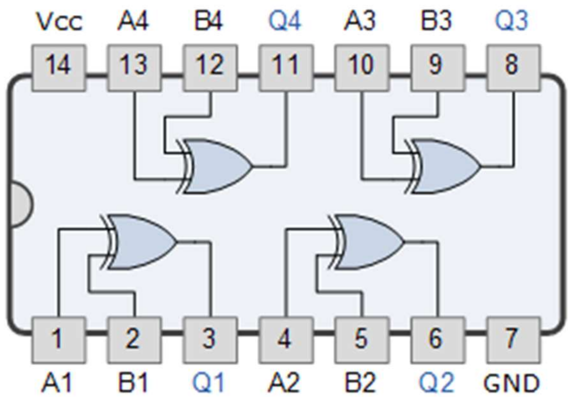
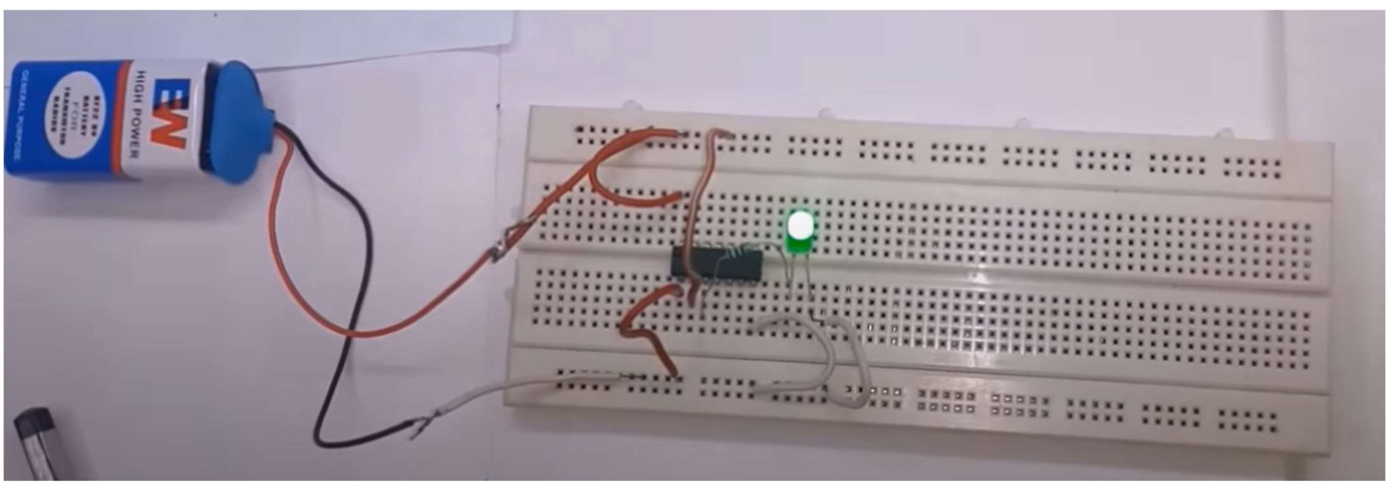


Fig 5

It contains four 2-input EX-OR gate in a 14-pin DIP.

Circuit connection of IC 7486**:**



[7] EX-NOR Gate: IC 74266

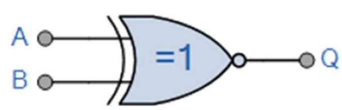
Basically the "Exclusive-NOR Gate" is a combination of the Exclusive-OR gate and the NOT gate but has a truth table similar to the standard NOR gate in that it has an output that is normally at logic level "1" and goes "LOW" to logic level "0"when ANY of its inputs are at logic level "1".

However, an output “1” is only obtained if **BOTH** of its inputs are at the same logic level, either binary “1” or “0”. For example, “00” or “11”. This input combination would then give us the Boolean expression of: $Q = (A \oplus B) = A.B + A.B$

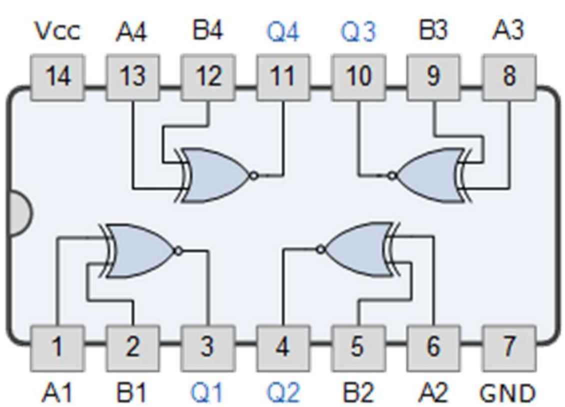
Then the output of a digital logic Exclusive-NOR gate **ONLY** goes “HIGH” when its two input terminals, A and B are at the “**SAME**” logic level which can be either at a logic level “1” or at a logic level “0”. In other words, an even number of logic “1’s” on its inputs gives a logic “1” at the output, otherwise is at logic level “0”.

Then this type of gate gives and output “1” when its inputs are “*logically equal*” or “*equivalent*” to each other, which is why an **Exclusive-NOR** gate is sometimes called an **Equivalence Gate**

The logic symbol for an Exclusive-NOR gate is simply an Exclusive-OR gate with a circle or “inversion bubble”, (o) at its output to represent the NOT function. Then the **Logic Exclusive-NOR Gate** is the reverse or “*Complementary*” form of the Exclusive-OR gate, $(A \oplus B)$ we have seen previously.

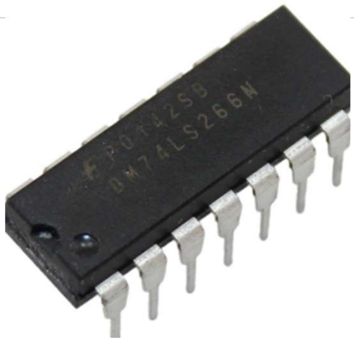
Symbol	Truth Table		
	B	A	Q
	0	0	1
	0	1	0
2-input Ex-NOR Gate	1	0	0
	1	1	1
Boolean Expression $Q = A \oplus B$	Read if A **AND** B the **SAME** gives Q		

74266 Quad 2-input Ex-NOR Gate



In the next tutorial about **Digital Logic Gates**, we will look at the digital Tri-state Buffer also called the non-inverting buffer as used in both TTL and CMOS logic circuits as well as its Boolean Algebra definition and truth table.

IC 7486



<u>Conclusion:</u> Hence, we have studied about basic gates ,universal gates & verified their truth table .