Lab 1: Verification of Gates

1.1 Aim

To study and verify the Truth Tables of AND, OR, NOT, NAND, NOR, XOR, XNOR logic gates for positive logic.

1.2 Objectives:

- To get familiar with the usage of the available lab equipment.
- To get familiar with Prototyping board (breadboard)
- To describe and verify the operation for the AND, OR, NOT, NAND, NOR, XOR, XNOR gates.
- To study the representation of these functions by truth tables, logic diagrams and Boolean algebra
- To Introduce a basic knowledge in integrated circuit devices operation
- To practice how to build a simple digital circuit using ICs and other digital components .
- Learn how to Wire a circuit

1.3 Apparatus/Equipment Required:

- Prototyping board (breadboard)
- DC Power Supply 5V
- Light Emitting Diode (LED)
- Digital ICs:
  - 7404 :Hex Inverter
  - 7408 :Quad 2 input AND

– 7432 :Quad 2 input OR

– 7400: Quad 2 input NAND

– 7402: Quad 2 input NOR

– 7486: Quad 2 input XOR

– 74266:Quad 2 input XNOR

- Connecting Wires

1.3.1 Pin Diagram

Figure1.1 shows the architecture of SAP-1, a bus-organized computer. All register outputs to the 8 bit W-bus are three states; this allows orderly transfer of data. All other register outputs are two state; these outputs continuously drive the boxes they are connected to. The layout of Fig.1.1 emphasizes the registers used in SAP- 1. For this reason, no attempt has been made to keep all control circuits in one block called the control unit, all input-output circuits in another block called the I/O unit, etc

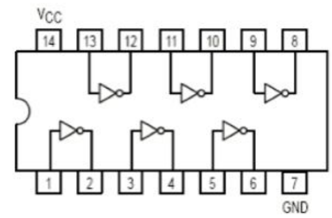
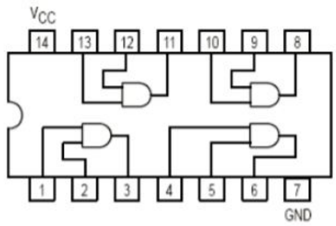
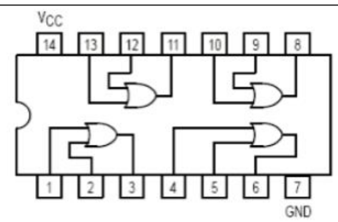
	**NOT Gate: IC 7404(HEX Inverter)** **14 Pin** **Supply voltage :5V**
	**AND Gate: IC 7408** **14 Pin** **Quad 2 input AND Gate** **Supply voltage :5V**
	**OR Gate: IC 7432** **14 Pin** **Quad 2 input OR Gate** **Supply voltage :5V**

Figure 1.1: Pin Specification of various Digital ICs.

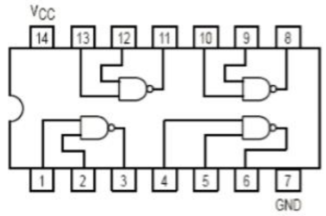
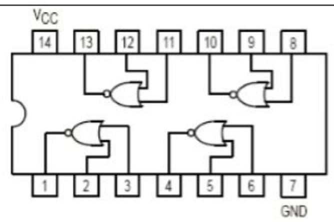
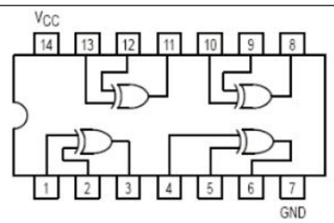
	**NAND Gate: IC 7400** **14 Pin** **Quad 2 input NAND Gate** **Supply voltage :5V**
	**NOR Gate: IC 7402** **14 Pin** **Quad 2 input NOR Gate** **Supply voltage :5V**
	**XOR Gate: IC 7486** **14 Pin** **Quad 2 input EXOR Gate** **Supply voltage :5V**

Figure 1.2: Pin Specification of various Digital ICs.

1.4 Theory

A Digital Logic Gate is an electronic device that makes logical decisions based on the different combinations of digital signals present on its inputs Logic gates are the building blocks of digital circuits. Combinations of logic gates form circuits designed with specific tasks in mind. They are fundamental to the design of computers. Digital logic using transistors is often referred as Transistor-Transistor Logic or TTL gates. These gates are the AND, OR, NOT, NAND, NOR, XOR and XNOR gates.

1.4.1 AND Gate

A multi-input circuit in which the output is 1 only if all inputs are 1.The symbolic representation of the AND gate is:

A dot (.) is used to show the AND operation i.e. A.B if A and B are the inputs to AND Gate.

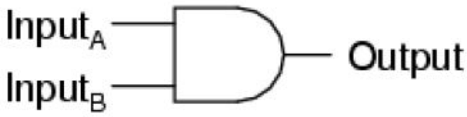


Figure 1.3: Logic Symbol of AND Gate

A	B	OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

Figure 1.4: Truth Table for AND Gate

1.4.2 OR Gate

A multi-input circuit in which the output is 1 when any input is 1. The symbolic representation of the OR gate is shown:

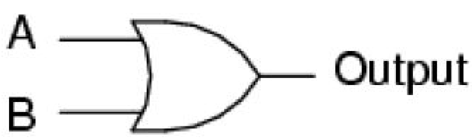


Figure 1.5: Logic Symbol of OR Gate

The OR gate is an electronic circuit that gives a high output (1) if one or more of its inputs are high. A plus (+) is used to show the OR operation.

A	B	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	1

Figure 1.6: Truth Table for OR Gate

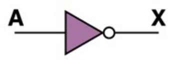
1.4.3 NOT Gate

The output is 0 when the input is 1, and the output is 1 when the input is 0. The symbolic representation of an inverter is :

Boolean Expression

$X = \bar{A}$

Logic Diagram Symbol



Truth Table

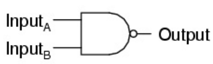
A	X
0	1
1	0

Figure 1.7: Logic Symbol and Truth Table for NOT gate

The NOT gate is an electronic circuit that produces an inverted version of the input at its output. It is also known as an inverter. If the input variable is A, the inverted output is known as NOT A. This is also shown as A′, or A with a bar over the top, as shown at the outputs.

1.4.4 NAND Gate

AND followed by INVERT. It is also known as universal gate. The symbolic representation of the NAND gate is:



$X = \overline{A.B}$

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

Figure 1.8: Logic Symbol and Truth Table for NAND gate

This is a NOT-AND gate which is equal to an AND gate followed by a NOT gate. The outputs of all NAND gates are high if any of the inputs are low. The symbol is an AND gate with a small circle on the output. The small circle represents inversion.

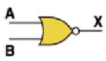
1.4.5 NOR Gate

OR followed by inverter. It is also known as universal gate. The symbolic representation is:

Boolean Expression

$X = \overline{(A + B)}$

Logic Diagram Symbol



Truth Table

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

Figure 1.9: Logic Symbol and Truth Table for NOR gate

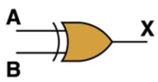
1.4.6 Exclusive-OR (XOR Gate)

The output of the Exclusive-OR (XOR) gate is 0 when its two inputs are the same and its output is 1 when its two inputs are different.

Boolean Expression

$X = A \oplus B$

Logic Diagram Symbol



Truth Table

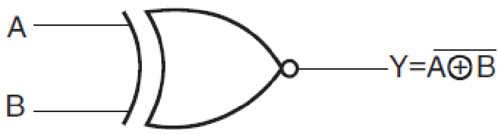
A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

Figure 1.10: Logic Symbol and Truth Table for XOR gate

The 'Exclusive-OR' gate is a circuit which will give a high output if either, but not both, of its two inputs are high. An encircled plus sign ( ) is used to show the XOR operation.

1.4.7 Exclusive-NOR (XNOR)

The XNOR gate is a digital logic gate whose function is the inverse of the operation exclusive OR (XOR) gate. The output of the Exclusive NOR gate, is 0 when its two inputs are the different and its output is 1 when its two inputs are same. An encircled plus sign and bar are used to show the XNOR operation.



$$Y = (\overline{A \oplus B}) = (A.B + \overline{A}.\overline{B})$$

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

Figure 1.11: Logic Symbol and Truth Table for XNOR gate

1.5 Procedure:

1. Collect the components necessary to accomplish this experiment.
2. Plug the IC chip into the breadboard.
3. Connect the supply voltage and ground lines to the chips. PIN7 = Ground and $PIN14 = +5V$.
4. According to the pin diagram of each IC mentioned above, wire only one gate to verify its truth table.
5. Connect the inputs of the gate to the input switches of the LED.
6. Connect the output of the gate to the output LEDs.
7. Once all connections have been done, turn on the power switch of the breadboard
8. Operate the switches and fill in the truth table (Write "1" if LED is ON and "0" if LED is OFF Apply the various combination of inputs according to the truth table and observe the condition of Output LEDs.
9. Repeat the above steps 1 to 5 for all the ICs.

1.6 Observation Table:

Input variables: A and B
Output variable: Y
LED ON: Logic 1
LED OFF: Logic 0

1.7 Results and Analysis:

- NOT Gate: When logic 1 is applied to one of NOT gate of 7404 IC, then output becomes zero. When input LED is ON (RED), the output LED become OFF (Green) vice versa.

Table 1.1: Output Observation Table

S.No	Inputs		Outputs						
	A	B	NOT	AND	OR	NAND	NOR	XOR	XNOR
1									
2									
3									
4									

- OR Gate: The output of an OR gate is a 1 if one or the other or both of the inputs are 1, but a 0 if both inputs are 0. When One or the other or Both of the input LEDS are ON (RED Light), then output LED is ON(RED) otherwise Output LED is OFF(Green Light)
- AND Gate: The output of an AND gate is only 1 if both its inputs are 1. For all other possible inputs the output is 0.When both the LEDS are On, then output LED is ON (RED Light) otherwise Output LED is OFF.
- NOR Gate: The output of the NOR gate is a 1 if both inputs are 0 but a 0 if one or the other or both the inputs are 1. NAND Gate: The output of the NAND gate is a 0 if both inputs are 1 but a 1 if one or the other or both the inputs are 0.
- XOR gate: The output of the XOR gate is a 1 if either but not both inputs are 1 and a 0 if the inputs are both 0 or both 1.
- XNOR gate: The output of the ExclusiveâĂŞNOR gate, is 0 when its two inputs are the different and its output is 1 when its two inputs are same.

1.9 Conclusion:

Any Boolean expression can be realized using NOT, AND, OR, NAND, NOR, XOR, XNOR gates.