Experiment 13- Realization of logic gates using DTL, TTL, ECL, etc.,

AIM

To study and verify the Truth Tables of OR, AND, NOT, NAND & NOR gates.

INTRODUCTION & THEORY

Any digital system, how so ever large, requires only a few basic operations which are repeatedly used. The most fundamental circuits are: OR, AND and NOT gates. These are referred to as logic gates or logic circuits, since these circuits Boolean algebra. Gate is a circuit with one or more inputs but only one output. Gates are digital (2 state) circuits because the input and output signals are either low or high voltages. Gates are often called logic circuits because they can be analyzed with Boolean Algebra. Gates are two categories,

1. Basic Gates - OR, AND & NOT gates.
2. Universal Gates - NAND & NOR gates.

OR GATE

The OR gate has two or more input signals but only one output signal. If any input signal is high, the output signal is high. Fig -1 shows the two input OR gate. If both inputs are low, the output is low. If either input is high, the diode with the high input conducts and the output is high. Because of the two inputs, we call this circuit a 2 - input OR gate. Truth Table -1 summarizes the action, Binary 0 stands for low voltage & Binary 1 for high voltage. Notice that 1 or more high inputs produce a high output, this is why the circuit is called an OR gate. From the Truth Table -1 working of the OR gate is as follows.

A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Truth Table 1

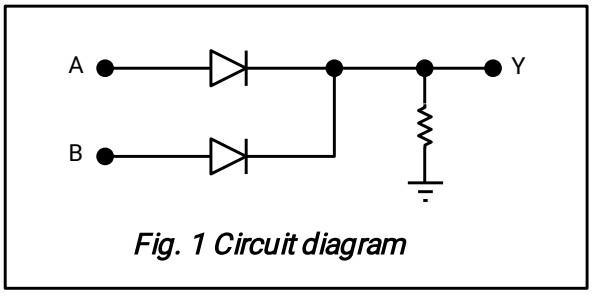


Fig. 1 Circuit diagram

❖ **CONDITION 1: A = 0, B = 0.**

Both the diodes are non-conducting and no current is assumed to flow, so the output LED indicates OFF which means output is 'Zero'.

❖ **CONDITION 2: A = 0, B =1**

Top diode is non-conducting, but the Bottom diode is conducting because of forward biasing for this diode is provided by giving a high (5V) signal at B. So current flows in the output and the LED indicates ' ON' (logic 1).

❖ **CONDTION 3: A =1, B =0**

Top diode conducts and the bottom diode is non-conducting and LED indicates ON.

❖ **CONDITION 4: A = 1, B =1.**

Both the diodes are conducting and the output LED indicates ON.

AND GATE

An AND gate has two or more input signals but only one output signal. All inputs must be high to get a high output. assumes the '1' state if all inputs assume the '1' state. Fig -2a shows one way to build an AND gate. In this circuit the inputs can be either low (ground) or high (+5V) . When both inputs are low Fig -2b, both diodes conduct and pull the output down to a low voltage. If one of the inputs is low and the other high (Fig -2c), the diode with the low input conducts and this pulls the output down to a low voltage. The diode with the high input, is reverse biased or cut off, symbolized by dark shading (Fig(2c). When both inputs are high (Fig-2d), both diodes are cut off. Since there is no current in the resistor, the supply voltage pulls the output voltage up to a high voltage +5V. Truth Table -2 summarizes the action as usual, Binary 0 stands for low voltage and Binary 1 for high voltage. From the Truth Table -2 working of the AND gate is as follows.

A	B	Y =A . B
0	0	0
0	1	0
1	0	0
1	1	1

Truth Table 2

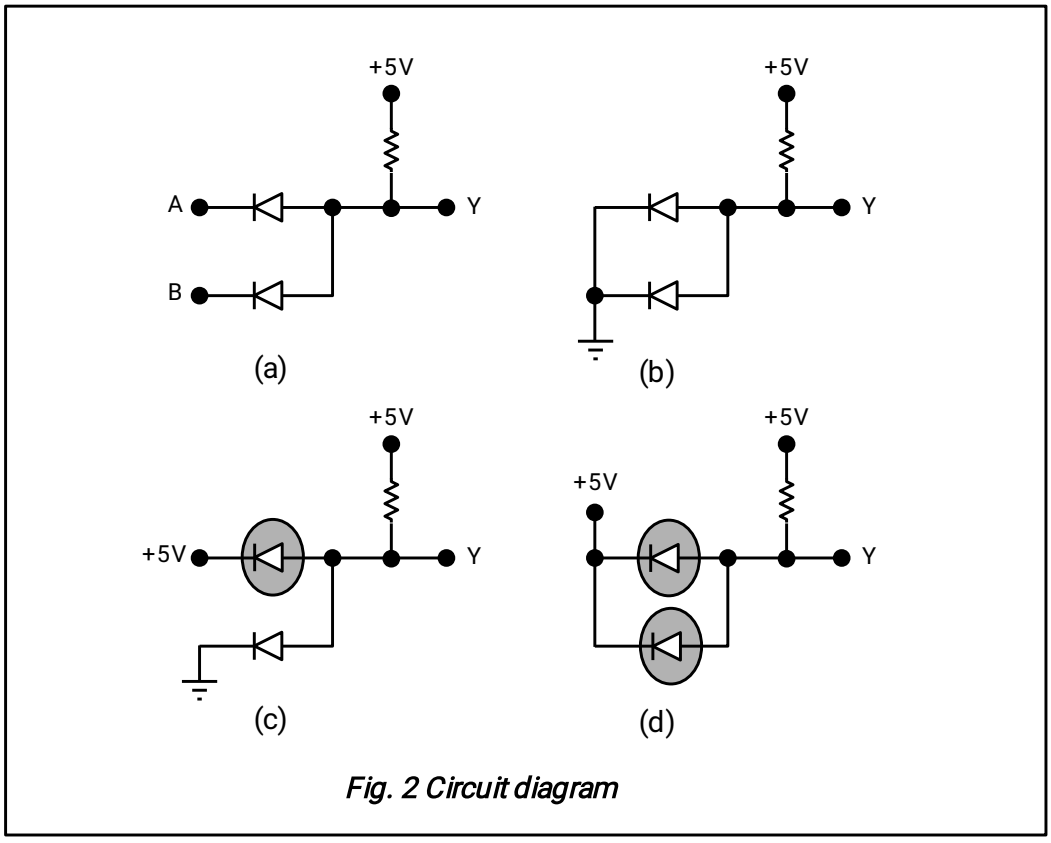


Fig. 2 Circuit diagram

❖ **CONDITION 1: A = 0, B=0**

Both the diodes are conducting because their anodes are at 5V with respect to the cathodes. So all the current flows through this diodes and no voltage appear at the output. So the output LED indicates OFF.

❖ **CONDITION 2: A = 0 , B = 1**

Top diode is conducting and the bottom diode is non conducting because its cathode is at 5V level (input high). Now also output voltage is zero and the LED indicates OFF.

❖ **CONDITION 3: A = 1, B=0**

Just same operation in condition 2 follows, except that here top diode is non-conducting and the bottom diode is conducting and output voltage is zero and the LED indicates OFF.

❖ **CONDITION 4: A=1, B=1**

Now both the diodes are non conducting because both the PN junctions are reverse biased. So output voltage is high and is indicated by LED ON.

NOT GATE

A NOT gate is also called an inverter. An inverter is a gate with only one input signal and one output signal; The output state is always the opposite of the input state Fig- 3 shows a Transistor inverter. This common emitter amplifier switches between cutoff and saturation. When V_{IN} is low (approx 0), the transistor cuts off and V_{OUT} is high. On the other hand, a high V_{IN} saturates the transistor, forcing V_{OUT} to go low. Truth Table -3 summarizes the operation. A low input produces a high output, and a high input results in a low output. An Inverter is also called a NOT gate because the output is not the same as the input. The output is sometimes called the complement (opposite) of the input.

A	$Y = \overline{A}$
0	1
1	0

Truth Table 3

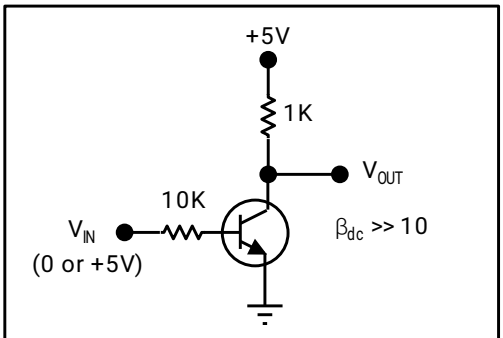


Fig. 3 Circuit diagram

Fig 3 shows the ckt of Not gate using Transistor and diodes and the Truth Table 3 shows the Truth Table of Not gate. Not gate is also called an Inverter gate. From the Truth Table -3 working of the NOT gate is as follows.

❖ CONDITION 1: A = 0

Whenever the input A = 0, the -5v via 4.7k resistor at the base of the transistor makes input junction is reverse biased. So transistor is in cut off region and output is high is indicated by the LED ON.

❖CONDITION 2: A = 1

When the input at A =1, input junction of transistor is forward biased so the output is zero. So this NOT gate states that the output is complement of the input. is indicated by the LED OFF.

NAND GATE

NAND gate has two or more inputs and only one output assumes to '0' when all the inputs are high.

A	B	$Y=\overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0

Truth Table 4

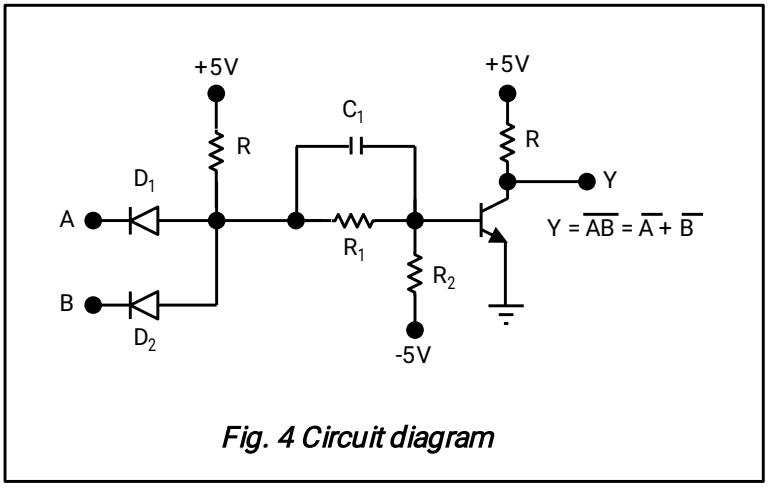


Fig. 4 Circuit diagram

❖ **CONDITION 1: A=0, B= 0**

When both A and B are at zero (low), both the diodes are conducting because their anodes are at +5V with respect to their cathodes. So no +Ve current flows in the base junction of the transistor. So transistor is in the cut off region, and the output is high is indicated by the LED ON..

❖ **CONDITION 2: A= 0 , B=1**

Now top diode conducts and the bottom diode non conduct. Now also output is high is indicated by the LED ON.

❖ CONDITION 3: A = 1, B =0

Same process in condition 2 follows except bottom diode conducts here and the top diode not conducting and output is high is indicated by the LED ON.

❖ CONDITION 4: A =1, B=1

Now, both the diodes are not conducting and some the current flows in the base junction of the transistor and transistor is in ON state. So the output is low and is indicated by the LED OFF.

NOR GATE

NOR gate has two or more inputs and only one output assumes to '0' when all the inputs are low.

Fig 5 shows the circuit of the 2 input NOR gate using diodes and transistors and the Truth Table 5 shows its Truth Table

A	B	$Y=\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

Truth Table 5

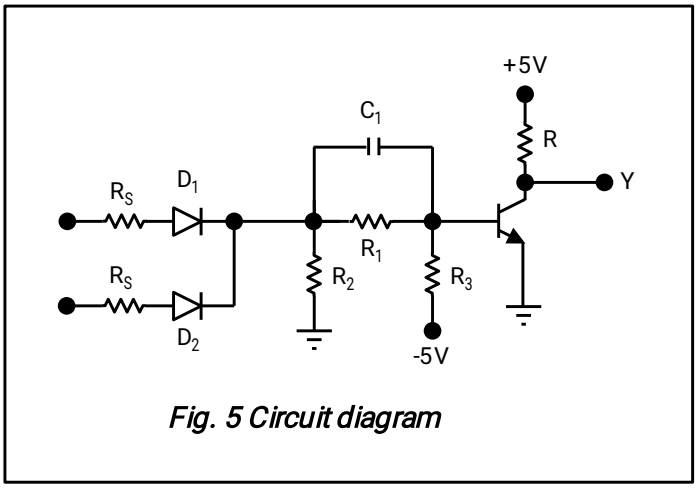


Fig. 5 Circuit diagram

❖ **CONDITION 1: A= 0, B=0**

When both A & B are at low, both the diodes are not conducting and no +Ve current flows in the base junction of the transistor, and Transistor is in the cut off state. So the output is high and is indicated by the LED ON.

❖ **CONDITION 2: A=0, B=1**

When A is equal to 0 and B is equal to 1, then the upper diode D_1 is not conducting and the lower diode D_2 is conducting. So the transistor base is at some positive voltage with respect to ground, transistor now conducts. So the output collector voltage is at low state and is indicated by the LED OFF.

❖ **CONDITION 3: A =1, B=1**

When A is equal to 1 and B is equal to 0, then the upper diode D_1 is conducting and the lower diode D_2 is not conducting. So again the transistor base is at some positive voltage with respect to ground, transistor now conducts. So the output collector voltage is at low state and is indicated by the LED OFF.

❖ **CONDITION 4: A =1, B=1**

When A is equal to 1 and B is equal to 1, then both the diodes D_1 and D_2 are conducting. so the output voltage is at low state and is indicated by the LED OFF.

HARDWARE SPECIFICATIONS

1. Two input OR gate using diodes - 1No
2. Two input AND gate using diodes - 1No
3. NOT gate using Transistor -1 No
4. Two input NAND gate diodes and transistor - 1 No
5. Two input NOR gate using Diode & Transistor - 1 No
6. Logic inputs -2 Nos
7. Logic Output Status indicators -2 Nos
8. Built in DC power supplies $\pm$ 5V
9. Set of Patch chords and User's Manual.

EQUIPMENT REQUIRED

1. Basic Logic Gates Trainer.
2. Set of Patch chords & User Manual.

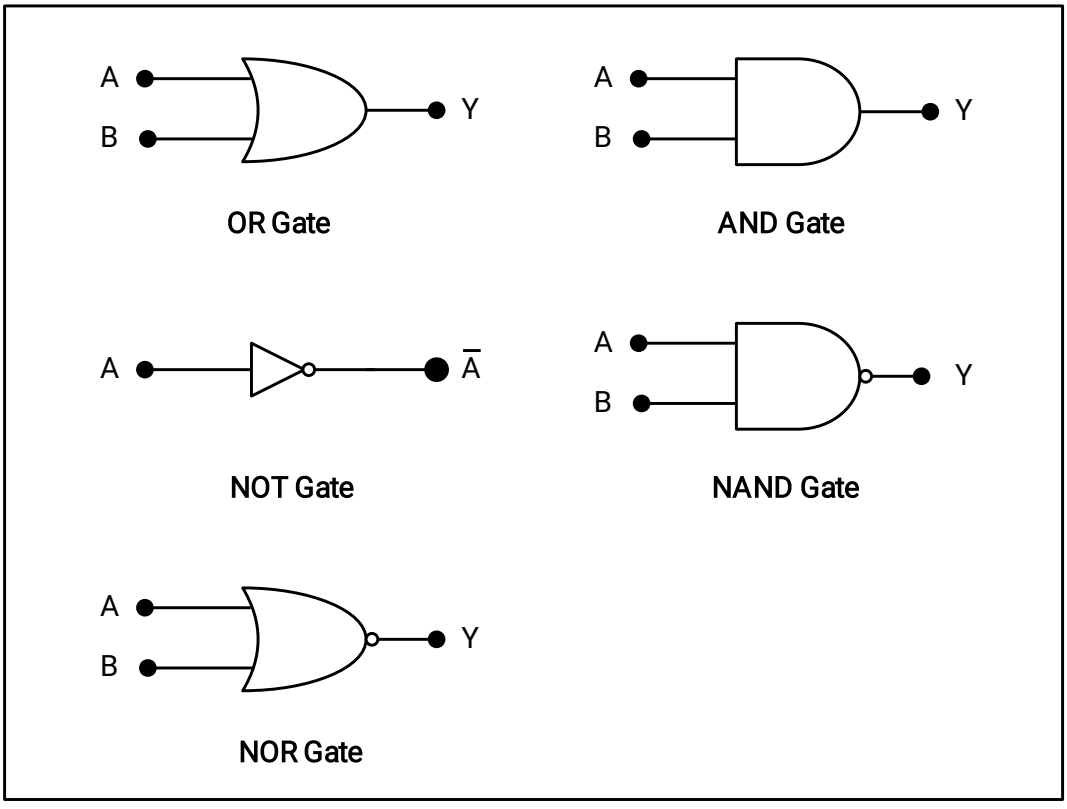
EXPERIMENTAL PROCEDURE

1. Connect the Power chord of the trainer to the AC mains and Switch ON the system.

2. Verify the working of OR gate, AND gate, NOT gate, NAND gate & NOR gate with the help of Truth Tables 1,2 3, 4 & 5.

NOTE : Feed the inputs from the Logic input switches

LOGIC GATES & ITS SYMBOLS



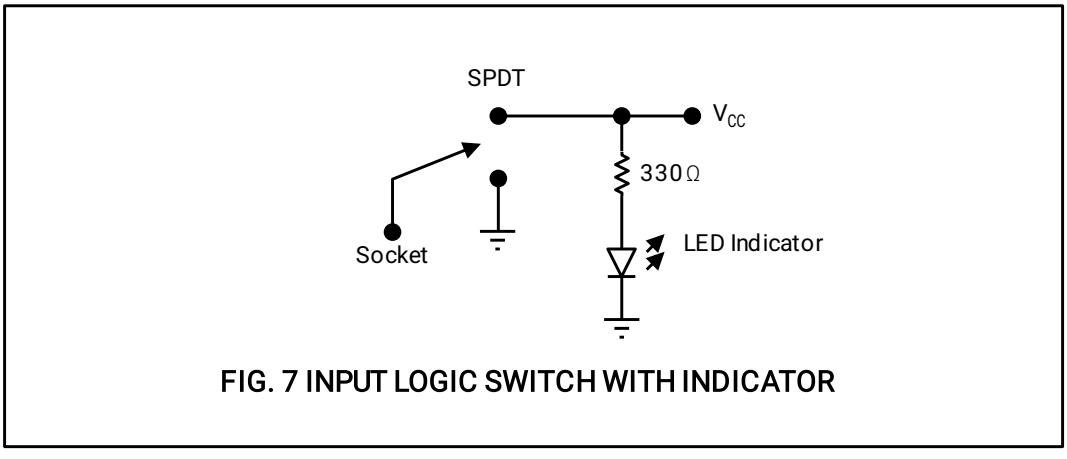


FIG. 7 INPUT LOGIC SWITCH WITH INDICATOR