# Experiment #3- Part#1

# Logic Gate Circuits

## Object

The purpose of this experiment is to implement the basic logic gate circuits and verify them.

## Required Parts and Equipment's

1. Electronic Test Board. (M60, M90)
2. 5V DC Power Supply.
3. Digital Voltmeter.
4. Two BC 337 NPN silicon Transistors.
5. Resistors.M90 (10kΩand 1KΩ)
6. Two 1N4001 Silicon Diodes.

## Theory

A logic gate is a switching circuit with two or more inputs and whose output will be either a high voltage or a low voltage, depending on the voltages on the various inputs. Logic gates are widely used in computers and in all types of digital circuits and systems.

Digital circuits are characterized by the fact that they contain voltages that exist at either of two levels, for example 0V and 5V. In other words, at any instant of time each circuit input and output voltage will either be at some LOW voltage ($V_L$) or some HIGH voltage ($V_H$). In practice, the LOW level is actually a range of voltages, as is the HIGH level. For example, between 0V and 0.8V might be the low level, and between 2V and 5V might be the HIGH level. The range of voltages between 0.8V and 2V is not allowed except during transitions between $V_H$ and $V_L$. This concept is illustrated in Fig.1.

There are several types of logic gates, and many different ways to construct each type using discrete components. The basic logic gates are the OR gate, AND Gate, NOT gate, NOR gate, and NAND gate.

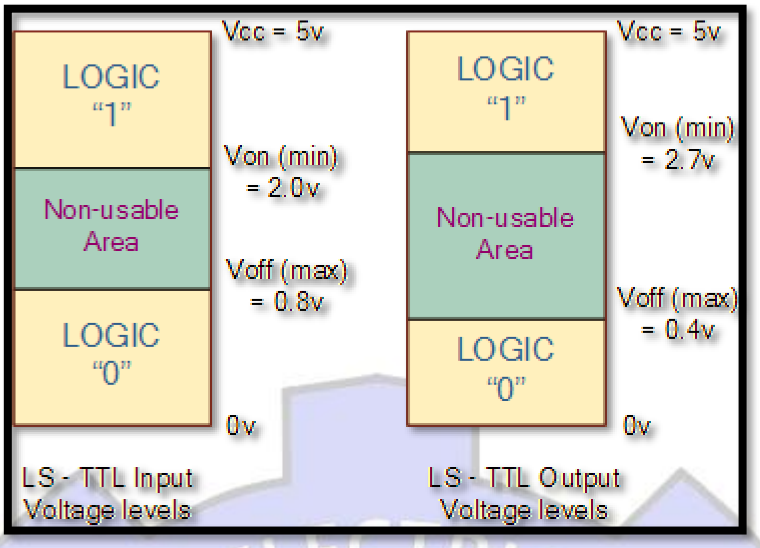
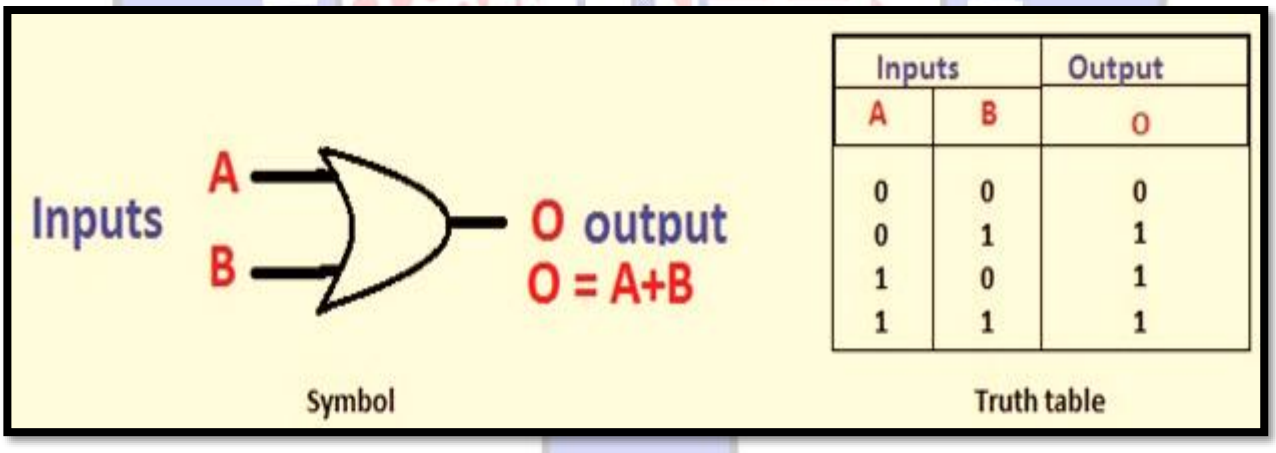



Figure1: Typical Voltage Levels in a Digital System

- **Diode OR Gate**

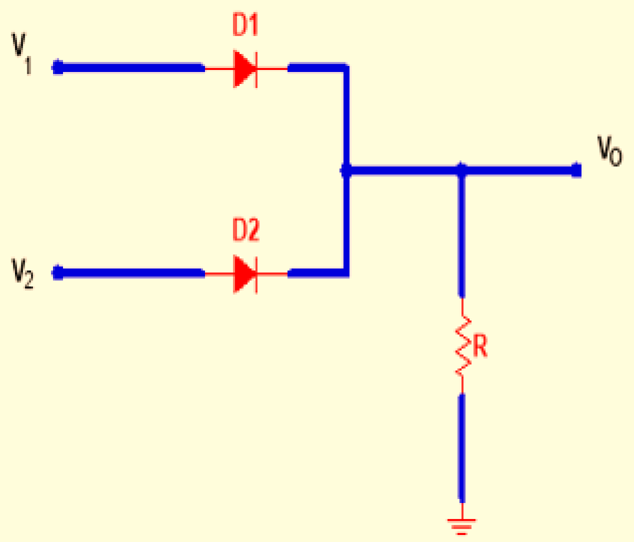
An OR gate is a circuit that has two or more inputs and whose output is equal to the OR sum (Logical Addition) of the inputs. Fig.2 shows the logic symbol and truth table of a two input OR gate.




| Inputs | | Output |
|---|---|---|
| A | B | O |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

Figure 2: The Logic Symbol and Truth Table of the OR Gate

The OR gate operates such that its output is HIGH (Logic 1) if either input A or B or both are at a logic -1 level. The OR gate output will be LOW (logic 0) only if all its inputs are at logic- 0. Fig.3 presents a discrete circuit for the OR gate using two diodes and a resistor. Each input can be at either 0V or 5V, so there are four possible input combinations.




| $V_1$ | $V_2$ | $V_o$ |
|---|---|---|
| 0V | 0V | 0V |
| 0V | 5V | 4.3V |
| 5V | 0V | 4.3V |
| 5V | 5V | 4.3V |

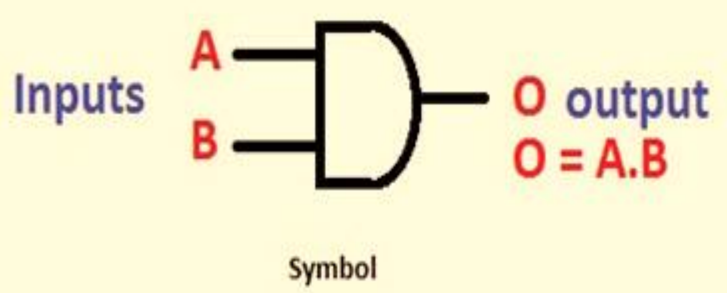
Figure 3: Two-input OR Gate Circuit

Examination of the truth table shows that the output will be at a HIHG level when either $V_1$ or $V_2$ or both are at a HIHG level. The value of $V_o$ is LOW only when both inputs are at a LOW level.

Consider first the case where $V_1 = V_2 = 0V$. In this case neither diode will conduct; thus, no current flows in the circuit, and the output voltage is zero. When $V_1 = 0V$ and $V_2 = 5V$ then diode $D_2$ will be forward biased because its anode is made positive relative to its cathode. Thus, current will flow through $D_2$ and R. If the diodes are assumed to be silicon, the forward voltage drop across $D_2$ will be 0.7V, so $V_0$ must equal 5V - 0.7V = 4.3V. Diode D1 is reverse biased because its cathode is at +4.3 V relative to ground, and its anode is at 0V. The third case, where V1 = 5V and $V_2 = 0V$, will obviously be the same as the second case except that D1 will be ON, and $D_2$ will be OFF. In the final case, where both $V_1$ and $V_2$ are 5V, both diodes are ON, so each will have a 0.7V drop. Again, the output will be 4.3V.

- **Diode AND Gate**

The second logic gate is the AND gate. Its symbol and truth table are presented in Fig.4. The output is equal to the AND product of the logic inputs (Logical Multiplication). The AND gate operates such that its output is HIGH only when all its inputs are HIGH. For all other cases the AND gate output is LOW.

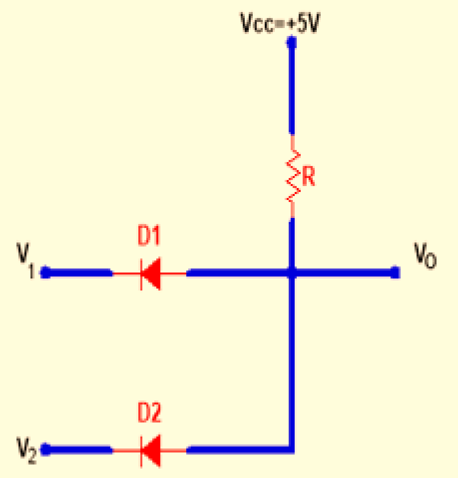



| Inputs | | Output |
|---|---|---|
| A | B | O |
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Truth table

Figure 4: The Logic Symbol and Truth Table of the AND Gate

The electronic circuit for the AND gate is shown in Fig.5. Consider the first case when $V_1 = V_2 = 0V$. In this case both diodes will be forward-biased and conduct current.




| $V_1$ | $V_2$ | $V_o$ |
|---|---|---|
| 0V | 0V | 0.7V |
| 0V | 5V | 0.7V |
| 5V | 0V | 0.7V |
| 5V | 5V | 5V |

Figure 5: Two-input AND Gate Circuit

The output voltage in this case will equal the voltage drop across the diodes, which is 0.7V. When $V_1 = 0V$ and $V_2 = 5V$, diode $D_1$ will have its cathode at 0V, and thus will be forward - biased. So, current will flow from the 5V supply through R and $D_1$. Diode $D_2$ is OFF, since its cathode is at +5V. The output voltage V0 will be 0.7V, which is the voltage drop across $D_1$. In the third case when $V_1 = 5V$ and

$V_2$ = 0V, diode $D_1$ will be OFF and $D_2$ will be ON and V0 will equal the voltage drop across $D_2$ which is 0.7V. Finally, when $V_1 = V_2$ = 5V, both diodes will be OFF and thus no current will flow through resistor R resulting in a zero voltage across R and 5V across the output ($V_0 = V_{CC} - V_R$ = 5V – 0 = 5V).