Study of Gate and Digital Logic Systems and their Variants

Shalini Shree

Ph.D. Scholar
Faculty of Master of Science Physics
Capital University, Jharkhand , India

Abstract
Logic Gates are represented in digital computers by physical quantities called signals. Electrical signals, such as voltage exist throughout the computer/circuit, are in either one of the two recognizable states. The two states represent a binary variable that can be equal to 1 or 0. For example, particular digital signal of 3 volts to represent binary 1 and 0.5 volt to represent binary 0. The input terminals of digital circuits accept binary signals of 3 and 0.5 volts and the circuits respond at the output terminals with signals of 3 and 0.5 volts to represent binary input and output corresponding to 1 and 0, respectively. Manipulation of binary logic information is done by logic circuits called Gates.

Gates are blocks of hardware that produce signals of binary 1 or 0 when input logic requirements are satisfied. A variety of logic gates are commonly used in digital systems. Each Gate has a distinct graphic symbols, and its operations can be described by means of an algebraic expression. the input-output relationship of the binary variable for each gate can be represented in tabular form by a truth table.

Keywords: Logic Gates, Binary System, Digital System

Graphic symbols represent a pictorial representation of the Gate.
Algebraic function represent an automatic calculation.
Truth table represent a binary truth value of different Gates.

Each gate has one or more than one binary input signals designated by A, B, C …… and one binary output signal designated by X.

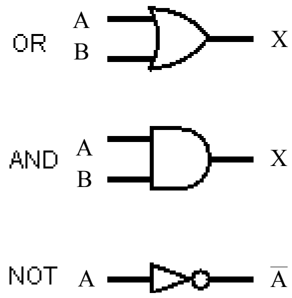
According to George Boole: He constructed a logical algebra which investigates into the nature of logic.

Digital technique is used in all areas of consumer electronic products, communication system and industrial controls. Digital circuits are the fundamental building blocks of a computer system. Initially systems used to be analog based. Digital technique has many advantages over analog system such as (1) reduces the cost, and (2) improves the performance.

Electronic circuits which process the analog signals are known as linear circuits. Digital circuits are different. Almost all digital circuits are designed for two state operation. This means using only two non-adjacent points on the load line either low or high.

There are three type of fundamental gates: (a) the **NOT** gates, (b) the **OR** gates, and (c) the **AND** gates. And all other gates are functions associated with the human brains like – NOR gate, NAND gate, exclusive-OR (XOR) gate, exclusive-NOR (exclusive-NOT-OR) (XNOR) gate etc.

Fundamental block diagram of Logic Gates are as following:



Logic Gates Composition

Low and High binary conditions are represented by different voltage levels. In the most logic gates the low state is zero volt (0 V) and the high state is five volts positive (+5 V).

Logic gates can be used in resistors, Transistors and diodes. A resistor can commonly be used as a pull-up or pull-down resistor. Pull-up and pull-down resistors are used when there are any unused logic gate inputs to connect to a logic level 1 or 0. This prevents any false switching of the gate. Pull-up resistors are connected to V_{cc} (+5 V), and pull-down resistors are connected to ground (0 V).

History of Logic Gates

The first common logic gates were electromagnetic relays, which were basically ON-OFF switches. The electromechanical relay was invented by Joseph Henry in 1835, but the brilliance of his invention was not realized until later when his relays were used in the telegraph. After the invention of the rotary dial in 1890, more complex relays with 10 positions were developed.

In 1898, Nikola Tesla filed a patent for an invention he called “teleautomation”, which he demonstrated with a radio-controlled miniature boat, the first remote control device ever made. The remote control system contained a method for decoding Hertzian waves. This system would toggle actions based on different signals, functioning as an AND gate.

The first digital, programmable computing devices' logic circuitry laid in vacuum tubes. This includes famous computers like ENIAC, Colossus, and Alan Turing's Pilot Ace. These early digital computers were enormous and had thousands of vacuum tubes. In order to make computing devices accessible to the public, the logic circuitry would need to shrink.

Review of Literature

Logic gates and flip flops are the basic building blocks of any digital system. Digital circuits consist of combinational AND/OR sequential logic circuits. The basic building blocks of combinational and sequential circuits are the logic gates. A logic gate is a combinational circuit in which the output depends on the present inputs only and the sequential circuit is one in which the output depends on the present inputs and past output. As the logic gates are used in building digital systems, it is necessary for each logic block to have the capacity to drive the following stages. There are several conventional logic families evolved due to the special requirements of application areas. No single logic family can be best suited for all the applications. Each logic family has got its own application area, advantages and limitations. There are several approaches for implementing optical logic devices. Most of the optical logic devices seem to be based on the property of a material or a device, which gives an output light depending upon the magnitude of the input light. The input light may be divided into multiple signals and the output is interpreted as an AND or an OR logic operation of the input light signals. Optical logic devices may be broadly classified into two categories. They are (1) All optical logic devices, and (2) Optoelectronic logic devices. All optical logic devices use nonlinear optical material to realize optical logic gates and are discussed in the following.

All Optical Logic Devices

Several research groups have been working for building optical devices. A wide variety of optical components are required in order to perform every function currently carried out by electronic circuits. These include polarization splitters, polarization rotators, TE/TM mode converters, straight and bent wave guides, Semiconductor Optical Amplifiers, side coupled resonator filters, tunable Fabry Perot filters, isolators, time delay components, phase shifters. As evidenced by an abundance of literature describing design, building and operation of the above components, significant progress has been achieved for future optical domain applications. However, for various reasons, successes in this area have been limited to special-purpose applications, and the general-purpose optical computer has been evasive. The major problem with optical transistors, logic gates, switches, or other nonlinear devices serving similar purposes, is the large amount of heat that would be generated by the high energy consumption of optical devices. For developing all optical systems, the ultimate practical devices are required to be small (micron or sub micron), fast (ps), low switching energy (10-15 J), operable at room temperatures, and incorporable into an integrated system. At present no optical device has achieved all of these requirements. All optical logic devices generally use both fiber-based and semiconductor based nonlinear elements. In the former case, the physical nonlinearity is the Kerr nonlinearity of silica glass. In the latter case, the nonlinearity results from a variety of ultrafast mechanisms in semiconductor gain media, including carrier heating, cross phase modulation and cross gain modulation. Many researchers have reported all optical logic gates like NOR using a Semiconductor Optical Amplifier (SOA), OR with NOR using an Ultrafast Nonlinear Interferometer (UNI), XOR using a Terahertz Optical Asymmetric Demultiplexer (TOAD) and so on. Even though logic gates using the UNI and the TOAD have the advantage of high speed, they are very complex and difficult to integrate with other logic gates.

Logic Gates

Most of the research groups have studied logic gates which responds to only one stimulus namely either electrical or optical signals. Some of these investigations are only a sort of interpretations for the optical logic. Most of them are not cascadable. In view of this, it is thought that there is a need to develop logic gates which can respond to both optical and electrical signals and are also cascadable so that complex hybrid opto-electronic systems can be built. The thought process behind visualizing these hybrid logic gates and demonstration of these ideas through building logic circuits using discrete components forms the content of this thesis. The thesis aims at explaining the importance of Electro-Optical hybrid concept and then attempts at how this new branch of hybrid opto-electronics has to be developed.

Enrique J. Blanco Martinez: Conventional methods for diagnosis of human disease are, at times, limited in different regards including time requirement, either experimental or data processing, sensitivity, and selectivity. It is then that a Point of Care Criteria, which considers the true utility and usefulness of the device, is employed to propose new diagnostic devices capable of overcoming the aforementioned shortcomings of conventional tools. Nucleic acid, characterized for its The predictable base-pairing nature, is considered to be a highly-selective, yet greatly modifiable device. Its behavior is then described through Boolean Logic, where “true” or “false” outputs are mathematically described as “1” and “0”, respectively. This mathematical approach is then referred to as Logic Gates, where outputs can be predicted based on satisfied environmental conditions. The mechanisms, capable of exhibiting Logic Gate behavior, are described.

M. Rangari, R. Saraswat, R. Jain: Reversible logic is promising as it is able to compute with various applications in very low power like nano-computing for example quantum computing. Reversible circuits are like conventional circuits despite they are build from reversible gates. Reversible circuits, have single, one-to-one mapping between the input and output vectors. Thus all output vectors are permutations of input vectors. A concise review of reversible logic gates basics will be studied. The basic reversible logic gates need to be optimized in reversible logic design and synthesis. Reversible gates need steady inputs for configuration of gate functions and junk outputs that helps in keeping reversibility. Therefore, it is very important to lessen the parameters such as junk bytes, quantum cost and delay in the schemating of reversible circuits. As reversible circuits have tremendous applications in a variety of emerging technologies such as quantum computing and quantum dot. Resulting this research work would also cover the promising nanotechnologies.

Matthew Morrison, N. Ranganathan: Reversible logic is widely being considered as the potential logic design style for implementation in modern nanotechnology and quantum computing with minimal impact on physical entropy. Recent advances in reversible logic allow for improved quantum computer algorithms and schemes for corresponding computer architectures. Significant contributions have been made in the literature towards the design of reversible logic gate structures and arithmetic units, however, there are not many efforts directed towards the design of reversible ALUs. In this paper, we propose the design of two programmable reversible logic gate structures targeted at ALU implementation and their use in the realization of an efficient reversible ALU is demonstrated. The proposed ALU design is verified and its advantages over the only existing ALU design are quantitatively analyzed.

Significance of Study

Logic gates are an important concept if one is studying electronics. These are important digital devices that are mainly based on the boolean functions. Logic gates are used to carry out logical operations on single or multiple binary inputs and give one binary output.

Logic gates are used to make decisions so that electrical outputs only 'turn on' when the correct logic sequence has been applied. Each logic gate has a name that helps to describe how different inputs will determine the possible outputs.

NOT: If input A is 'high' then output Q will be ...
OR: If inputs A or B, or A and B are high, output ...
AND: If inputs A and B are high, output Q will ...

Key Features of Logic Gate

1. Logic gates will make decisions based on a combination of digital signals coming from its inputs.
2. Most of logic gates have two inputs and one output.
3. Logic gates are based on Boolean Algebra.
4. At any given moment, every terminal is in one of the two binary conditions, false or true.
5. Some logic gates include buffered outputs or provide bus hold support that retains the bus's last active status when the bus is disabled or does not have an active driver.
6. Some logic gates are radiation-hardened or provide protection from electrostatic discharge (ESD). Devices with Schmitt triggers include circuitry that introduces hysteresis and counteracts noise.

Objectives of the Study

Research objectives are to describe what we expect to achieve by a project. Research objectives are usually expressed in lay terms and are directed as much to the client as to the researcher.

1. To make students familiar with modern hierarchy of digital hardware and enlighten them the state-of-the-art computer hardware design methodologies.
2. The contents give a basic idea of how to design and simulate logic circuits.
3. Introduce the concept of digital and binary systems.
4. Be able to design and analyze combinational logic circuits.
5. Be able to design and analyze sequential logic circuits.
6. Understand the basic software tools for the design and implementation of digital circuits and systems.
7. Reinforce theory and techniques taught in the classroom through experiments and projects in the laboratory.

Bibliography

1. F. J. Hill, G. R. Peterson. Introduction to Switching Theory and Logical Design. 3rd Ed.. New York: John Wiley, 1981.
2. R. S. Sandige. Modern Digital Design. New York: McGraw-Hill, 1990.
3. J. F. Wakerly. Digital Design Principles and Practices. Englewood Cliffs, New Jersey: Prentice Hall, 1990.
4. A. C. Huntley, A. Bittorf, M. Taragin. Configuring for the World Wide Web: Recommendations for dermatologists. Journal of the American of Dermatology, Vol. 34, 125, 1996.
5. S. G. Shiva. Introduction to Logic Design. Glenview. 2nd Ed., Marcel Dekker Inc., 1998.