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Logic Gates and Boolean Algebra

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Abstract: Digital circuits can be constructed from a small number of primitive elements by combining them in innumerable ways. In the following paper introduces the gate, a circuit with one or more input signals but only one output signal. Gates are digital (two state) circuits because the input and output signals are either Low or high Voltages. Gates are often called logical circuit because they can be analyzed with Boolean algebra.

Keywords: Gates, Inverter, Logic Circuit, Truth Table.

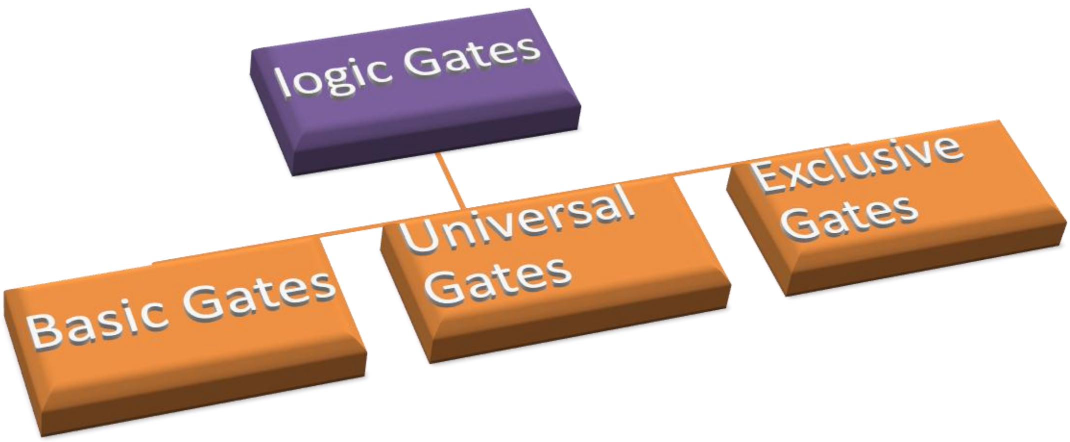
I. INTRODUCTION

For centuries mathematician felt there was a connection between mathematics and logic, but no one before George Boole could find this missing link.In1854 he invented symbolic logic, known today as Boolean algebra. Each variable in Boolean algebra has either of two values: True or False. The original purpose of this two- state algebra was to solve logic problems.

Boolean algebra has no practical application until 1938, when Claude Shannon used it to analyze telephone switching circuits. He let the variables represent closed and open relays. In other words, Shannon came up with a new application for Boolean algebra. Because of Shannon's work, engineers realized that Boolean algebra could be applied to computer electronics.

II. LOGIC GATES

Gates is an electronic circuit with one or more inputs but only one output, actually they are block of hardware that produce a logic 0 (zero) or logic 1(one) output signal based on input logic signals. They also had known as logic circuits because with the proper input they establish logical manipulation paths.



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A. Basic Gates

1. AND Gate:

The AND gate has two or more input signals but only one output signal. In AND Gate all inputs must be high then only to get a high output.

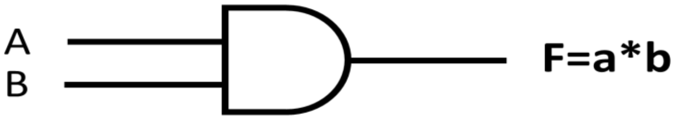

Fig.1.1 A 2 input AND gate

Table1.1: Two input AND Gate

A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

Table 1.1 reviews the action. As usual binary zero stands for low voltage and binary one for high voltage. As you see, **A** and **B** must be high to get a high output. This circuit is known as an AND gate.

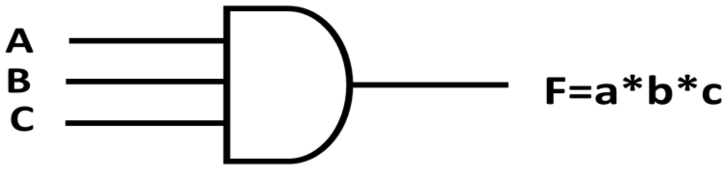

Fig.1.2 A 3 input AND gate

Table1.2: Three input AND Gate

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

No matter how many inputs an AND gate has the action can be summarized like this All inputs must high to get a high output.

2. OR Gate

In this type of gate if any input signal is high then output will be high. Output goes to low only when all the inputs are low.

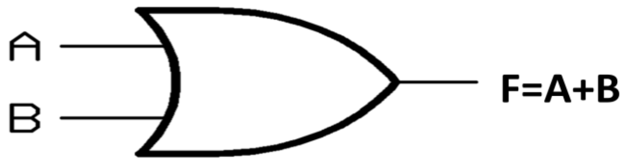

Fig.2.1 A 2 input OR gate

Table2.1: Two input OR Gate

A	B	F
0	0	0
0	1	1
1	0	1
1	1	1

Table 2.1 reviews the action. As usual binary zero stands for low voltage and binary one for high voltage. As you see, Notice that one or more high inputs produce a high output, this circuit is called an OR gate.

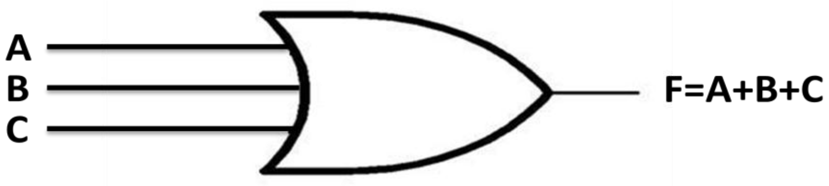

Fig.2.2 A 3 input OR gate

Table 2.2: Three input OR Gate

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

Table 2.2 summarizes the action. A table like this is called a ***truth table;*** it lists all the input possibilities and the corresponding outputs. When constructing a truth table always list the input words in binary progression as shown (000,001,010, ... , ... , 111) this guarantees that all input possibilities will be accounted for.

Here, in OR gate no matter what devices are used, OR gates always produce a high output when one or more inputs are high.

3. NOT Gate (Inverter)

Not Gate is also known as Inverter, In Not Gate only one input signal and one output signal, the output state is always opposite of the input state.

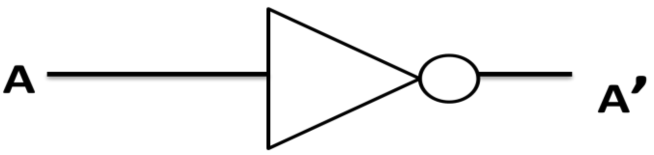

Fig.3.1 an Inverter gate

Table 3.1

V_{in}	V_{out}
Low	**High**
High	**Low**

Table 3.2

A	A'
0	**1**
1	**0**

Table 3.1 summarizes the operation. A low input produces, a high output, in same way a high Input result in a low output means that in Not Gate always provides opposite Output (Result) from Inputs. In Table 3.2 represent the similar information in Binary type**,** binary Zero (0) means for low voltage and binary One (1) for high voltage.

III. BOOLEAN ALGEBRA

Boolean algebra differs from both the ordinary algebra and the binary number system. In Boolean algebra, X+X=X, because the variable X has only a logical value. It doesn't have any numerical significance. In ordinary algebra, X+X=2x and X.X=X^2, because the variable X has numerical value here. In Boolean algebra,1+1=1,whereas in the binary number system,1+1=10,and in ordinary algebra 1+1=2.There is nothing like subtraction and division in Boolean algebra.

Boole invented two state algebra to solve logic problems. This new algebra had no practical use until Shannon applied it to telephone switching circuits. Today Boolean algebra is the backbone of computer circuit analysis and design.

1. AND Sign

A word equation for Fig. ***Fig.1.1*** *is*		
	F=A AND B	(2.1)
In Boolean algebra the multiplication sign stands for the AND operation.Therfore,Eq 2.1 can be written		
	F= • A B	
Or simply	***F=AB***	(2.2)
Give the inputs, you can substitute and solve for the output. For instance, if both inputs are low,		
	F = AB = 0 • 0 = 0	

Because 0 ANDed with 0 gives 0.If A is Low and B is High,		
	F = AB = 0•1 = 0	
If A is High and B is Low,		
	F = AB = 1•0 = 0	
When both inputs are high,		
	F = AB = 1•1 = 1	Because 1 ANDed with gives 1.

2. OR Sign

A word equation for Fig. ***Fig.2.1*** *is*		
	F=A OR B	(2.3)
If A=0 and B=0 then,		
	F= 0 OR 0 =0	
Output is 0 because both the inputs A and B are 0.		
If A=1 and B=0 then,		
	F = A + B means F = 1 + 0 = 1	
Because 1 comes out of an OR gate when ***Either inputs is 1.***		
If A=0 and B=1 then,		
	F = A + B means F = 0 + 1 = 1	
If A=1 and B=1 then,		
	F = A + B means F = 1 + 1 = 1	Because 1 ORed with 1 gives1.

3. Inversion Sign

In Boolean algebra a variable can be either a 0 or a1.for a digital circuit, this means that a signal voltage can be either Low or High. ***Fig.3.1*** is an example of digital circuit. Here the output A' is always complement of A		
A word equation for Fig.3.1 is		
	A' = NOT A	(2.4)
If A is 0 then,		
	A' = NOT 0 = 1	
On the second way, If A is 1 then,		
	A' = NOT 1 = 0	

IV. Conclusion

There is a one to one correspondence between an electrical circuits and Boolean functions. Boolean function uses for any an electronic circuit and vice versa. Because Boolean function only require AND, OR, and NOT Boolean operators, we can build any electronic circuit using these operations exclusively, Now days logical gate AND, OR and Inverter not used directly in circuit. Because there are first reasons, NAND gates are generally less expensive to build than other gates. Secondary, it is also much easier to build up complex integrated circuit from the same basic building blocks than it is to construct an integrated circuit using different basic grate.

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