GST 108: Quantitative Reasoning

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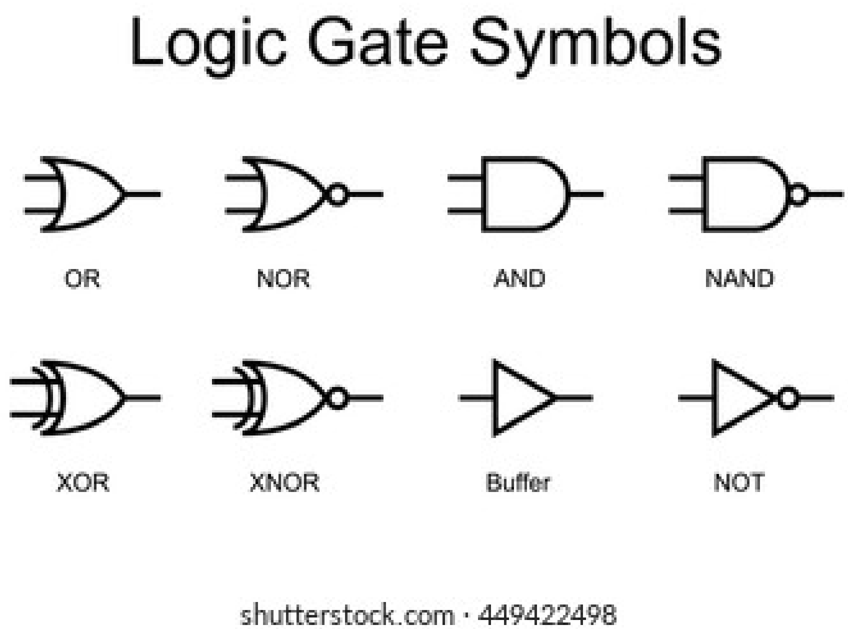
Contents

1 INTRODUCTION

A logic gate is a building block of a digital circuit which is at the heart of any computer operation.



1.1 Logic Gates

Logic gates perform logical operations that take binary input (0s and 1s) and produce a single binary output. They are used in most electronic device including:

Table 1: Logic Gates

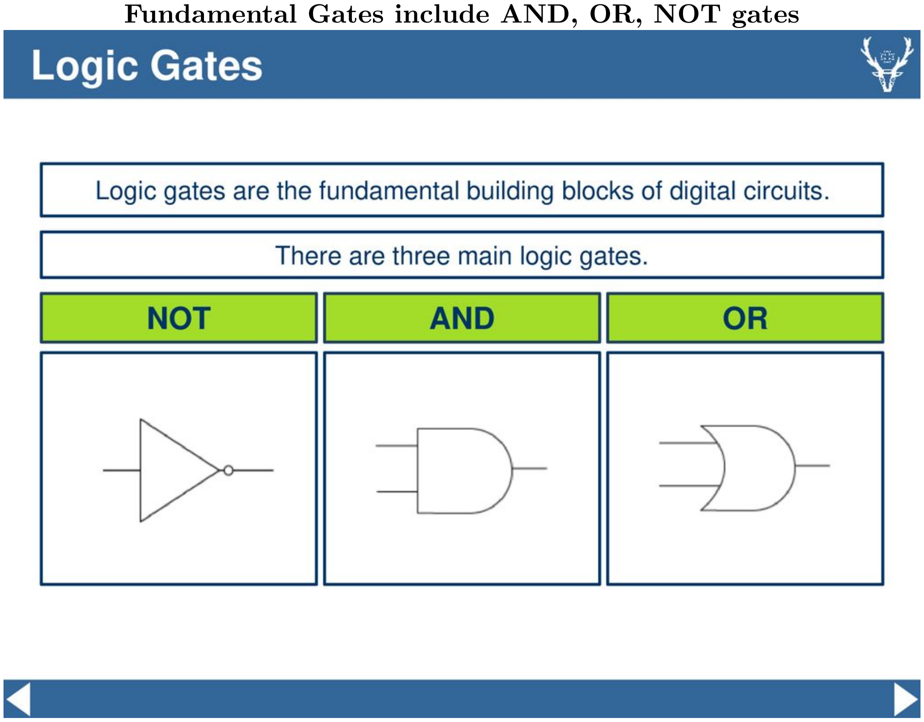
Smartphones	Tablets	Memory Devices
		

2 Definition Of a Gate

A gate is a basic electronic circuit which operates on one or more signals to produce an output signal. Logic gates are digital circuits constructed from diodes, transistors, and resistors connected in such a way that the circuit output is the result of a basic logic operation (OR, AND, NOT) performed on the inputs. [1]

3 Types Of Logic Gates

Fundamental Gates include AND, OR, NOT gates



3.1 AND Gate

The expression C = A X B reads as "C equals A AND B" The multiplication sign (X) stands for the AND operation, same for ordinary multiplication of 1s and 0s. The AND operation produces a true output (result of 1) only for the single case when all of the input variables are 1 and a false output (result of 0) where one or more inputs are 0.

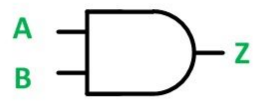


Table 2: AND TABLE

A	B	C= A x B
1	1	1
1	0	0
0	1	0
0	0	0

3.2 OR GATE

The expression C = A + B reads as "C equals A OR B". It is the inclusive "OR" The Addition (+) sign stands for the OR operation. The OR operation produces a true output (result of 1) when any of the input variable is 1 and a false output (result of 0) only when all the input variables are 0.

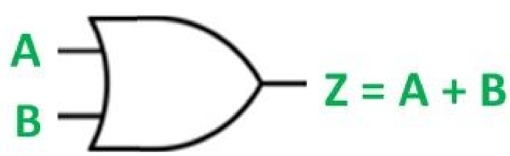


Table 3: OR TABLE

A	B	C= A + B
1	1	1
1	0	1
0	1	1
0	0	0

3.3 NOT GATE

The NOT gate is called a logical inverter. It has only one input. It reverses the original input (A) to give an inverted output C. C = NOT A or C = $\overline{A}$

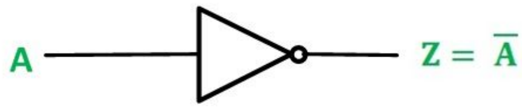


Table 4: NOT TABLE

A	**C = $\overline{A}$**
1	**0**
0	**1**

3.4 NOR GATE

The NOR (NOT OR) gate circuit is an inverter OR gate
C = $\overline{(A+B)}$ Reads as C = NOT of A or B
The NOR Gate gives a true output (result of 1) only when both inputs are false (0)

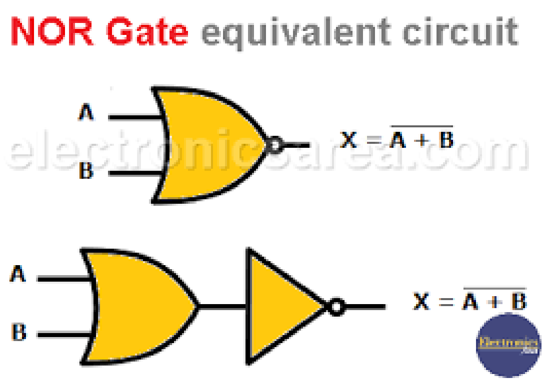


Table 5: NOR TABLE

A	**B**	**A+B**	**C= (A+B)**
1	**1**	**1**	**0**
1	**0**	**1**	**0**
0	**1**	**1**	**0**
0	**0**	**0**	**1**

3.5 NAND GATE

The NAND (NOT AND) Gate is an inverted AND Gate C = $(\overline{(A * B)})$ Reads as C = NOT of A AND B The NAND Gate gives a false output (result of 0) only when both inputs are true (1)

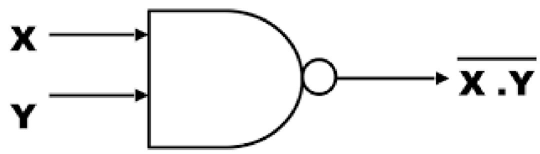


Table 6: NAND GATE

A	**B**	**A x B**	**C=** $\overline{(A * B)}$
1	**1**	**1**	**0**
1	**0**	**0**	**1**
0	**1**	**0**	**1**
0	**0**	**0**	**1**

The NAND Gate is a universal gate because it can be used to form any other kind of gate

3.6 XOR GATE

An XOR (exclusive OR) gate acts in the same way as the exclusive OR logical connector. It gives a true output (result of 1) if one, and only one, of the inputs to the gate is true (1), i.e either or but not both

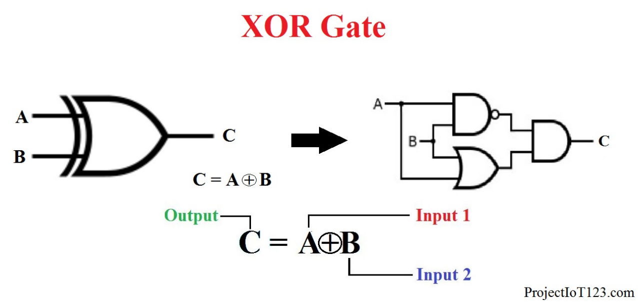


Table 7: XOR GATE

A	B	$\overline{A}$	$\overline{B}$	$\overline{A}$.B	$\overline{B}$.A	$\overline{A}$.B + $\overline{B}$.A
1	1	0	0	0	0	0
1	0	0	1	0	1	1
0	1	1	0	1	0	1
0	0	1	1	0	0	0

3.7 XNOR GATE

The XNOR (exclusive - NOR) gate is a combination XOR gate followed by an inverter. It is represented by the $\odot$ Its gives a true output (1), if the inputs are the same, and a false output (0) if the inputs are different.

$$C = \overline{(A \odot B)} = \overline{\overline{A}.B + \overline{B}.A}$$

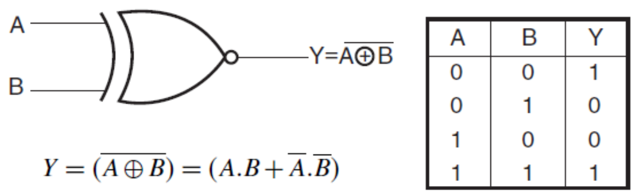
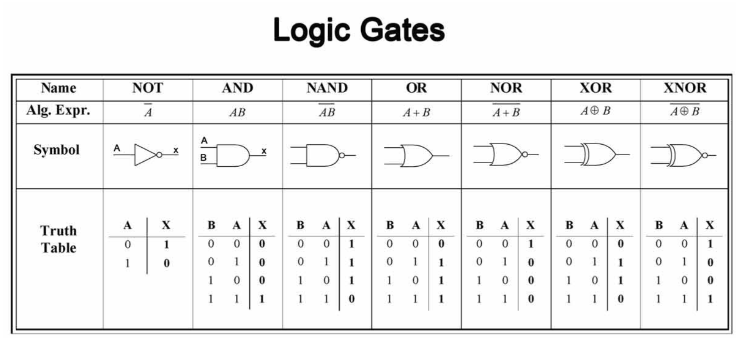


Table 8: XNOR GATE

A	**B**	$\overline{A}$	$\overline{B}$	$\overline{A}$ **.B**	$\overline{B}$ **.A**	$\overline{A}$ **.B +** $\overline{B}$ **.A**	$\overline{\overline{A}.B + \overline{B}.A}$
1	**1**	**0**	**0**	**0**	**0**	**0**	**1**
1	**0**	**0**	**1**	**0**	**1**	**1**	**0**
0	**1**	**1**	**0**	**1**	**0**	**1**	**0**
0	**0**	**1**	**1**	**0**	**0**	**0**	**1**

4 Summary

4.1 LOGIC GATES AND THEIR TRUTH TABLE



Logic Gates

Name	NOT	AND	NAND	OR	NOR	XOR	XNOR
Alg. Expr.	$\overline{A}$	AB	$\overline{AB}$	$A+B$	$\overline{A+B}$	$A\oplus B$	$\overline{A\oplus B}$
Symbol	A x	A B x					
Truth Table	A X 0 1 1 0	B A X 0 0 0 0 1 0 1 0 0 1 1 1	B A X 0 0 1 0 1 1 1 0 1 1 1 0	B A X 0 0 0 0 1 1 1 0 1 1 1 1	B A X 0 0 1 0 1 0 1 0 0 1 1 0	B A X 0 0 0 0 1 1 1 0 1 1 1 0	B A X 0 0 1 0 1 0 1 0 0 1 1 1

4.2 Summary contd.

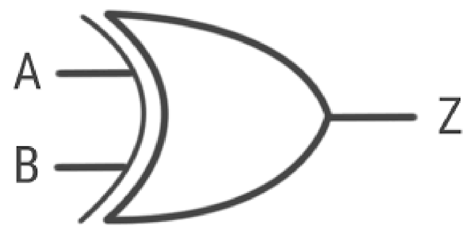
Using different combination of logic gates, complex operations can be performed. With the Universal logic gates - NAND and NOR, any other gate can be built.

There is no limit to the number of gates that can be arranged together in a single device. However, in practice, there is a limit to the number of gates that can be packed into a given physical space. Arrays of logic gates are found in digital integrated circuits. The logic gates are abstract representations of real electronic circuits. [2]

In computers, Logic gates are built using transistors combined with other electrical components like resistors and diodes. These electrical components are wired together in order to transform a particular input to give a desired output.

5 QUIZ

1. What is the output of an AND gate if the inputs are 1 and 0?
2. Explain the difference between the AND gate and the OR gate.
3. What is the output of a NOT gate if the inputs is 0?
4. Which logic gate is this?



5. Which gate is also known a logical converter?

References

[1] N. Okoacha, “Logic gates [powerpointslides],” *GST 108: Introduction to Quantitative Reasoning*, pp. 1–9, 2021.

[2] N. Okoacha, “Logic gates [powerpointslides] -summary,” *GST 108: Introduction to Quantitative Reasoning*, pp. 20–21, 2021.