

# Module 2 - Boolean Algebra & Basic Logic Gates

- [Objective](#)
- [Theory](#)

# Objective

- 1. Proof Boolean Algebra statements using basic logic gates.**
- 2. Understand how to use Integrated Circuits (IC).**

# Theory

Boolean algebra is a mathematical system that describes the notations and operations on Boolean values. Boolean values are things that take on one out of two possible values. For example, a bit that can be a 1 or a 0.

Boolean algebra can be used to describe digital systems because digital signals are Boolean values: HIGH/VCC = 1 and LOW/GND = 0. So, a function of a digital system can be analyzed by using boolean algebra.





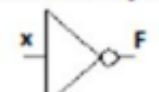
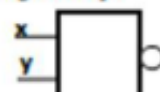
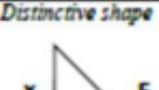

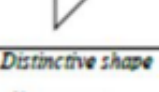
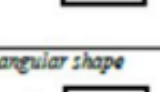

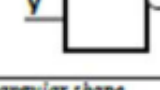

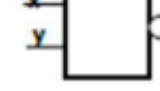

The laws of Boolean algebra are:

1	$A + A = A$	Idempotent Law for OR
2	$A * A = A$	Idempotent Law for AND
3	$A + B = B + A$	Commutative Law for OR
4	$A * B = B * A$	Commutative Law for AND
5	$A + (B + C) = (A + B) + C$	Associative Law for OR
6	$A * (B * C) = (A * B) * C$	Associative Law for AND
7	$A * (B + C) = A * B + A * C$	Distributive Law for AND over OR
8	$A + B * C = (A + B) * (A + C)$	Distributive Law for OR over AND
9	$A + 1 = 1$	Law of Union
10	$A * 0 = 0$	Law of Intersection
11	$A * (A + B) = A$	Law of Absorption
12	$A + A * B = A$	Law of Absorption
13	$A * 1 = A$	Identity Law for AND
14	$A + 0 = A$	Identity Law for OR
15	$\overline{\overline{A}} = A$	Double Negative Law
16	$A + \overline{A} = 1$	Law of Complement for OR
17	$A * \overline{A} = 0$	Law of Complement for AND
18	$\overline{A + B} = \overline{A} * \overline{B}$	DeMorgan's Law
19	$\overline{A * B} = \overline{A} + \overline{B}$	DeMorgan's Law
20	$A \oplus B = A * \overline{B} + \overline{A} * B = \overline{A} * B + A * \overline{B}$	Exclusive OR (XOR)
21	$\overline{A \oplus B} = A * B + \overline{A} * \overline{B}$	Exclusive NOR (XNOR)
22	$A + \overline{A} * B = A + B$	Law of the "disappearing opposite"
23	$(A + B) * (A + C) = A + B * C$	Reverse of Law #8
24	$(A + B) * (C + D) = A * C + A * D + B * C + B * D$	FOIL (First,Outer,Inner,Last) Distribut

Those laws are used to simplify Boolean algebra expressions. The result is that the amount of components needed to implement a function into a digital system shrinks and so the cost for that system decreases. For example:

$$\begin{aligned}
 &(\overline{A} + B) * (A + B) \\
 &= B * (\overline{A} + A) && \text{Inverse of Distributive Law for AND over OR} \\
 &= B * (1) && \text{Idempotent Law for OR}
 \end{aligned}$$

Logic gates are the basic components that make up a digital system. A logic gate implements a logic operation. Below is a list of logic gates with its symbol, function, and truth table:

Gerbang Logika																		
Gerbang	Symbol Grafis	Fungsi Aljabar	Tabel kebenaran															
AND	<i>Distinctive shape</i> 	$F = x \cdot y$	<table border="1"> <thead> <tr> <th>x</th> <th>y</th> <th>F</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	x	y	F	0	0	0	0	1	0	1	0	0	1	1	1
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OR	<i>Distinctive shape</i> 	$F = x + y$	<table border="1"> <thead> <tr> <th>x</th> <th>y</th> <th>F</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	x	y	F	0	0	0	0	1	1	1	0	1	1	1	1
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NAND	<i>Distinctive shape</i> 	$F = (x \cdot y)'$	<table border="1"> <thead> <tr> <th>x</th> <th>y</th> <th>F</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> </tr> </tbody> </table>	x	y	F	0	0	1	0	1	1	1	0	1	1	1	0
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