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Industrial Controls (1)

By

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Lecture (5)

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Logic Gates
&
Memory Components

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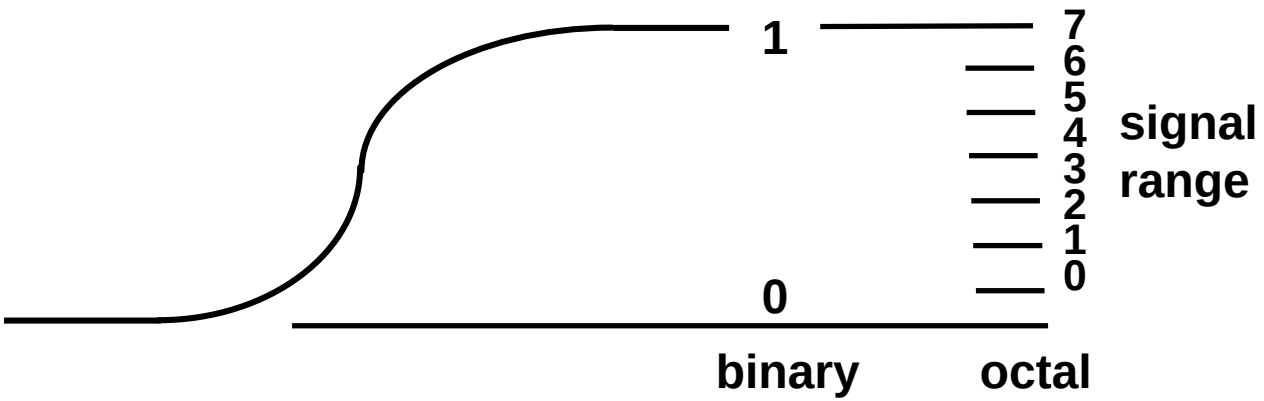
Logic Gates

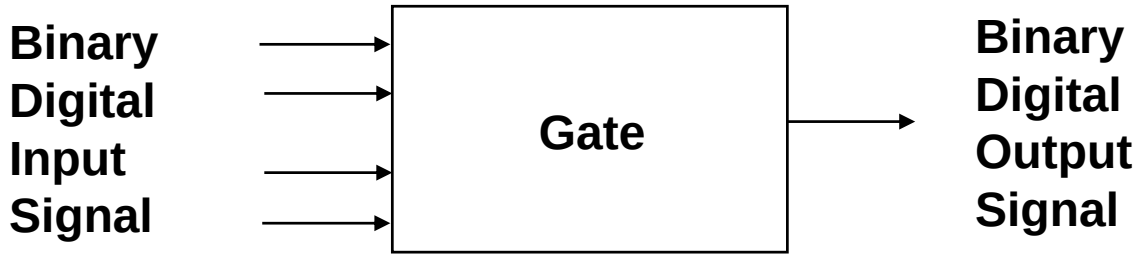
Digital Computers:

- Imply that the computer deals with digital information, i.e., it deals with the information that is represented by binary digits.
- Why BINARY ? instead of Decimal or other number system ?

Consider electronic signal



Basic Logic Block (Gate)



Types of Basic Logic Blocks:

1. **Combinational Logic Block**

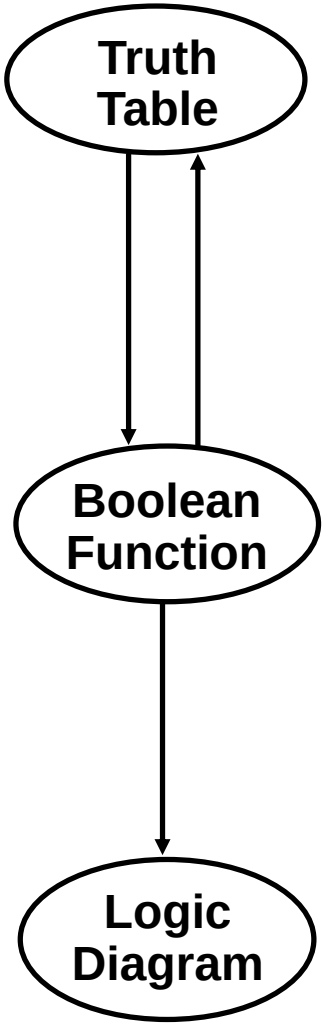
- Logic Blocks whose output logic value depends only on the input logic values.
- Sequential Logic Block Logic Blocks whose output logic value depends on the input values and the state (stored information) of the blocks.

Cont.

2. **Functions of Gates can be described by**

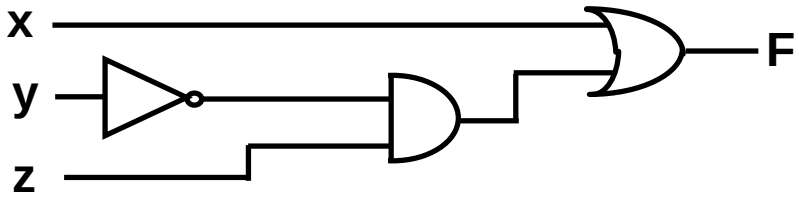
- Truth Table.
- Boolean Function.
- Karnaugh Map

Logic circuit design



x	y	z	F
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

$F = x + y'z$



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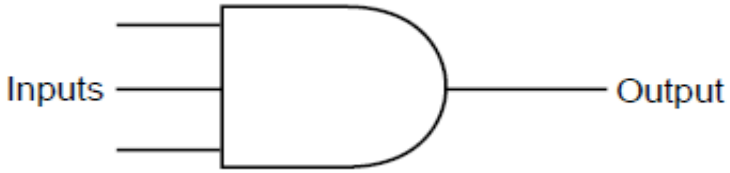
Combinational Gates

1. AND
2. OR
3. NOT
4. NAND
5. NOR
6. XOR
7. XNOR
8. Buffer

1. AND Gate

- The AND output is TRUE (1) only if all inputs are TRUE.
- An AND function can have an unlimited number of inputs, but it can have only one output.
- **Symbol for the AND function:**



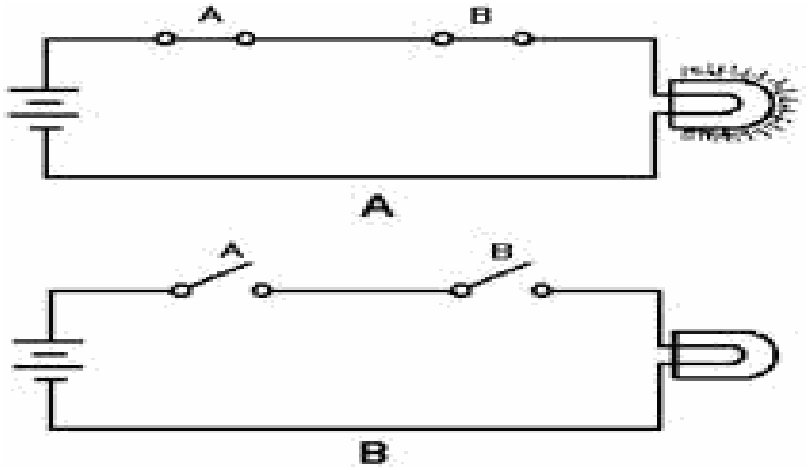
- **truth table:**

AND Truth Table		
Inputs		Output
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Two-input AND gate and its truth table.

Cont.

- **Electrical Circuit**



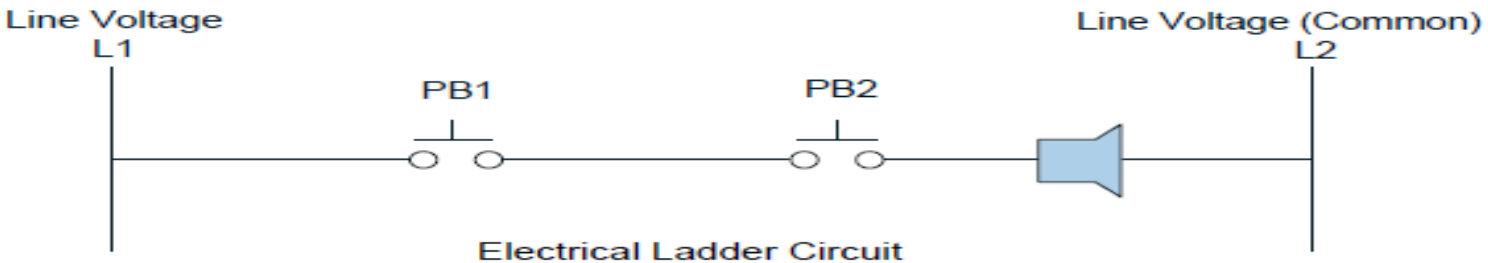
Example (1)

- Show the logic gate, truth table, and circuit representations for an alarm horn that will sound if its two inputs, push buttons PB1 and PB2, are 1 (ON or depressed) at the same time.

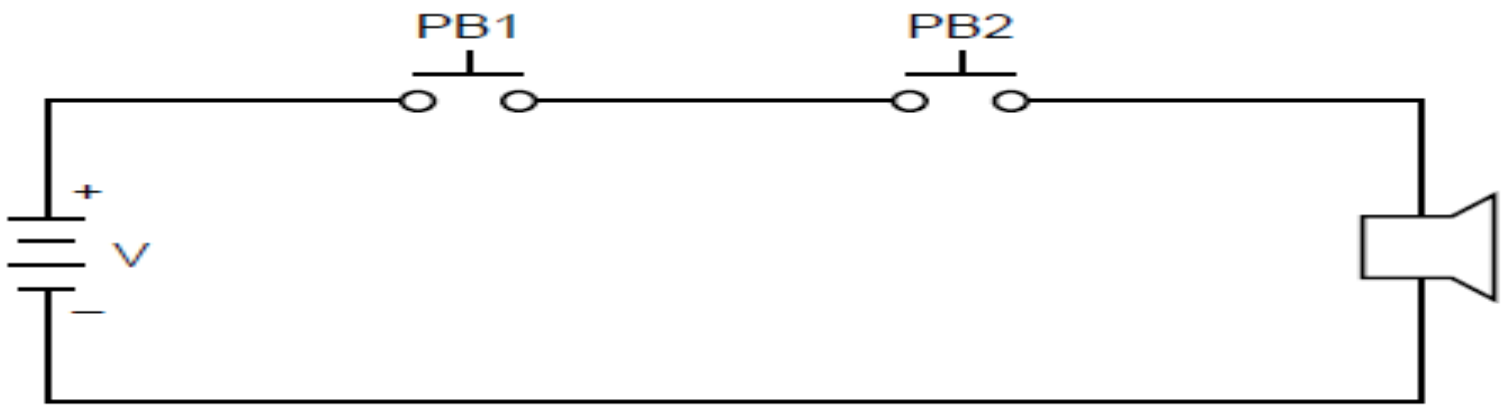
Solution (1)

Logic Representation

PB1	PB2	Alarm Horn
Not pushed (0)	Not pushed (0)	Silent (0)
Not pushed (0)	Pushed (1)	Silent (0)
Pushed (1)	Not pushed (0)	Silent (0)
Pushed (1)	Pushed (1)	Sounding (1)



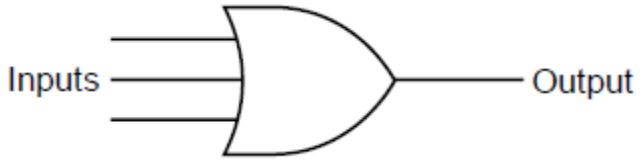
Electrical Ladder Circuit



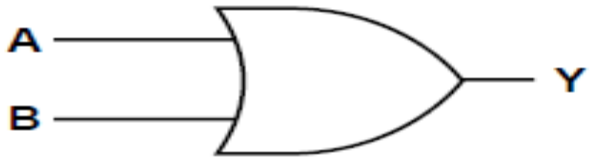
Electrical Circuit

2. OR Gate

- The OR output is TRUE (1) if one or more inputs are TRUE (1).
- can have an unlimited number of inputs but only one output.
- **Symbol for the OR function:**



- **truth table:**



OR Truth Table		
Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

Two-input OR gate and its truth table.

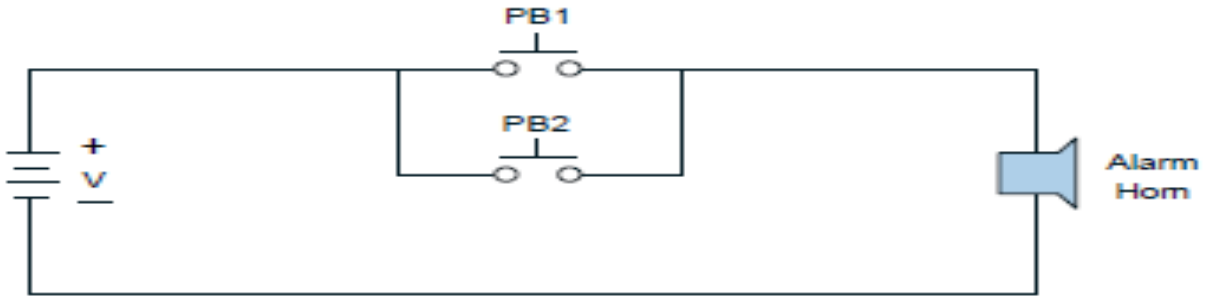
Example (2)

- Show the logic gate, truth table, and circuit representations for an alarm horn that will sound if either of its inputs, push button PB1 or PB2, is 1 (ON or depressed).

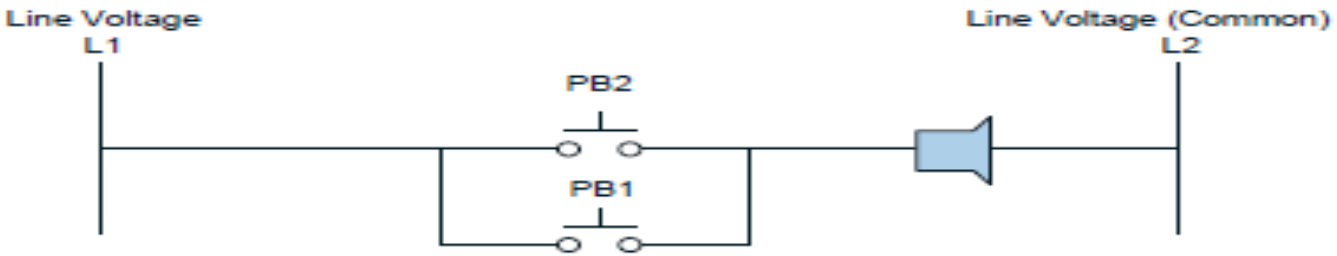
Solution (2)

Logic Representation

PB1	PB2	Alarm Horn
Not pushed (0)	Not pushed (0)	Silent (0)
Not pushed (0)	Pushed (1)	Sounding (1)
Pushed (1)	Not pushed (0)	Sounding (1)
Pushed (1)	Pushed (1)	Sounding (1)



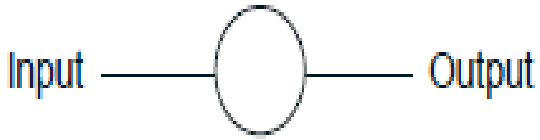
Electrical Circuit



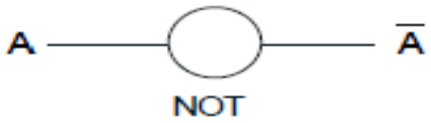
Electrical Ladder Circuit

3. NOT Gate

- The NOT output is TRUE (1) if the input is FALSE (0).Conversely, if the output is FALSE (0), the input is TRUE (1).
- The result of the NOT operation is always the inverse of the input; therefore, it is sometimes called an inverter.
- can have only one input.
- **Symbol for the NOT function:**



- **truth table:**



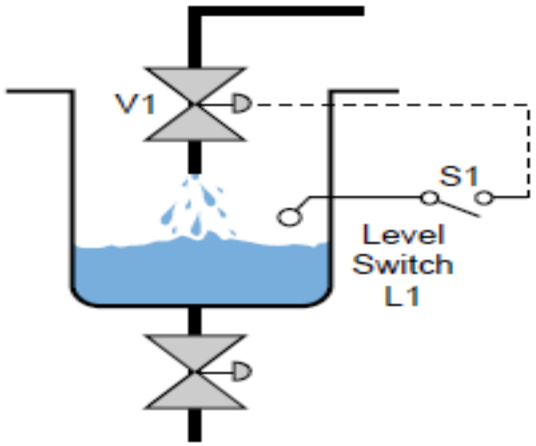
NOT Truth Table	
Input	**Output**
A	$\overline{A}$
0	1
1	0

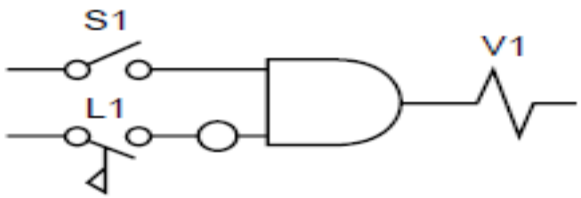
NOT gate and its truth table.

Example (3)

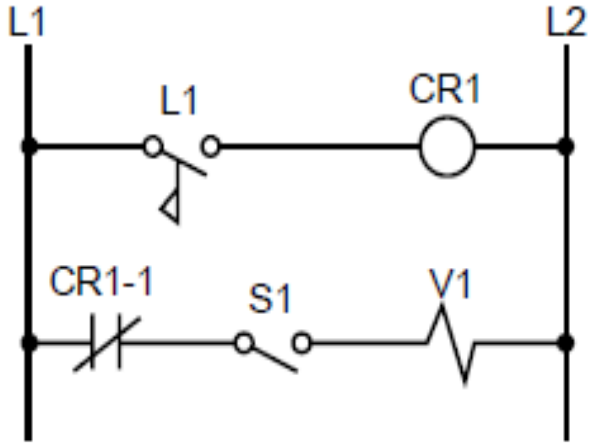
- Show the logic gate, truth table, and circuit representation for a solenoid valve (V1) that will be open (ON) if selector switch S1 is ON and if level switch L1 is NOT ON (liquid has not reached level).

Solution (3)





Logic Representation



Electrical Ladder Circuit

S1	L1	$(\overline{L1})$	V1
0	0	1	0
0	1	0	0
1	0	1	1
1	1	0	0

Truth Table

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4. NAND Gate

- A negated AND gate is called a **NAND** gate.

- **logic symbol and truth table:**

Two-input NAND gate and its truth table.

NAND Truth Table		
Inputs		Output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

5. NOR Gate

- NOT symbol is placed at the output of an OR gate. The normal output is negated, and the function is referred to as a NOR gate.
- **logic symbol and truth table:**

Two-input NOR gate and its truth table.

NOR Truth Table		
Inputs		Output
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

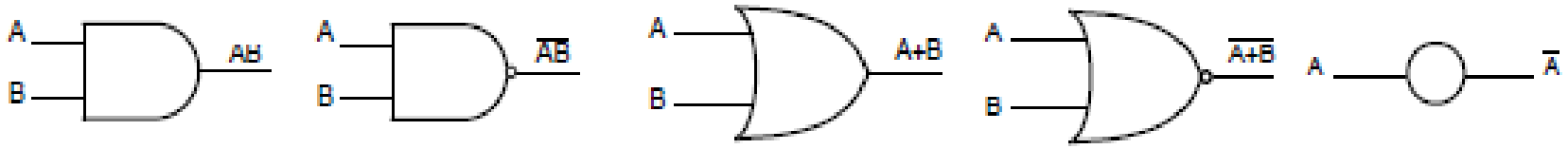
Principles of Boolean Algebra and Logic

Logical Symbol	Logical Statement	Boolean Equation
	*Y* is 1 if *A* AND *B* are 1	$Y = A \cdot B$ or $Y = AB$
	*Y* is 1 if *A* OR *B* is 1	$Y = A + B$
	*Y* is 1 if *A* is 0 *Y* is 0 if *A* is 1	$Y = \overline{A}$

Boolean algebra as related to the AND, OR, and NOT functions.

Logic operations using Boolean algebra

1. Basic Gates. Basic logic gates implement simple logic functions. Each logic function is expressed in terms of a truth table and its Boolean expression.



A	B	AB
0	0	0
0	1	0
1	0	0
1	1	1

AND

A	B	$\overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0

NAND

A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

OR

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

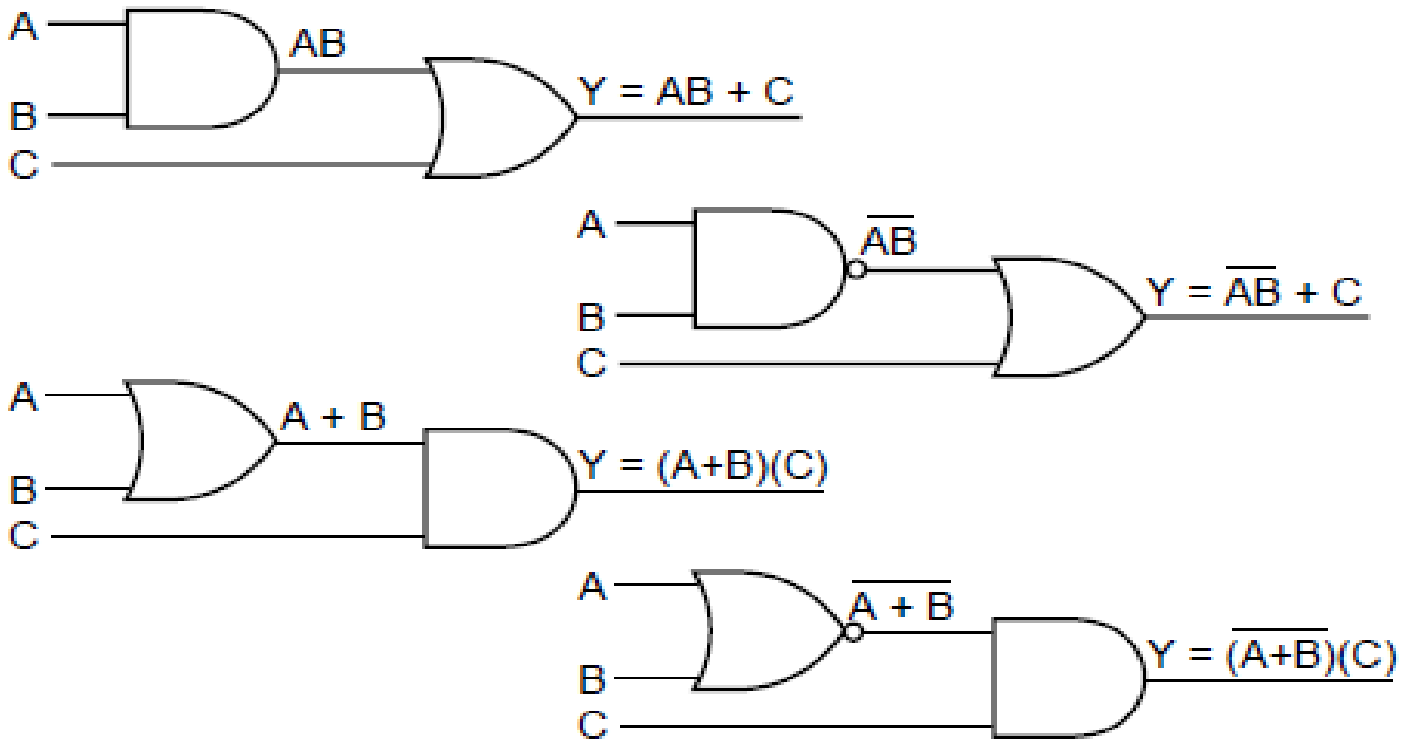
NOR

A	$\overline{A}$
0	1
1	0

NOT

Cont.

2. Combined Gates. Any combination of control functions can be expressed in Boolean terms using three simple operators: (•), (+), and (¯).



Cont.

3. Boolean Algebra Rules. Control logic functions can vary from simple to very complex combinations of input variables. However simple or complex the functions may be, they satisfy the following rules. These rules are a result of a simple combination of basic truth tables and may be used to simplify logic circuits.

Commutative Laws

$A + B = B + A$

$AB = BA$

Associative Laws

$A + (B + C) = (A + B) + C$

$A(BC) = (AB)C$

De Morgan's Laws

$\overline{(A + B)} = \overline{A}\,\overline{B}$

$\overline{(AB)} = \overline{A} + \overline{B}$

$\overline{\overline{A}} = A,\ \overline{1} = 0,\ \overline{0} = 1$

$A + \overline{A}B = A + B$

$AB + AC + B\overline{C} = AC + B\overline{C}$

Distributive Laws

$A(B + C) = AB + AC$

$A + BC = (A + B)(A + C)$

Law of Absorption

$A(A + B) = A + AB = A$

The Memory System
&
Components

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Memory Sections

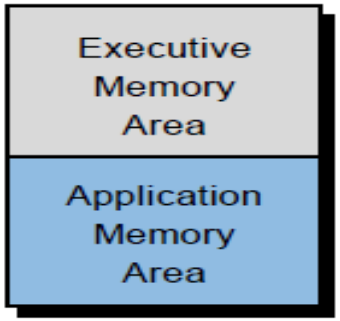
- The total memory system in a PLC is actually composed of two different memories:

1. **the executive memory.**

- The executive memory is a collection of permanently stored programs that are considered part of the PLC itself.

2. **the application memory.**

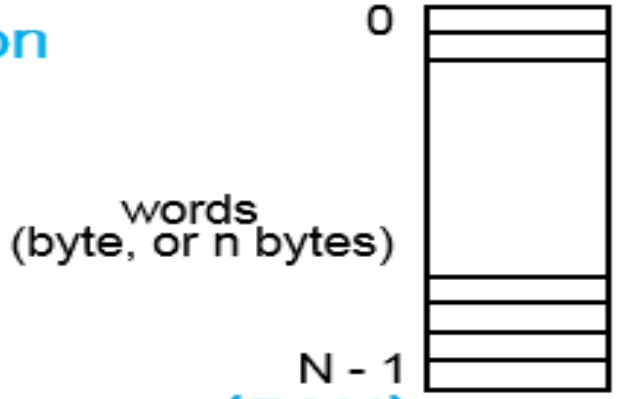
- The application memory provides a storage area for the user-programmed instructions that form the application program.



Simplified block diagram of the total PLC memory system.

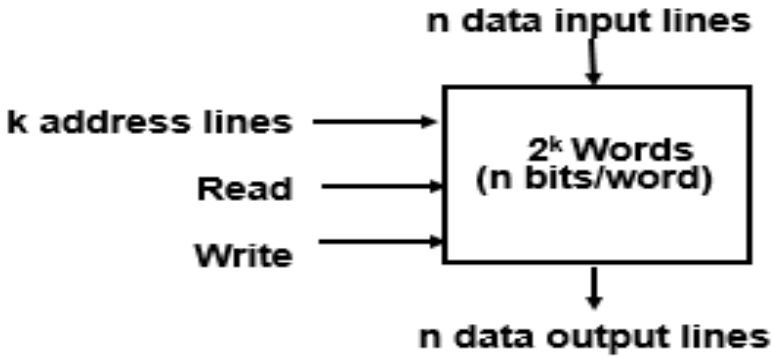
Memory Types

Logical Organization



Random Access Memory (RAM)

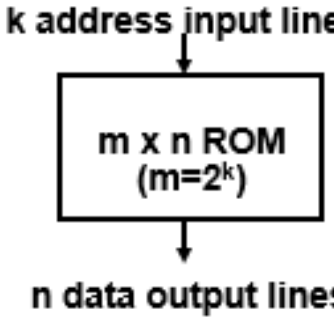
- Each word has a unique address
- Access to a word requires the same time independent of the location of the word
- Organization



READ ONLY MEMORY(ROM)

Characteristics

- Perform read operation only, write operation is not possible
- Information stored in a ROM is made permanent during production, and cannot be changed
- Organization



Information on the data output line depends only on the information on the address input lines.

--> Combinational Logic Circuit

$X_0 = A'B' + B'C$
$X_1 = A'B'C + A'BC'$
$X_2 = BC + AB'C'$
$X_3 = A'BC' + AB'$
$X_4 = AB$

Canonical minterms

$X_0 = A'B'C' + A'B'C + AB'C$
$X_1 = A'B'C + A'BC'$
$X_2 = A'BC + AB'C' + ABC$
$X_3 = A'BC' + AB'C' + AB'C$
$X_4 = ABC' + ABC$

address	*Output*				
ABC	X_0	X_1	X_2	X_3	X_4
000	1	0	0	0	0
001	1	1	0	0	0
010	0	1	0	1	0
011	0	0	1	0	0
100	0	0	1	1	0
101	1	0	0	1	0
110	0	0	0	0	1
111	0	0	1	0	1

Types of ROM

1. **ROM**

- Store information (function) during production.
- Mask is used in the production process.
- Unalterable.
- Low cost for large quantity production used in the final products.

2. **PROM (Programmable ROM)**

- Store info electrically using PROM programmer at the user's site.
- Unalterable.
- Higher cost than ROM.
- used in the system development phase.
- Can be used in small quantity system

Cont.

2. **EPROM (Erasable PROM)**

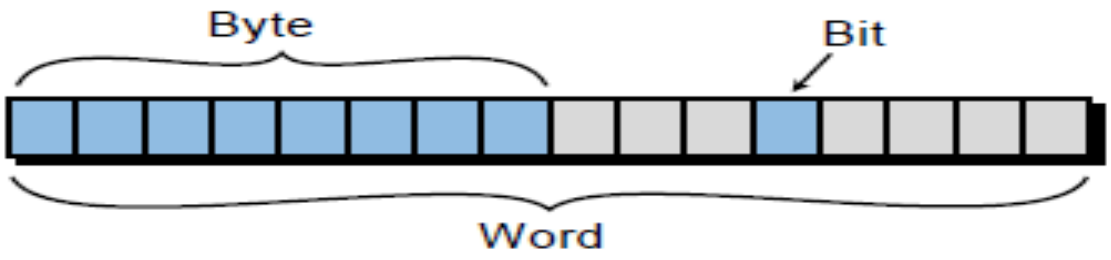
- Store info electrically using PROM programmer at the user's site.
- Stored info is erasable (alterable) using UV light (electrically in some devices) and rewriteable.
- Higher cost than PROM but reusable (used in the system development phase).
- Not used in the system production due to eras ability.

Memory Structure and Capacity

- PLC memories can be thought of as large, two-dimensional arrays of single unit storage cells, each storing a single piece of information in the form of **1or 0** (binary numbering format).
- each cell can store only one binary digit and bit is the acronym for "binary digit," each cell is called a bit.
- A bit is considered to be ON if the stored information is 1(voltage present) and OFF if the stored information is 0 (voltage absent).

Cont.

- A group of bits handled simultaneously is called a byte.
- Although byte size is normally eight bits, this size can vary depending on the specific controller.
- The third and final structural information unit used within a PLC is a word.
- words are usually one byte or more in length



Units of PLC memory: bits, bytes, and words.

Thank You For Your Attention

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