CE232 DIGITAL SYSTEM

Topic 3. Logic Gates

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Subtopic

3.1 Basic Logic Gates

3.2 Type of Logic Gates

3.3 Boolean Function with Logic Gates

3.1 Basic Logic Gates

3.1 Basic Logic Gates

- Logic Gates are used to perform logic function
- Logic Gates also used to design logic circuit
- Logic Gates perform operation on one or more logic function and provide single output
- There are 3 Basic Gates, 2 Universal Gates, and 2 Special Gates

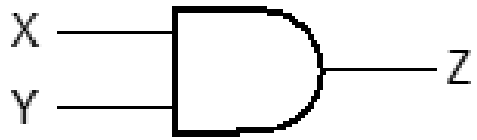
3.1 Basic Logic Gates

- Basic gates : AND, OR, NOT
- Universal gates : NAND, NOR (by using those gates we can implement all other gates
- Special gate : EX-OR, EX-NOR (XOR, NOR)

3.1 Basic Logic Gates

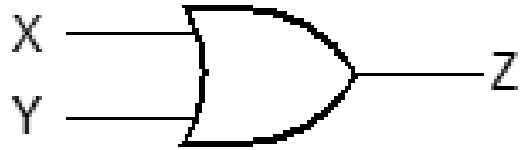
BASIC GATES

- AND = multiplication functionality



AND gate

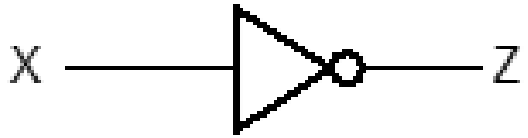
- OR = addition functionality



OR gate

3.1 Basic Logic Gates

- NOT = complement functionality



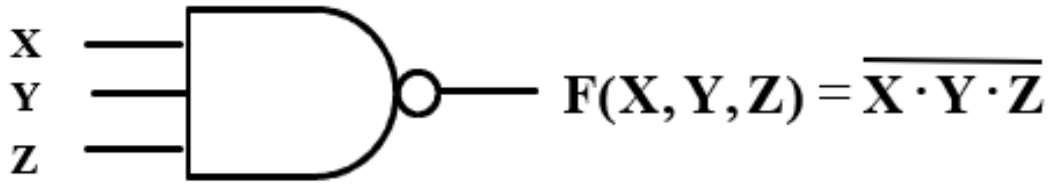
NOT gate or inverter

where $Z = \bar{X}$

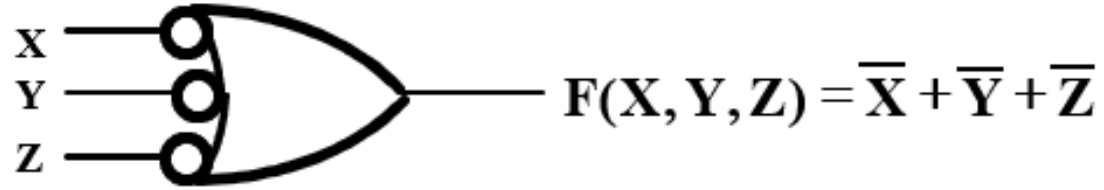
3.1 Basic Logic Gates

UNIVERSAL GATES

- NAND : AND + NOT



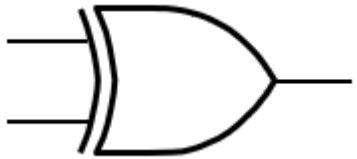
- NOR : OR + NOT



3.1 Basic Logic Gates

SPECIAL GATES

- XOR : eXclusive OR



- XNOR : eXclusive NOR (complement of XOR)

3.1 Basic Logic Gates

There are other concepts that will be used in this topic

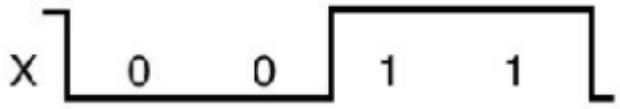
- Truth table

Has **one column for each input variable** (for example, A and B), and **one final column showing all of the possible results** of the logical operation that the table represents

- Timing diagram

Representation of a set of signals in the time domain

For example



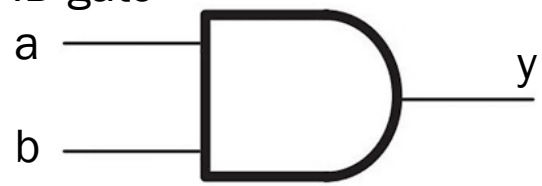
3.2 Type of Logic Gates

3.2 Type of Logic Gates

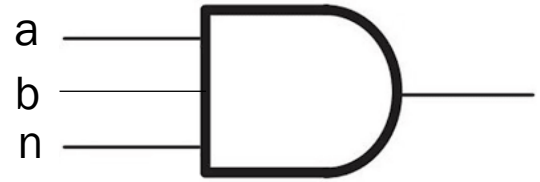
BASIC GATES

AND GATE : Logical multiplication

2 input AND gate



n input AND gate

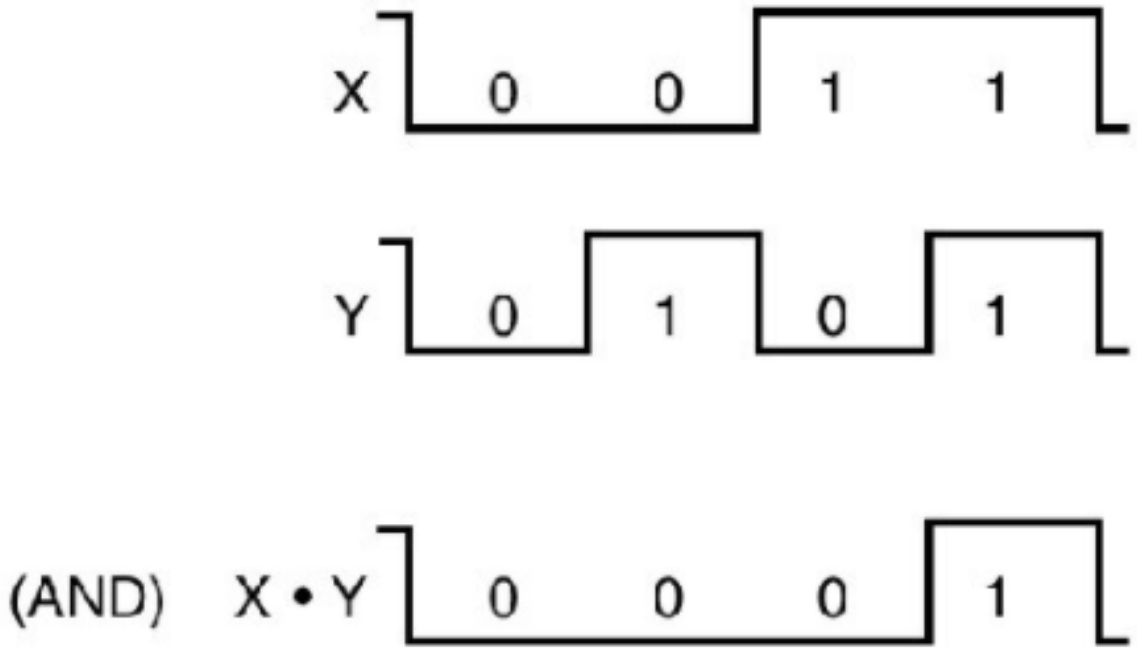


Truth table

Inputs		Output
A	B	Y=A.B
0	0	0
0	1	0
1	0	0
1	1	1

3.2 Type of Logic Gates

Timing diagram AND GATE

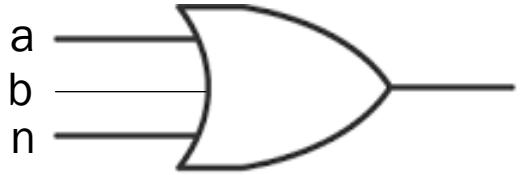


3.2 Type of Logic Gates

OR GATE : Logical addition

2 input OR gate

n input OR gate

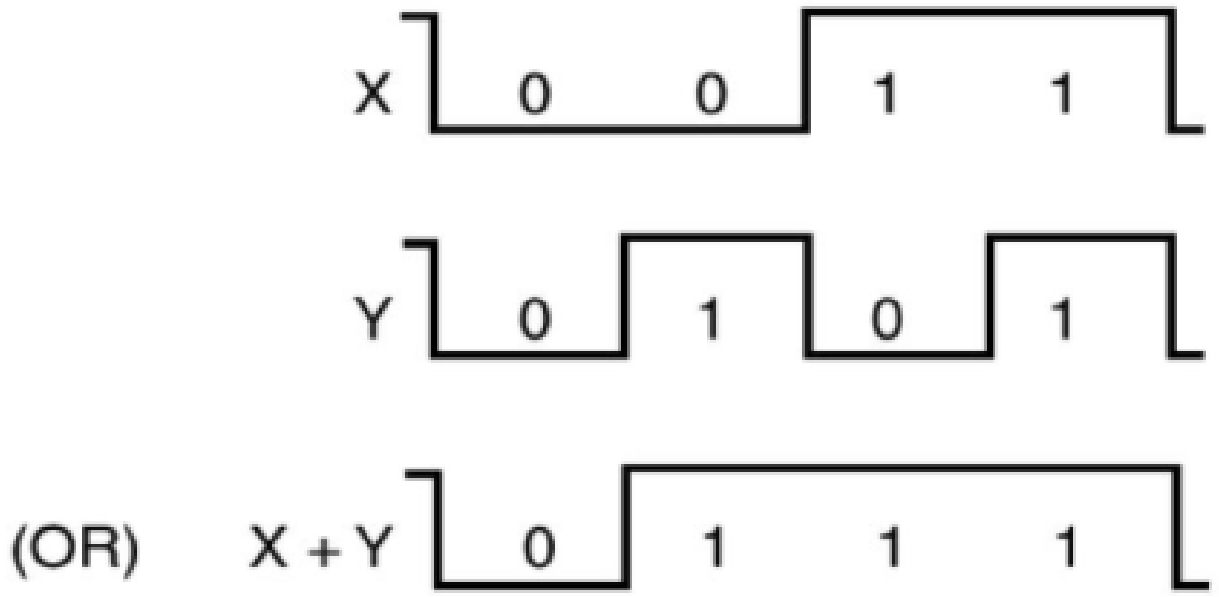


Truth table

Inputs		Output
A	B	Y=A+B
0	0	0
0	1	1
1	0	1
1	1	1

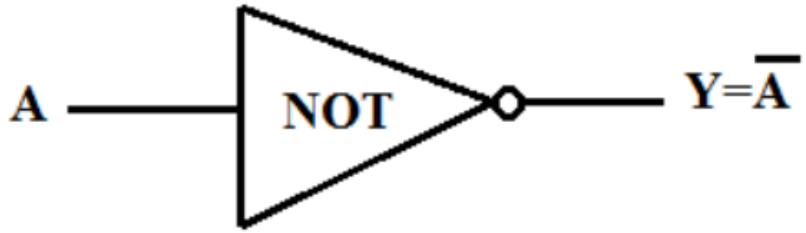
3.2 Type of Logic Gates

- Timing diagram OR GATE



3.2 Type of Logic Gates

NOT GATE : complement

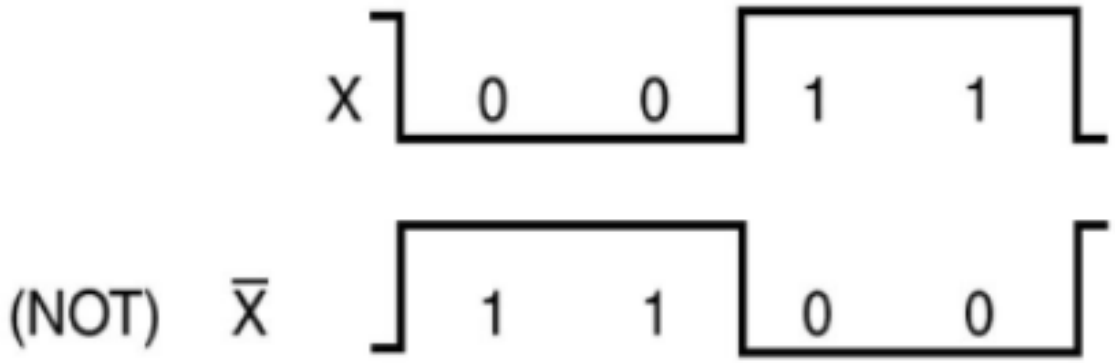


Truth table

Input	Output
A	Y=$\overline{A}$
0	1
1	0

3.2 Type of Logic Gates

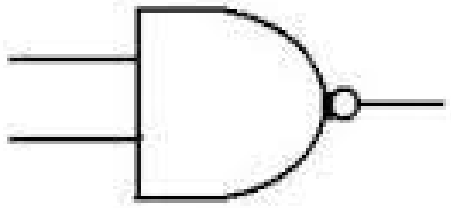
- Timing diagram NOT GATE



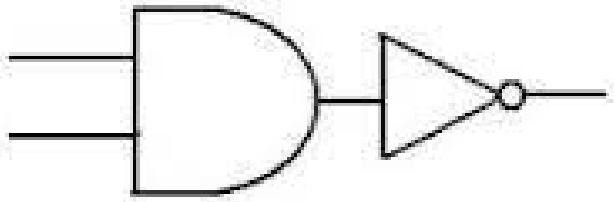
3.2 Type of Logic Gates

UNIVERSAL GATE

NAND GATE : AND + NOT



The symbol can also be represented as

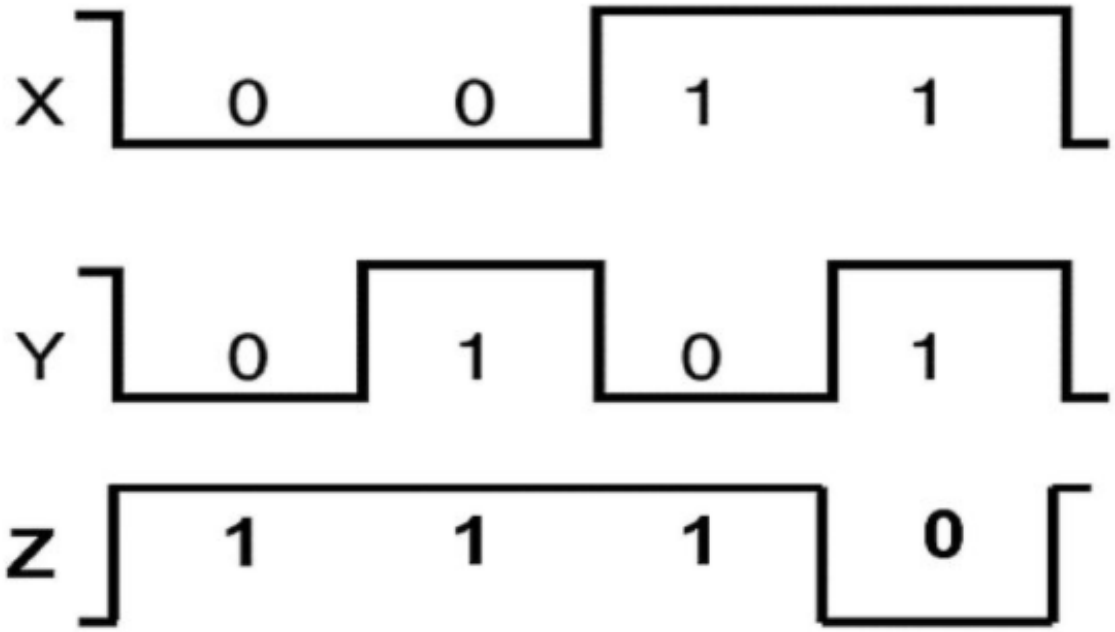


Truth table

Inputs		Output
A	B	$Y=\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

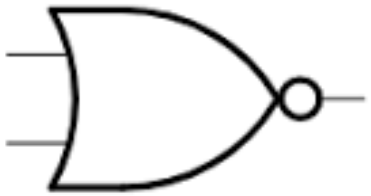
3.2 Type of Logic Gates

Timing diagram NAND GATE

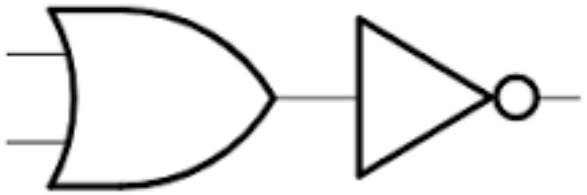


3.2 Type of Logic Gates

NOR GATE : OR + NOT



The symbol can also be represented as

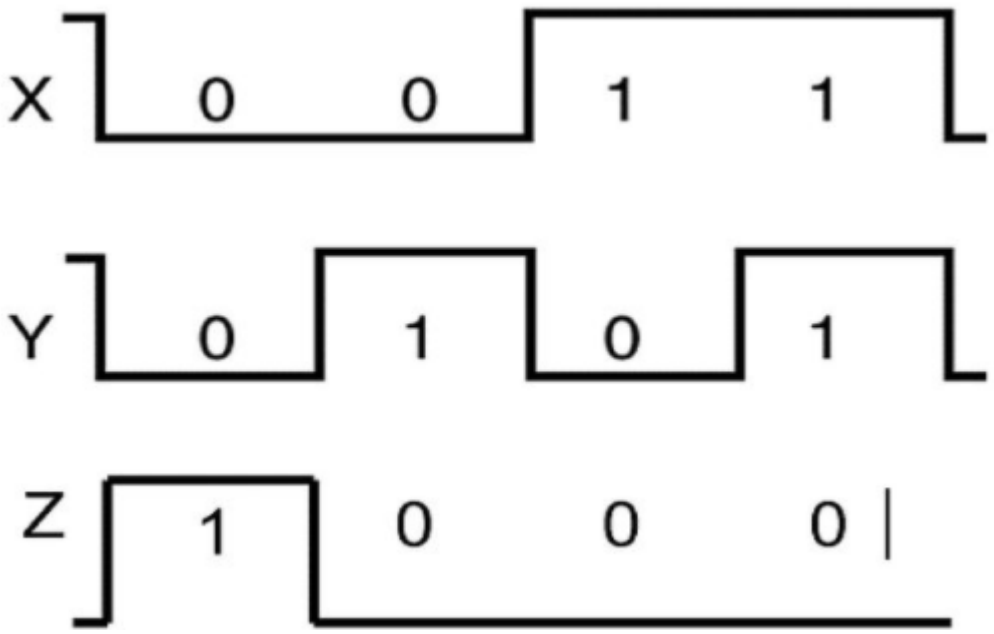


Truth table

Inputs		Output
A	B	$Y=\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

3.2 Type of Logic Gates

- Timing diagram NOR GATE



3.2 Type of Logic Gates

SPECIAL GATE

EX-OR GATE: Exclusive OR

has the output only high when an odd number of inputs are high

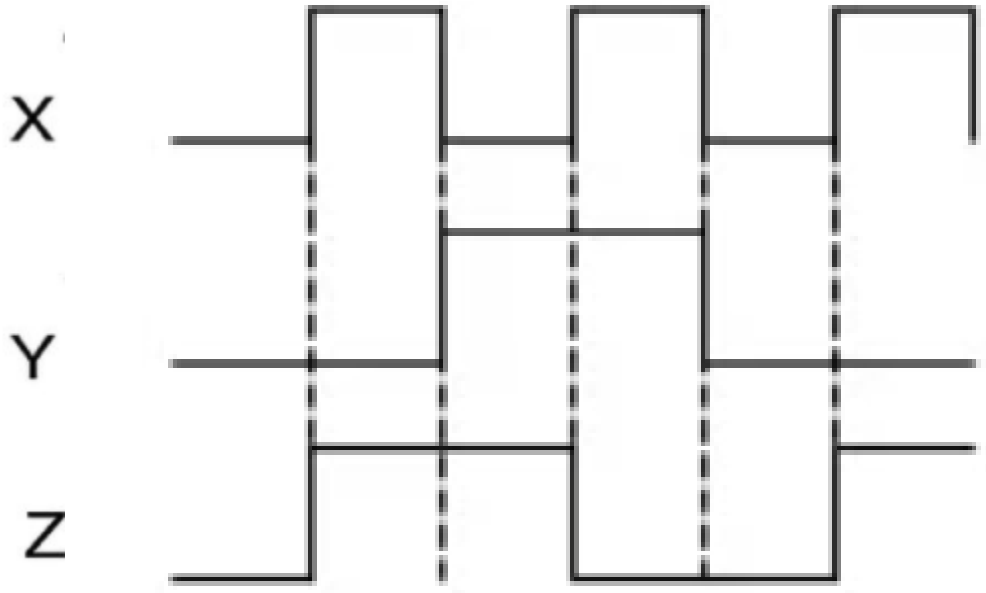
he output is low when both the inputs are low, and both the inputs are high

Truth table

Inputs		Output
A	B	Y=A⊕B
0	0	0
0	1	1
1	0	1
1	1	0

3.2 Type of Logic Gates

Timing diagram EX-OR GATE



3.2 Type of Logic Gates

EX-NOR GATE : Exclusive NOR

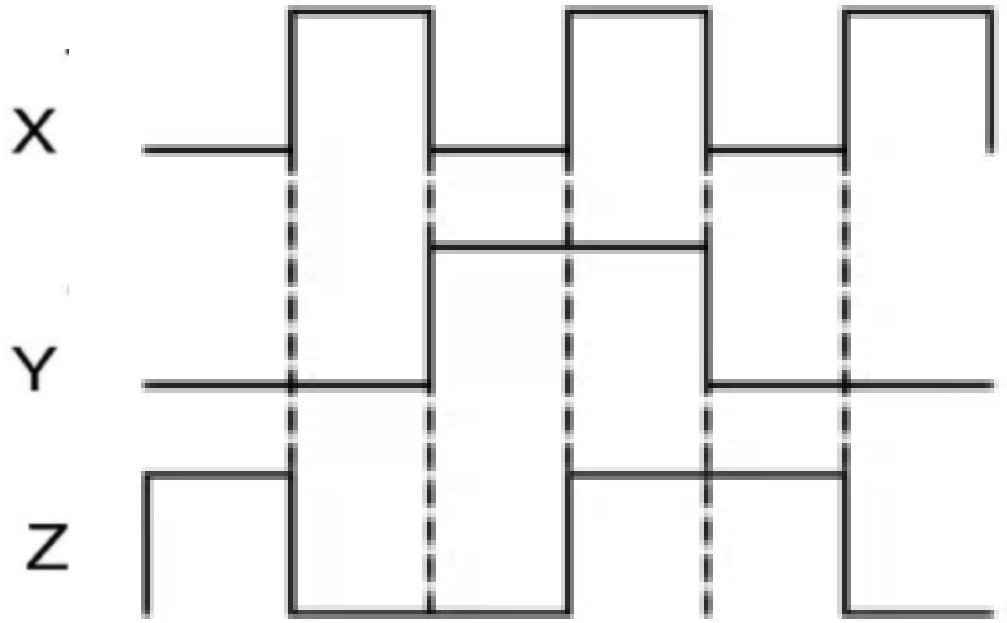
has the output only high when both the inputs have the same values either high or low

Truth table

Inputs		Output
A	B	$Y=\overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

3.2 Type of Logic Gates

- Timing diagram EX-NOR GATE



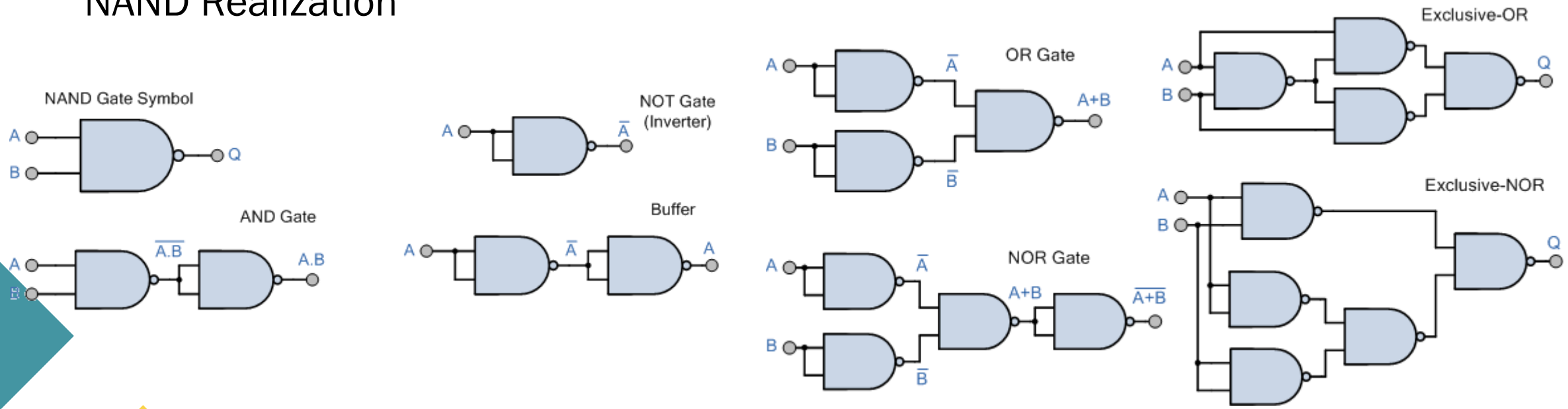
3.2 Type of Logic Gates

Properties of XOR and XNOR GATE

- $X \oplus 0 = X$ $\quad X \otimes 0 = X'$
- $X \oplus 1 = X'$ $\quad X \otimes 1 = X$
- $X \oplus X = 0$ $\quad X \otimes X = 1$
- $X \oplus X' = 1$ $\quad X \otimes X' = 0$
- $X \oplus Y' = X' \oplus Y = (X \oplus Y)' = X \otimes Y$
- $X \oplus Y = X' \oplus Y'$ (same with XNOR)
- $X \oplus Y = Y \oplus X$ (commutative, same with XNOR)
- $X \oplus (Y \oplus Z) = (X \oplus Y) \oplus Z$ (associative, same with XNOR)

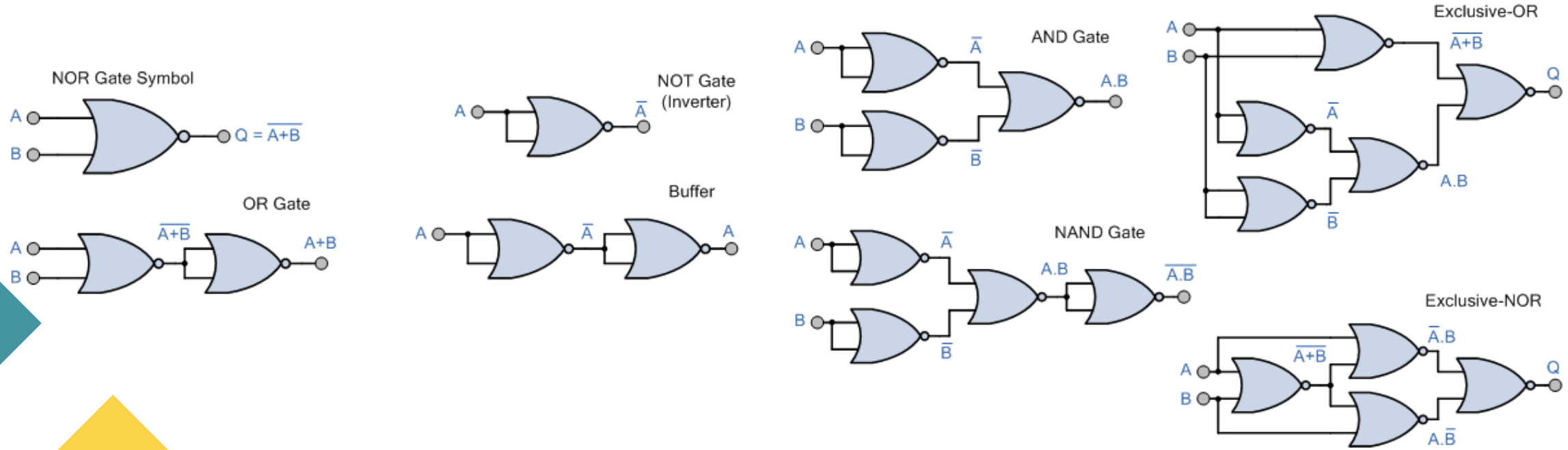
3.2 Type of Logic Gates

NAND Realization



3.2 Type of Logic Gates

NOR Realization

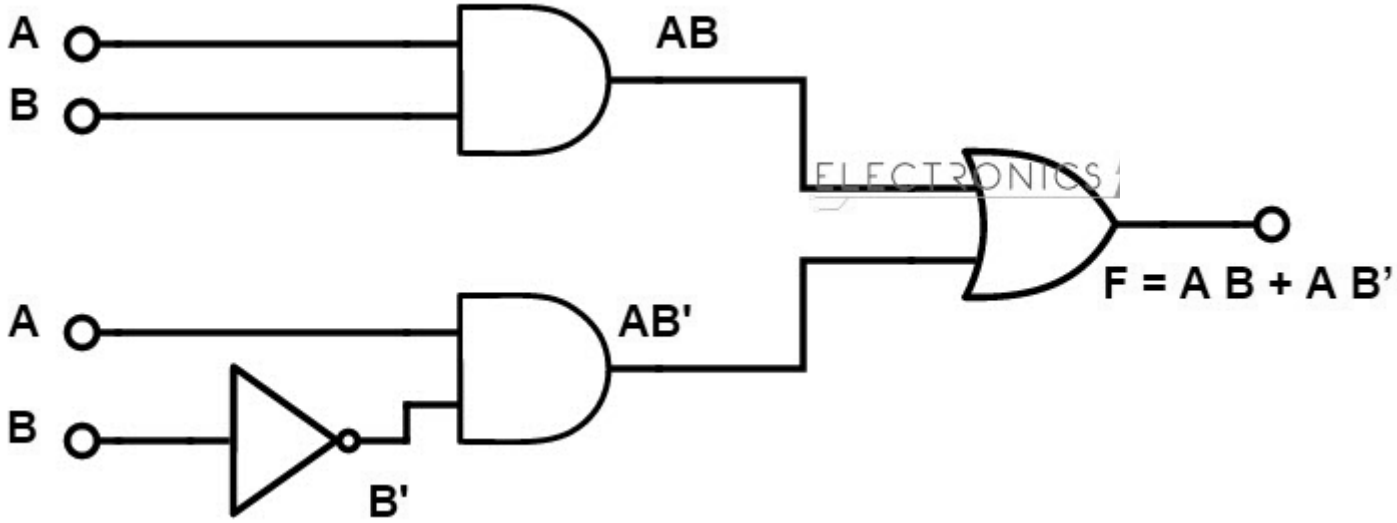


3.3 Boolean Function with Logic Gates

3.3 Boolean Function with Logic Gates

Example.

Implement $A\bar{B} + AB$ using logic gate



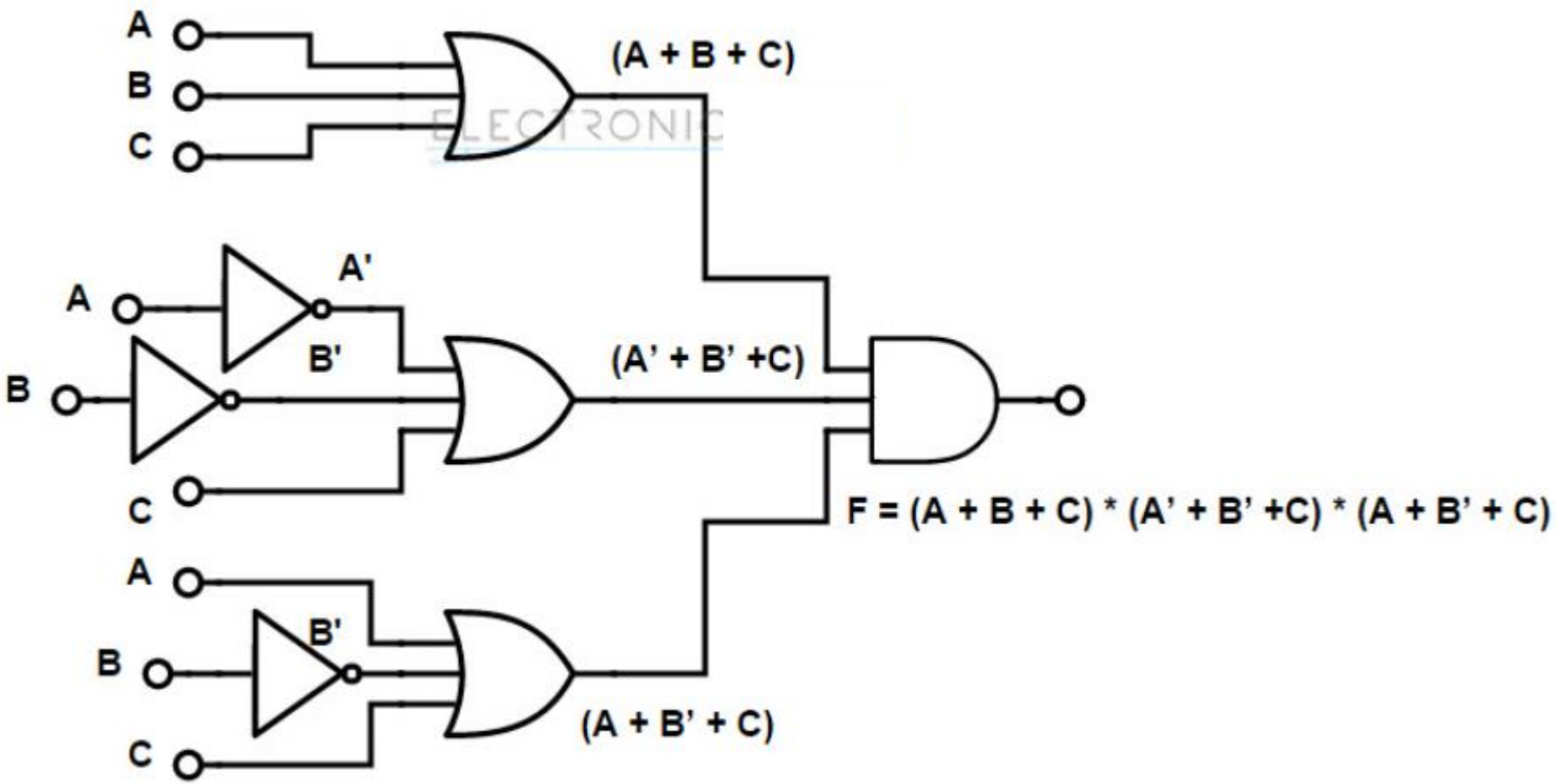
3.3 Boolean Function with Logic Gates

Example.

Implement $(A + B + C)$.

$(\bar{A} + \bar{B} + C)$.

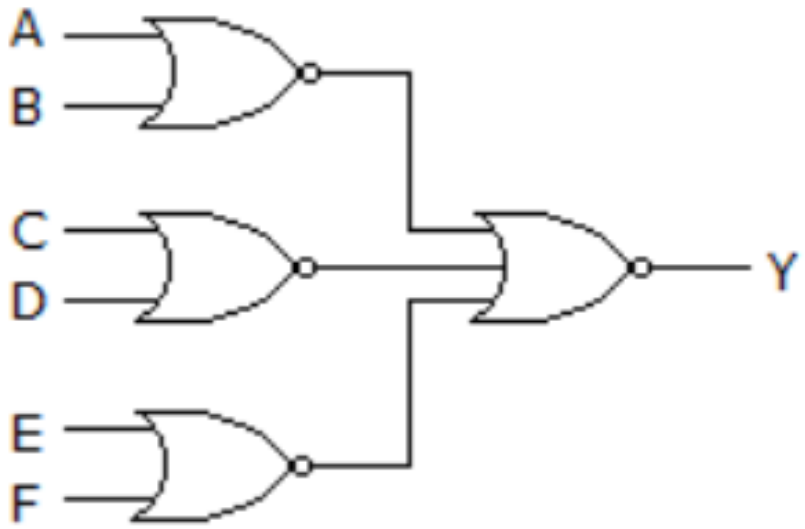
$(A + \bar{B} + C)$ using logic gate



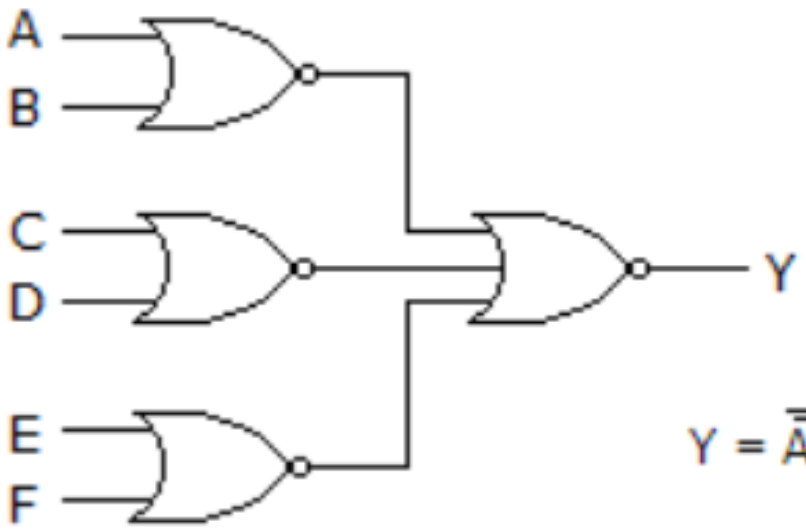
3.3 Boolean Function with Logic Gates

Example.

Find the Boolean equation of the following logic circuit



3.3 Boolean Function with Logic Gates

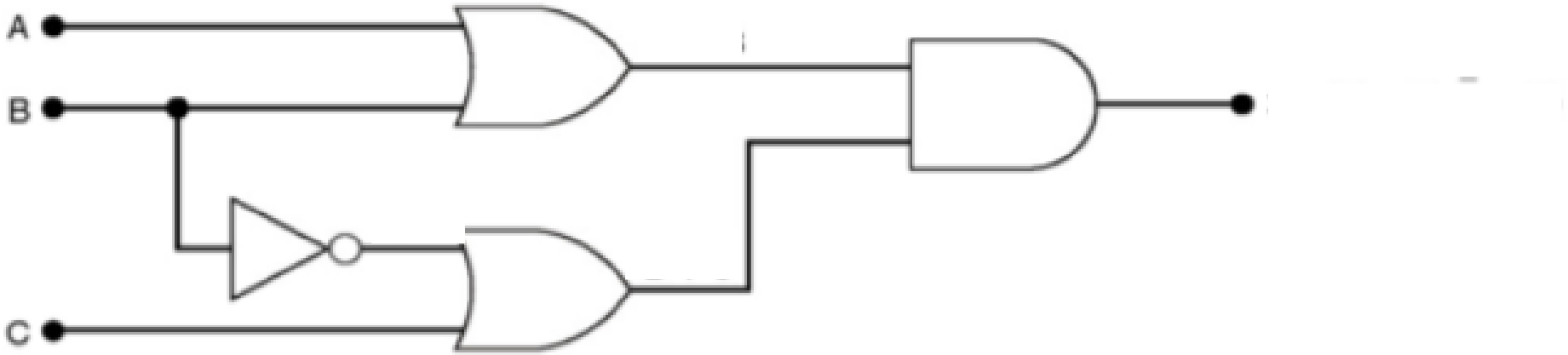


$$Y = \overline{\overline{A} + B + \overline{C} + D + \overline{E} + F} = (A + B)(C + D)(E + F).$$

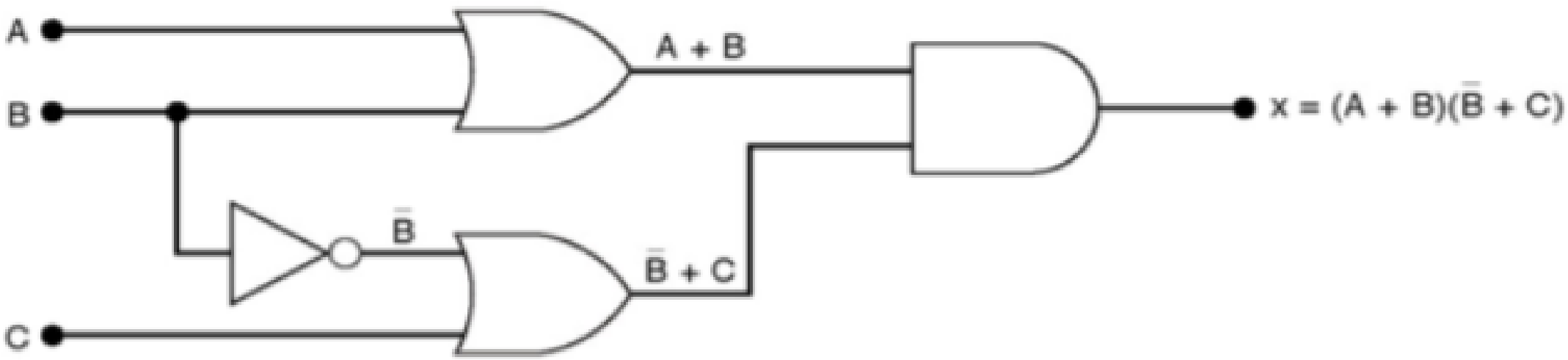
3.3 Boolean Function with Logic Gates

Example.

Find the Boolean equation of the following logic circuit



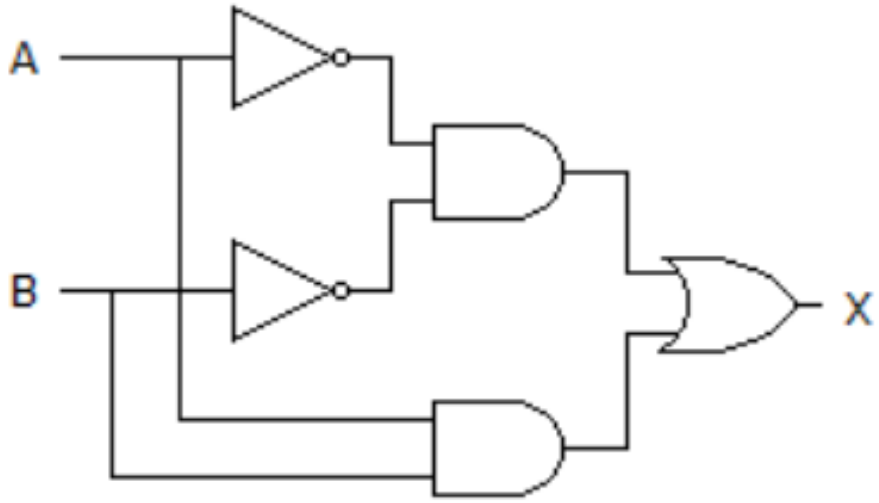
3.3 Boolean Function with Logic Gates



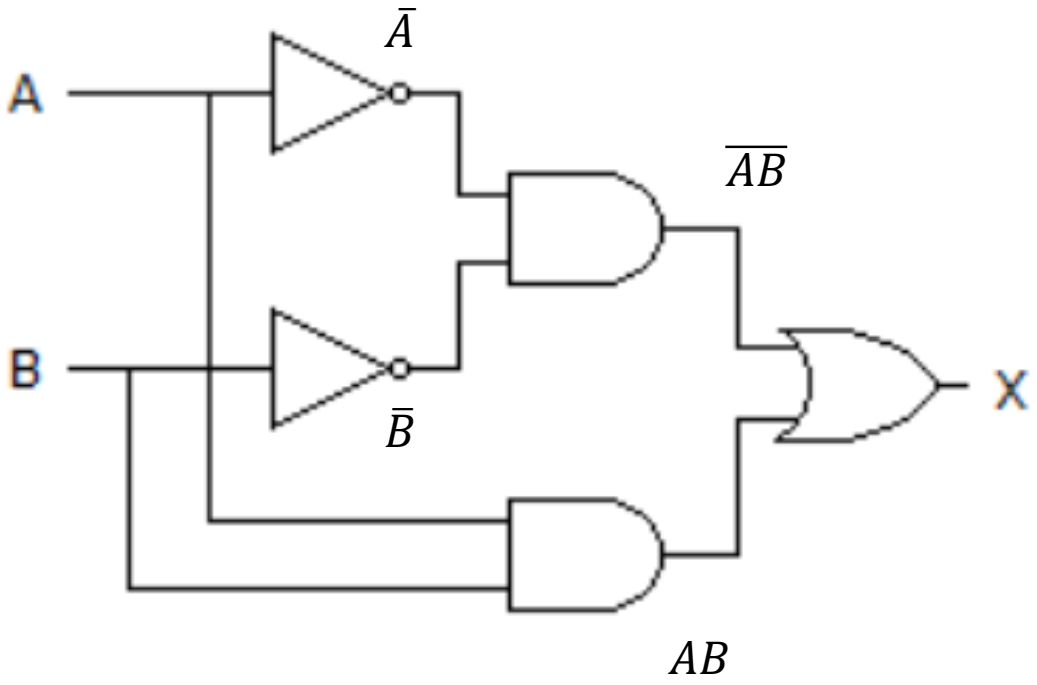
3.3 Boolean Function with Logic Gates

Example.

Find the logic expression for the logic circuit below



3.3 Boolean Function with Logic Gates

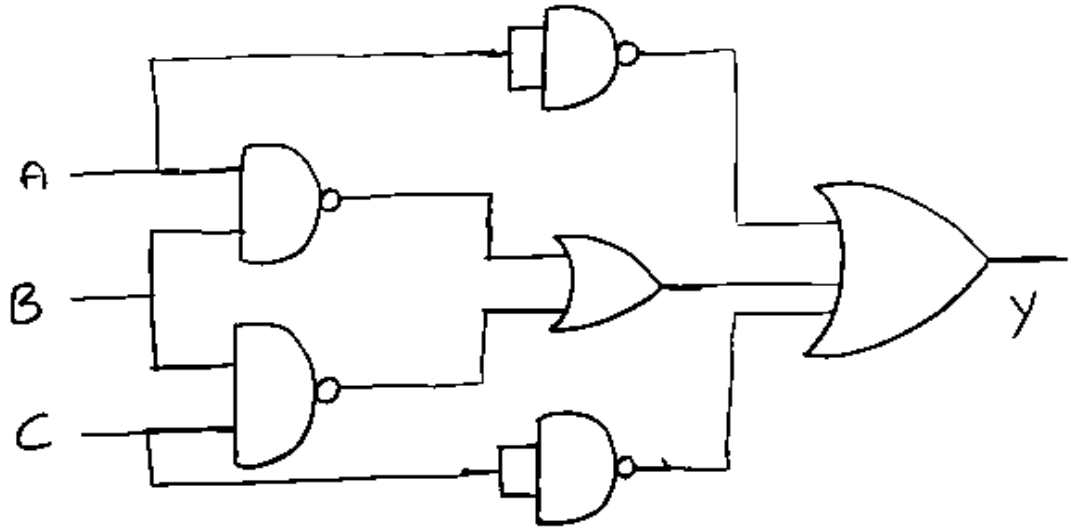


$$X = \overline{AB} + AB$$

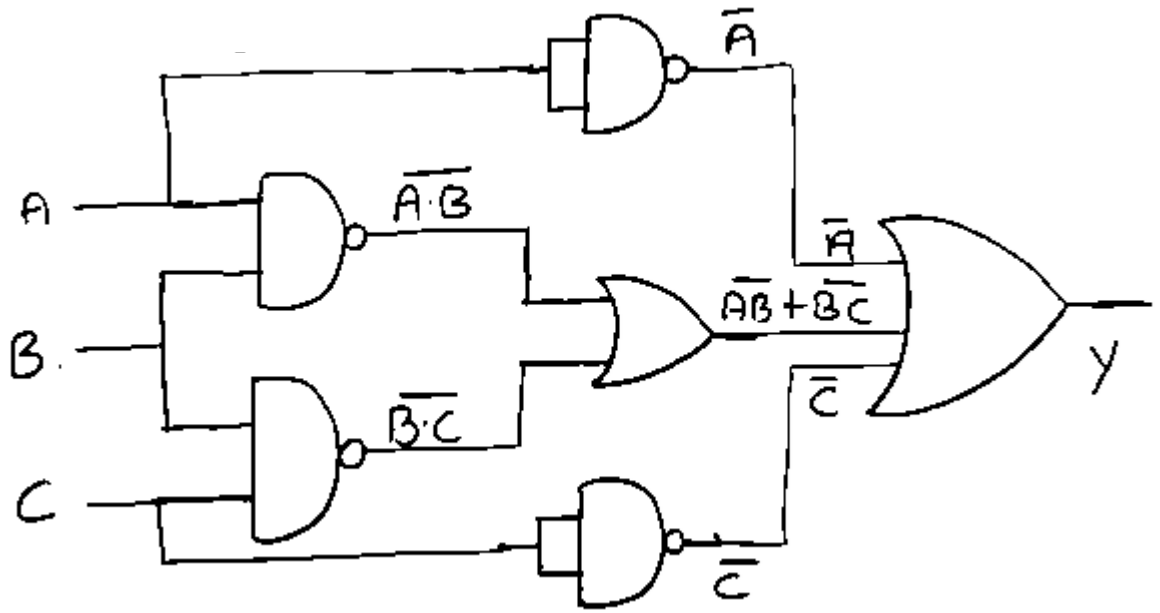
3.3 Boolean Function with Logic Gates

Example.

Find the output for the logic circuit below.



3.3 Boolean Function with Logic Gates



3.3 Boolean Function with Logic Gates

The output is

$$Y = \bar{A} + \overline{AB} + \overline{BC} + \bar{C}$$
$$= \bar{A} + \bar{A} + \bar{B} + \bar{B} + \bar{C} + \bar{C}$$
$$= \bar{A} + \bar{B} + \bar{C}$$

References

M. Morris Mano, Digital Design, 5th ed, Prentice Hall, 2012, **Chapter 2**

Next Topic : K-MAP