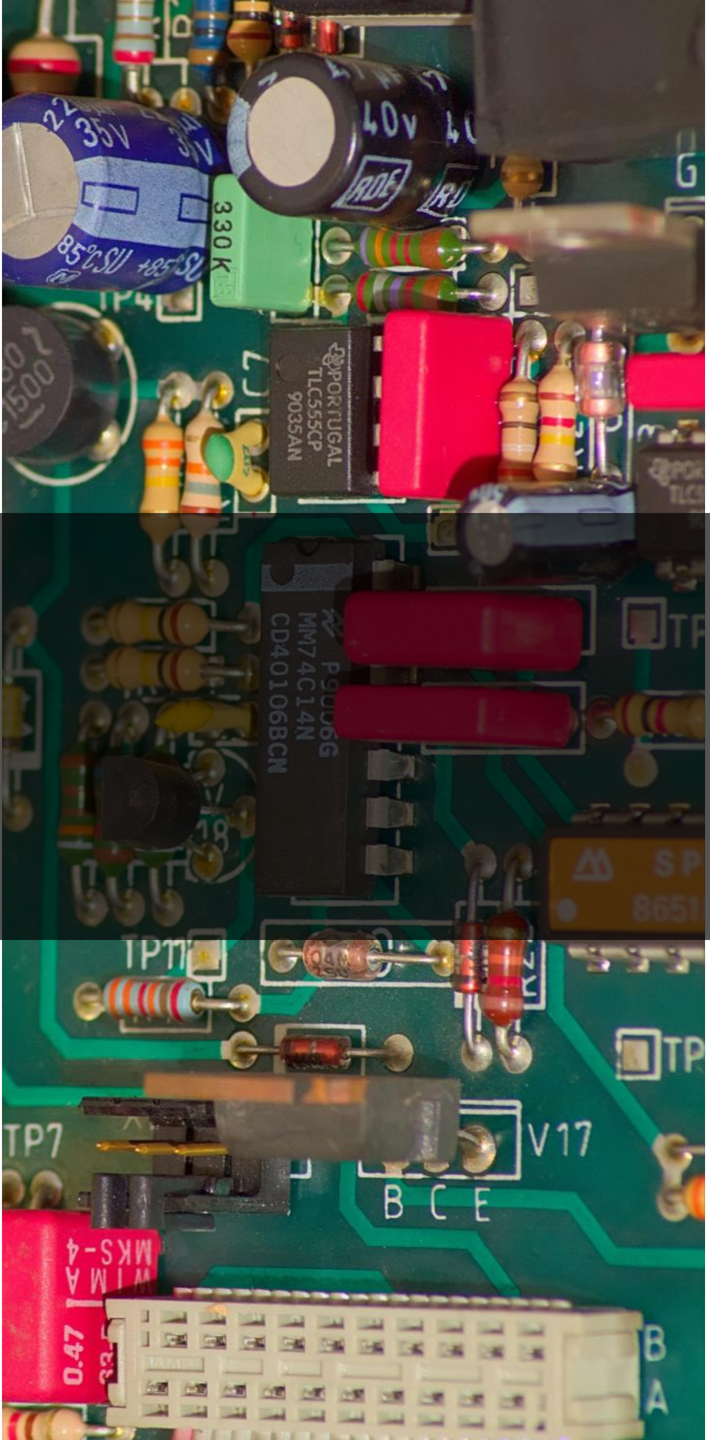


University of Al Maarif

Department of Medical Instruments Techniques Engineering

Class: 2nd

Digital Electronics

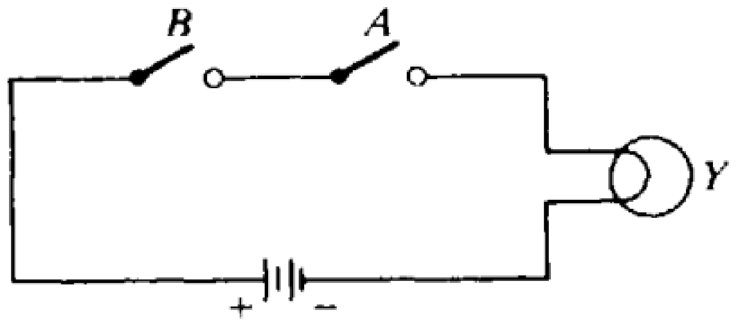
MIET2203

Lecture 3: Logic gates

Lecturer: Mohammed Jabal

2024 - 2025

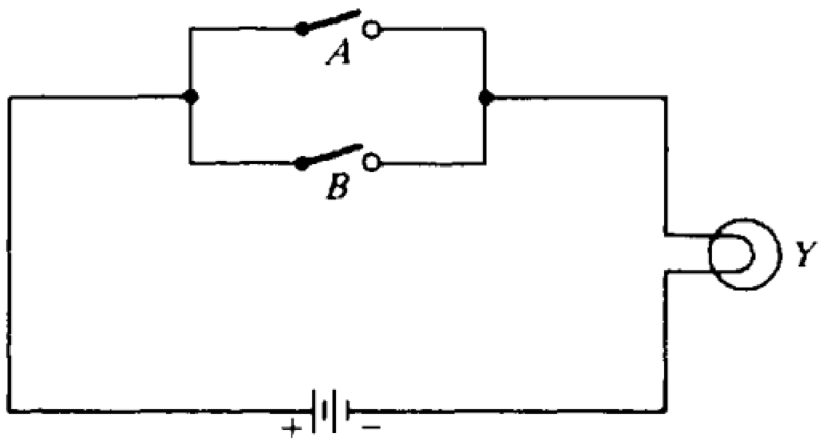
Objective



(a) AND circuit using switches

Input switches		Output light
B	A	Y
open	open	no
open	closed	no
closed	open	no
closed	closed	yes

(b) Truth table



(a) OR circuit using switches

Input switches		Output light
B	A	Y
open	open	no
open	closed	yes
closed	open	yes
closed	closed	yes

(b) Truth table

1. AND gate

- The **AND** gate is an electronic circuit that gives a **high** output (1) only if **all its inputs are high**. A dot **(.)** is used to show the AND operation i.e. (A.B). Bear in mind that this dot is sometimes omitted i.e. AB

$$X = (A.B)$$

- $N = 2^n$

where N is the number of possible input combinations and n is the number of input variables. To illustrate,

For two input variables: N = 2^2 = 4 combinations

For three input variables: N = 2^3 = 8 combinations

Truth table for a 2-input AND gate.

Inputs		Output
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

1 = HIGH, 0 = LOW

1. AND gate

EXAMPLE 3–2

TABLE 3–3

Inputs			Output
A	*B*	*C*	*X*
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

(a) Develop the truth table for a 3-input AND gate.

(b) Determine the total number of possible input combinations for a 4-input AND gate.

Solution

(a) There are eight possible input combinations ($2^3 = 8$) for a 3-input AND gate. The input side of the truth table (Table 3–3) shows all eight combinations of three bits. The output side is all 0s except when all three input bits are 1s.

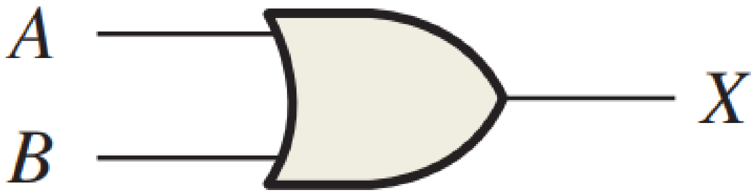
(b) $N = 2^4 = \mathbf{16}$. There are 16 possible combinations of input bits for a 4-input AND gate.

Related Problem

Develop the truth table for a 4-input AND gate.

2. OR gate

- The **OR** gate is an electronic circuit that gives a **high** output (1) if **one or more of its inputs are high**. A plus (+) is used to show the OR operation.



$$X = (A + B)$$

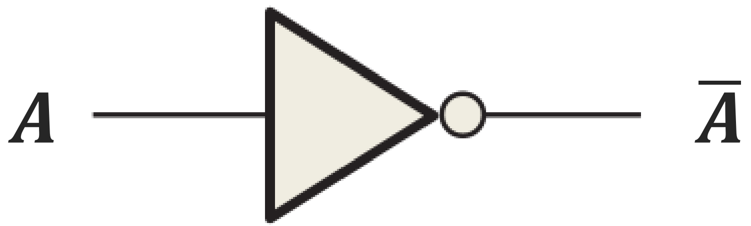
Truth table for a 2-input OR gate.

Inputs		Output
A	*B*	*X*
0	0	0
0	1	1
1	0	1
1	1	1

1 = HIGH, 0 = LOW

3. NOT gate

- The **NOT** gate is an electronic circuit that produces an **inverted version** of the input at its output. It is also known as an **inverter**. If the input variable is A, the inverted output is known as **NOT A**. This is also shown as **A'**, or **A with a bar** over the top.

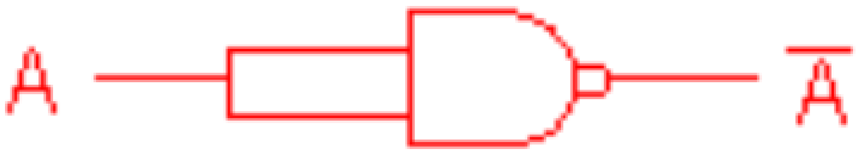


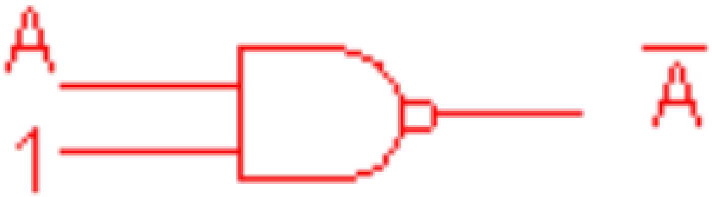
Inverter truth table.

Input	Output
LOW (0)	HIGH (1)
HIGH (1)	LOW (0)

3. NOT gate

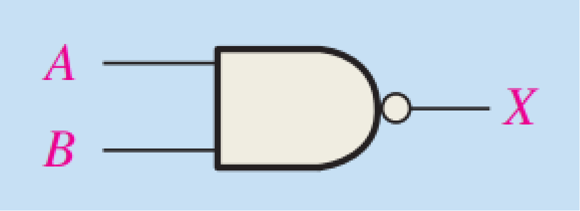
- The diagrams below show two ways that the **NAND** logic gate can be configured to produce a **NOT** gate. It can also be done using **NOR** logic gates in the same way.

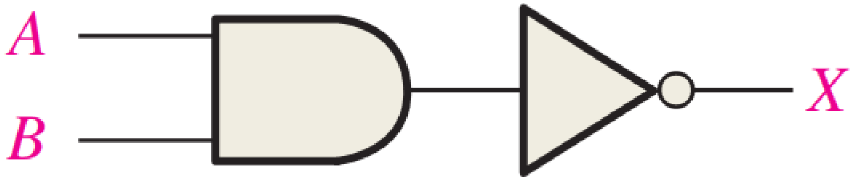




4. NAND gate

- This is a **NOT-AND** gate which is equal to an **AND** gate followed by a **NOT** gate. The outputs of all **NAND** gates are **high** if any **of the inputs are low**. The symbol is an AND gate with a small circle on the output. The small circle represents inversion.





$$X = (\overline{A.B})$$

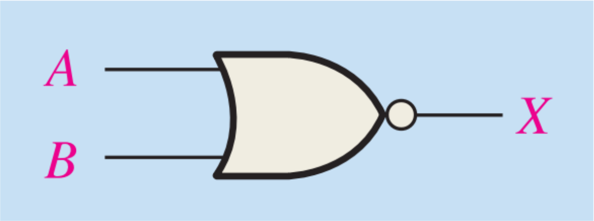
Truth table for a 2-input NAND gate.

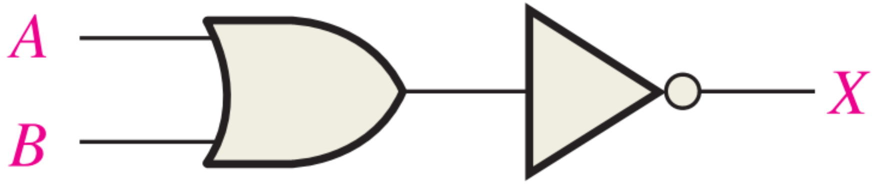
Inputs		Output
A	**B**	**X**
0	0	1
0	1	1
1	0	1
1	1	0

1 = HIGH, 0 = LOW.

5. NOR gate

• This is a **NOT-OR** gate which is equal to an **OR** gate followed by a **NOT** gate. The outputs of all **NOR** gates are **low** if any of the inputs are **high**. The symbol is an **OR** gate with a small circle on the output. The small circle represents inversion.





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

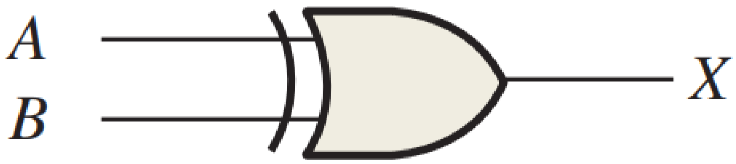
Truth table for a 2-input NOR gate.

Inputs		Output
A	*B*	*X*
0	0	1
0	1	0
1	0	0
1	1	0

1 = HIGH, 0 = LOW.

6. EX-OR gate

- The **'Exclusive-OR'** gate is a circuit which will give a **high** output if either, but not both, **of its two inputs are high**. An encircled plus sign ⊕ is used to show the EX-OR operation.



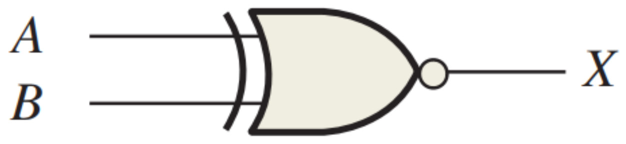
$$X = (A \oplus B)$$

Truth table for an exclusive-OR gate.

Inputs		Output
A	*B*	*X*
0	0	0
0	1	1
1	0	1
1	1	0

7. EX-NOR gate

• The **'Exclusive-NOR'** gate circuit does the opposite to the **Ex-OR** gate. It will give a **low** output if either, but not both, of its two inputs are **high**. The symbol is an EXOR gate with a small circle on the output. The small circle represents inversion.



$$X = \overline{(A \oplus B)}$$

Truth table for an exclusive-NOR gate.

Inputs		Output
A	*B*	*X*
0	0	1
0	1	0
1	0	0
1	1	1

Timing diagram

- A **timing diagram** is basically a **graph** that **accurately** displays the relationship of two or more waveforms with **respect** to each other on a **time basis**.

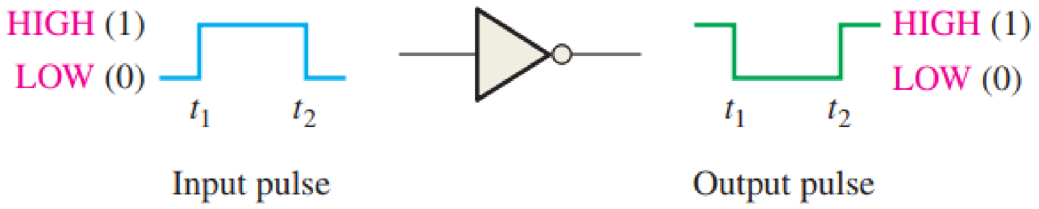


FIGURE 3–2 Inverter operation with a pulse input.

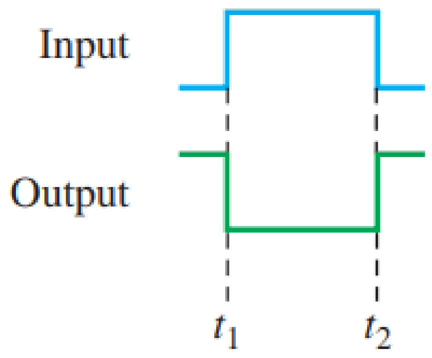


FIGURE 3–3 Timing diagram for the case in Figure 3–2.

Timing diagram

EXAMPLE 3–3

If two waveforms, *A* and *B*, are applied to the AND gate inputs as in Figure 3–11, what is the resulting output waveform?

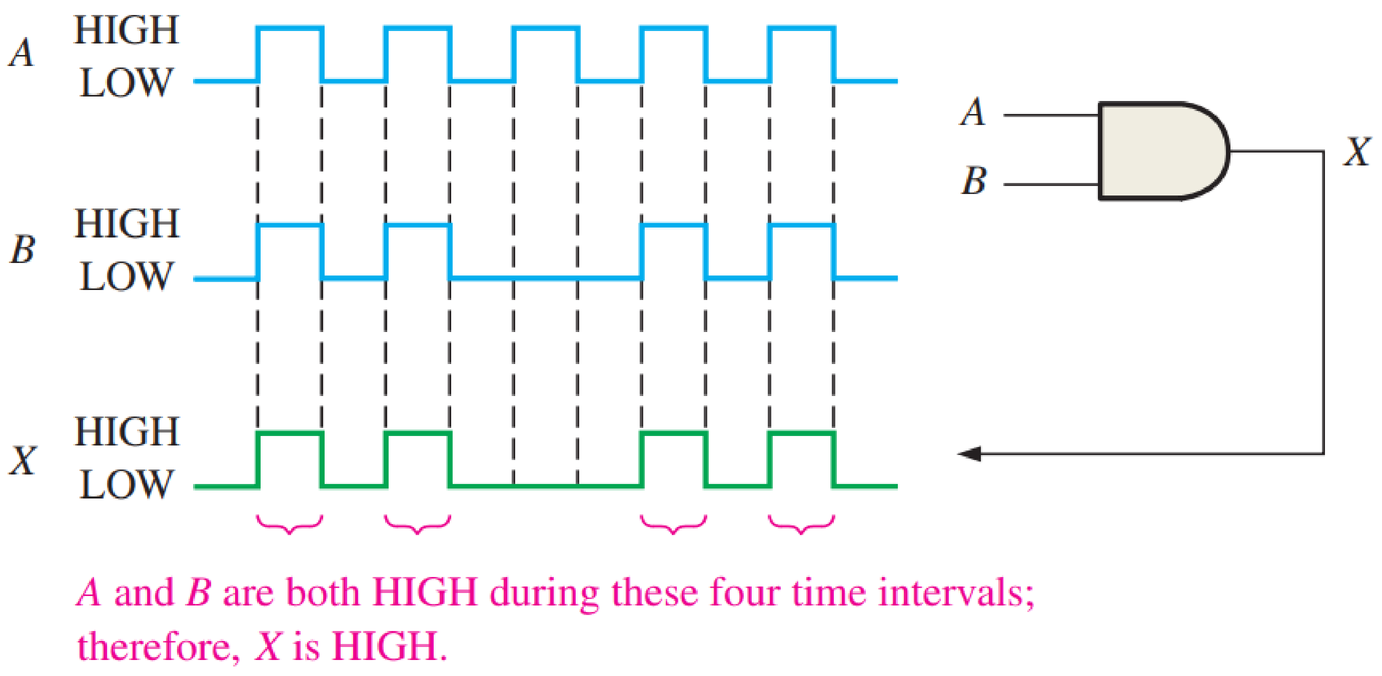


FIGURE 3–11

Timing diagram

EXAMPLE 3–7

If the two input waveforms, *A* and *B*, in Figure 3–21 are applied to the OR gate, what is the resulting output waveform?

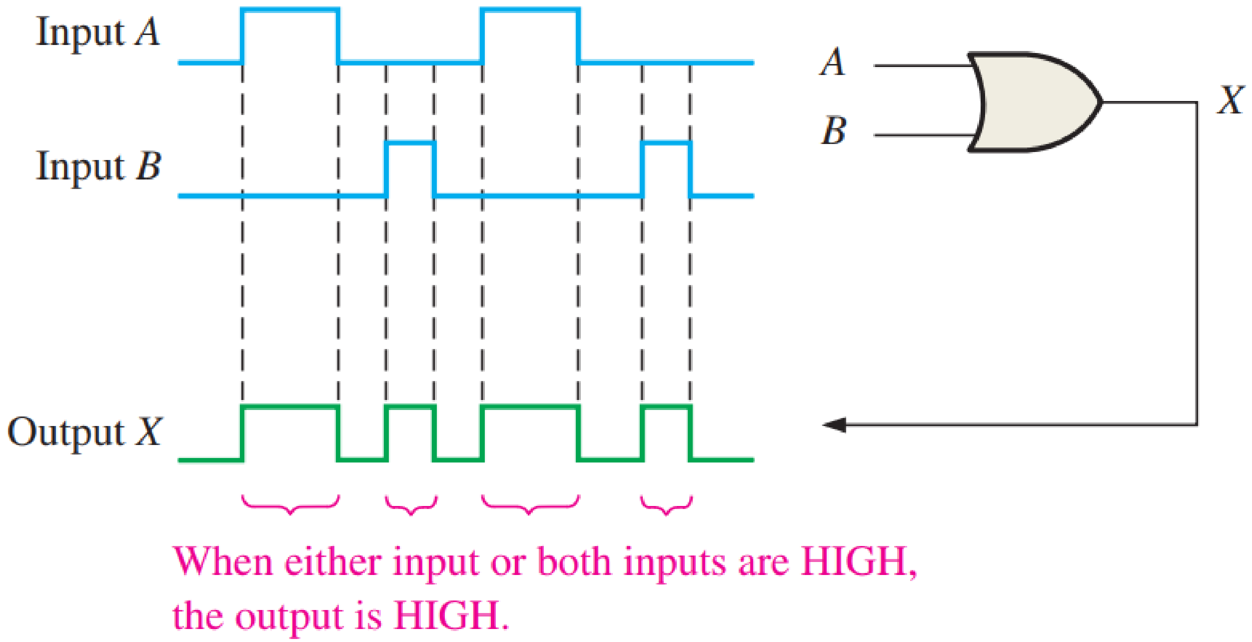


FIGURE 3–21

Timing diagram

EXAMPLE 3–11

Show the output waveform for the 3-input NAND gate in Figure 3–29 with its proper time relationship to the inputs.

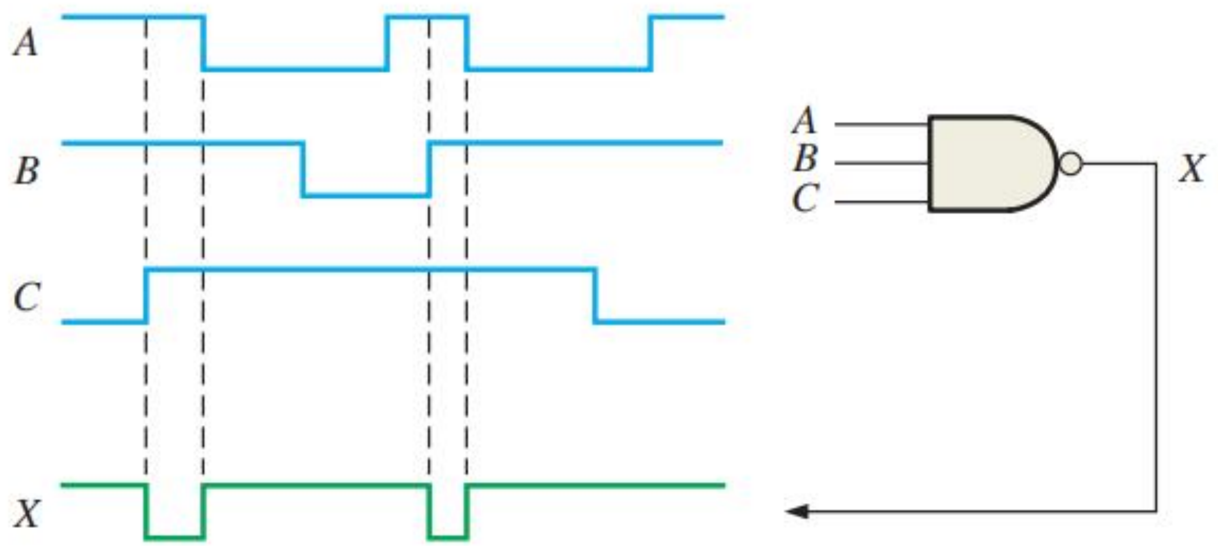
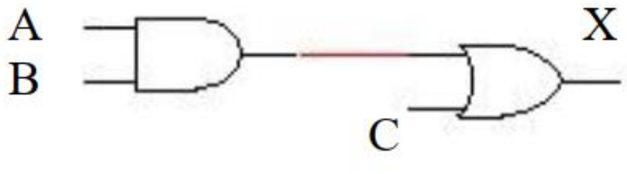


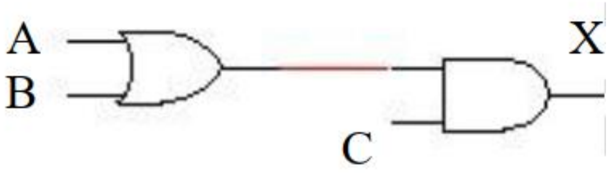
FIGURE 3–29

Describing logic circuits algebraically

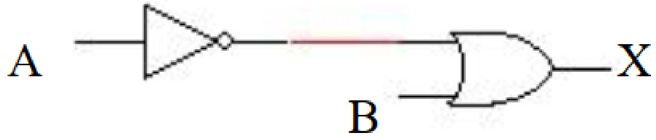
- Any logic circuit, no matter how complex, may be completely described using the Boolean operations previously defined. Determine the output expression for the logic shown below :-



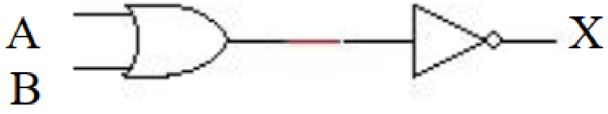
X=A.B+C



X=(A+B).C



$X = \bar{A} + B$



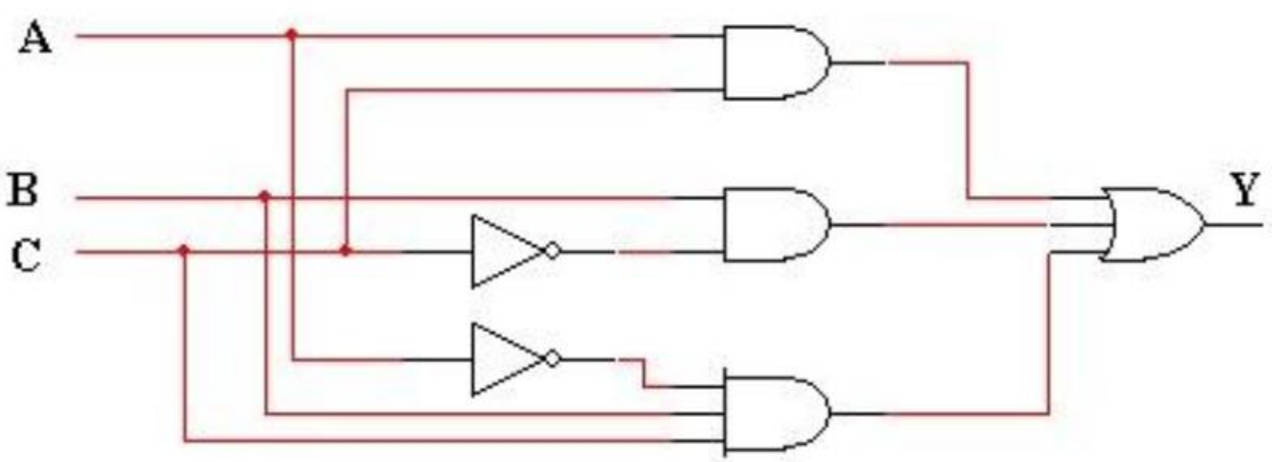
$X = \overline{A + B}$

Implementing circuits from Boolean expressions

- If the operation of a circuit is defined by a **Boolean** expression, a **logic circuit** can be implemented directly from that **expression**.

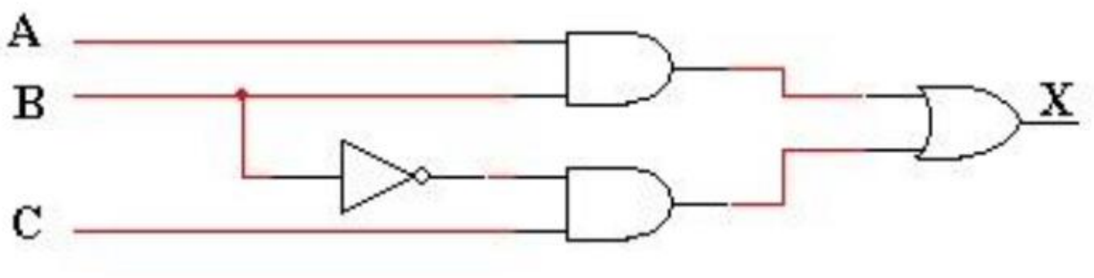
Implement the logic circuits defined by the following Boolean expressions :

a) $Y = AC + B\bar{C} + \bar{A}BC$



Implementing circuits from Boolean expressions

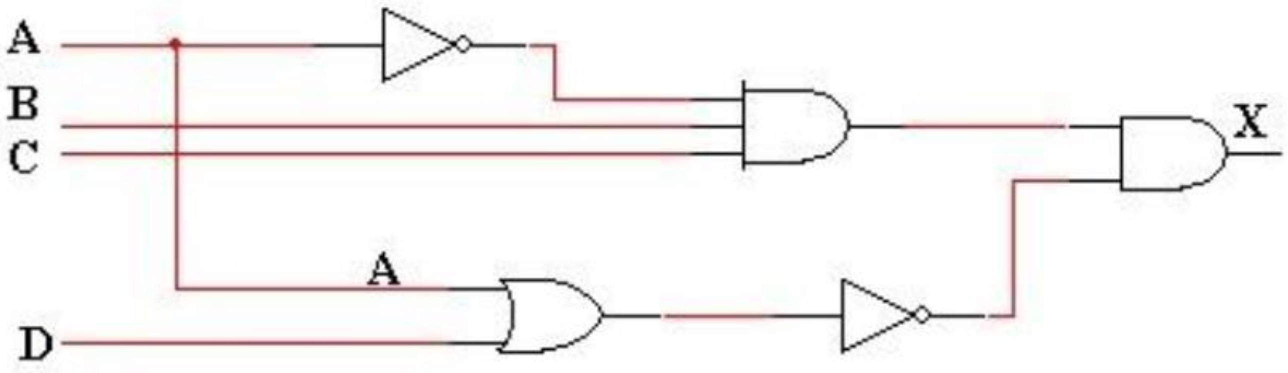
b) $X = AB + \bar{B}C$



Exercise:

a) determine the output expression for the following circuit

b) determine the output logic level if A=1, B=0 and C=1, D=1



References

[1] Digital fundamentals / Thomas L. Floyd. —Eleventh edition.

[2]