AND GATE

1. The AND gate is a logic circuit that has two or more inputs and a single output.

2. If any of the inputs are 0s, the output is 0.

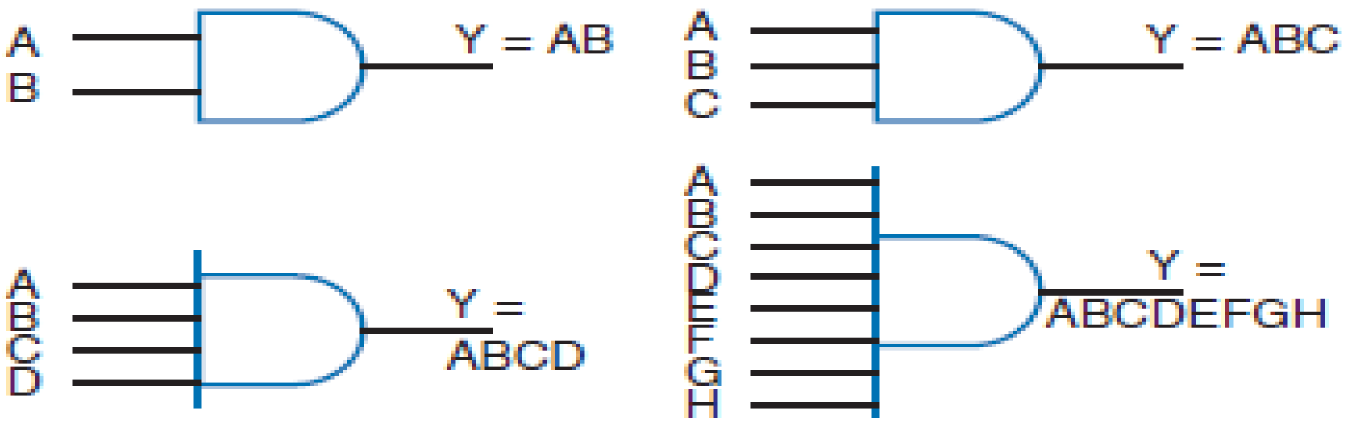
FIGURE 33–2

Truth table for a two-input AND gate.

INPUTS		OUTPUT
A	B	Y
0	0	0
1	0	0
0	1	0
1	1	1

FIGURE 33–1

Logic symbol for an AND gate.



$$Y = A \cdot B \text{ or } Y = AB.$$

OR GATE

1. An OR gate produces a 1 output if any of its inputs are 1s. The output is a 0 if all the inputs are 0s.

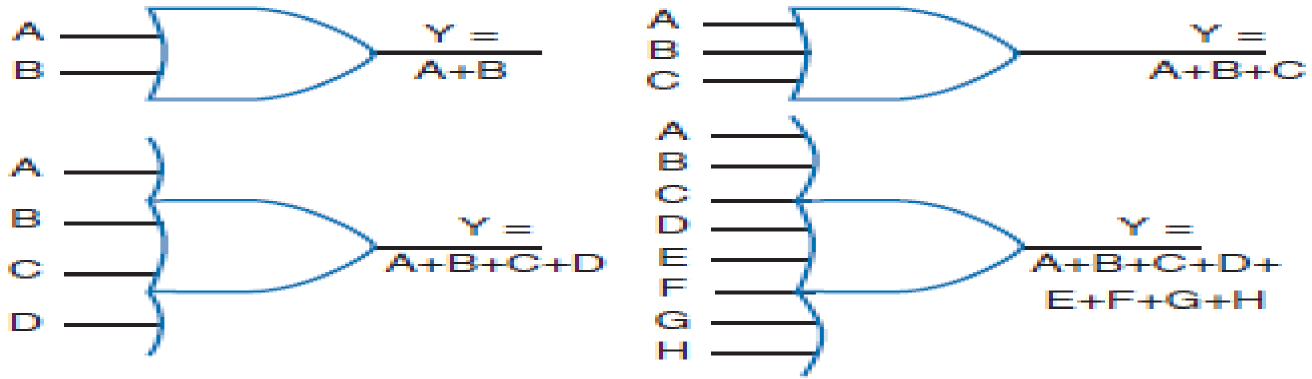
$$Y = A + B.$$

FIGURE 33–3

Truth table for a two-input OR gate.

INPUTS		OUTPUT
A	B	Y
0	0	0
1	0	1
0	1	1
1	1	1

FIGURE 33–4
Logic symbol for an OR gate.



NOT GATE

1. The simplest logic circuit is the NOT gate.
2. It performs the function called inversion, or complementation, and is commonly referred to as an Inverter.

FIGURE 33–6

Logic symbol for an inverter.

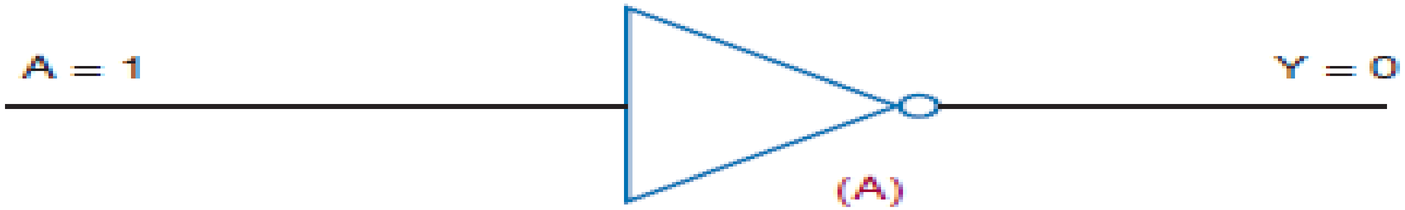


FIGURE 33–5

Truth table for an inverter.

INPUTS	OUTPUT
A	Y
0	1
1	0

- The input to an inverter is labeled A and the output is labeled $\overline{A}$ (read “A NOT” or “NOT A”).

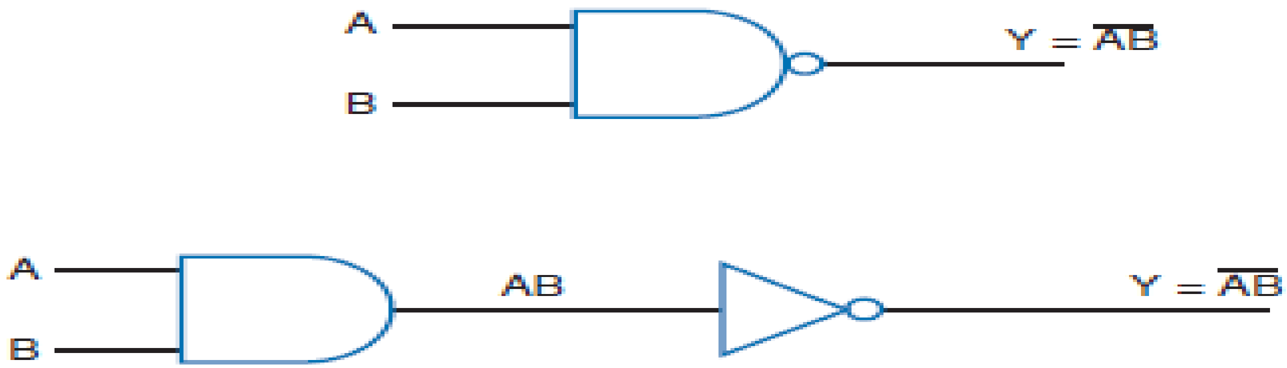
- The bar over the letter A indicates the complement of A.

NAND GATE

1. A NAND gate is a combination of an inverter and an AND gate.

FIGURE 33–7

Logic symbol for an NAND gate.



- The algebraic formula for NAND-gate output i $Y = \overline{AB}$,

FIGURE 33–8

Truth table for a two-input NAND gate.

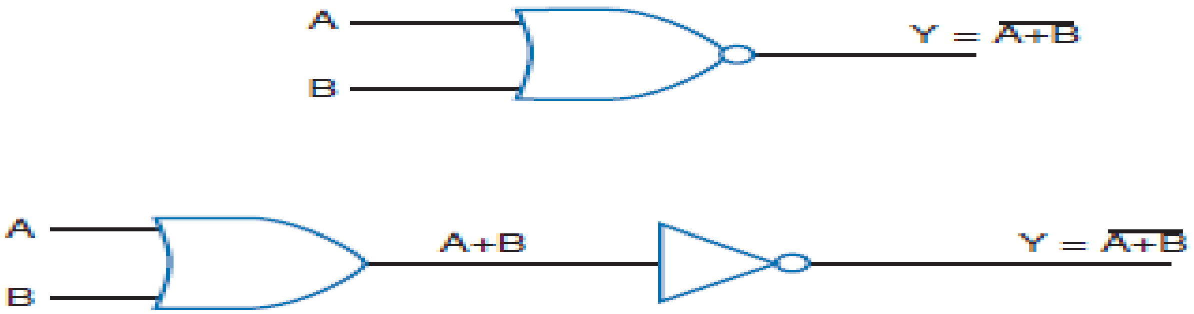
INPUTS		OUTPUT
A	B	Y
0	0	1
1	0	1
0	1	1
1	1	0

NOR GATE

1. A **NOR gate is a combination of an inverter and an** OR gate. Its name derives from its NOT-OR function.

2. Also shown is its equivalency to an OR gate and an inverter.

FIGURE 33–10
Logic symbol for a NOR gate.



- The algebraic expression for NOR-gate output is

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

A	B	out
0	0	1
0	1	0
1	0	0
1	1	0

EXCLUSIVE -OR

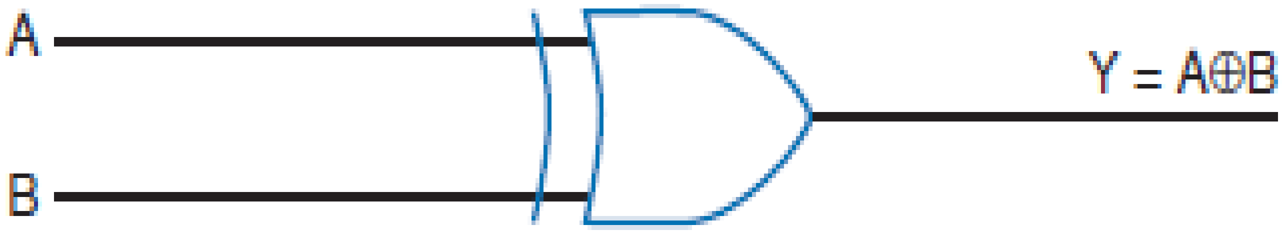
- The XOR gate is a digital logic gate that implements an exclusive or; that is, a true output (1/HIGH) results if one, and only one, of the inputs to the gate is true.

- The algebraic output is written as

$$Y = A \oplus B.$$

FIGURE 33–12

Logic symbol for an exclusive OR gate.

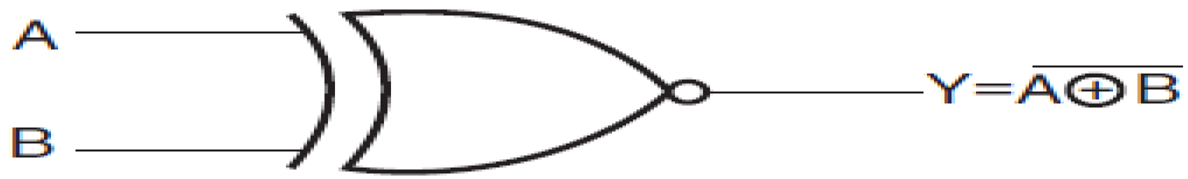


A	B	A **XOR** B
0	0	0
0	1	1
1	0	1
1	1	0

1. The complement of the XOR gate is the XNOR (**exclusive NOR) gate.**

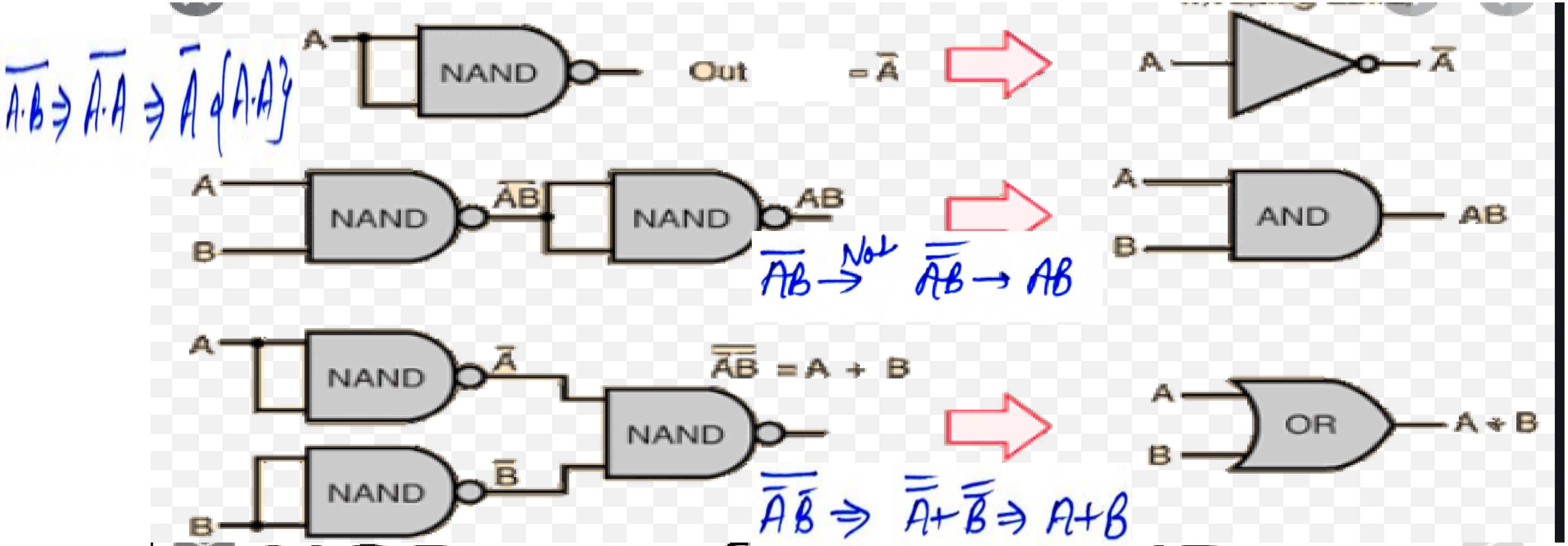
2. **Its symbol is shown in** Figure 33–14.

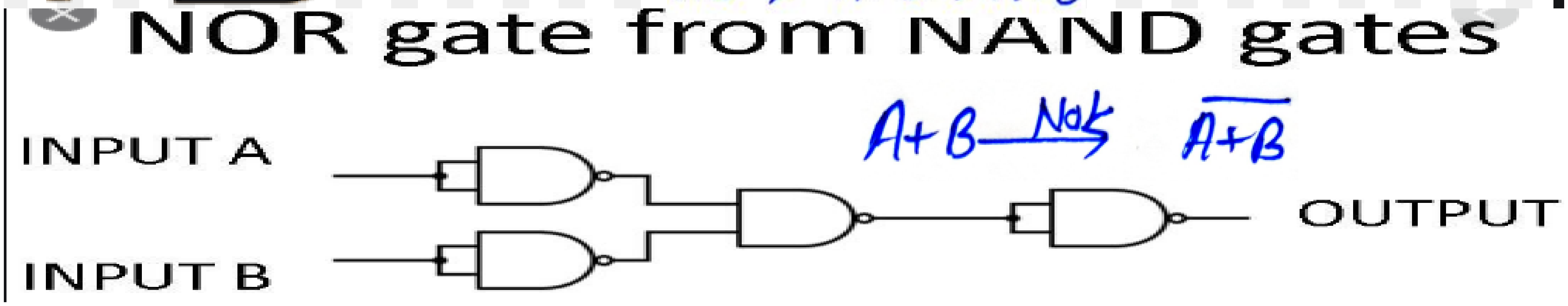
3. The algebraic output is written as $Y = \overline{A \oplus B}$, read as "Y equals A exclusive nor B."



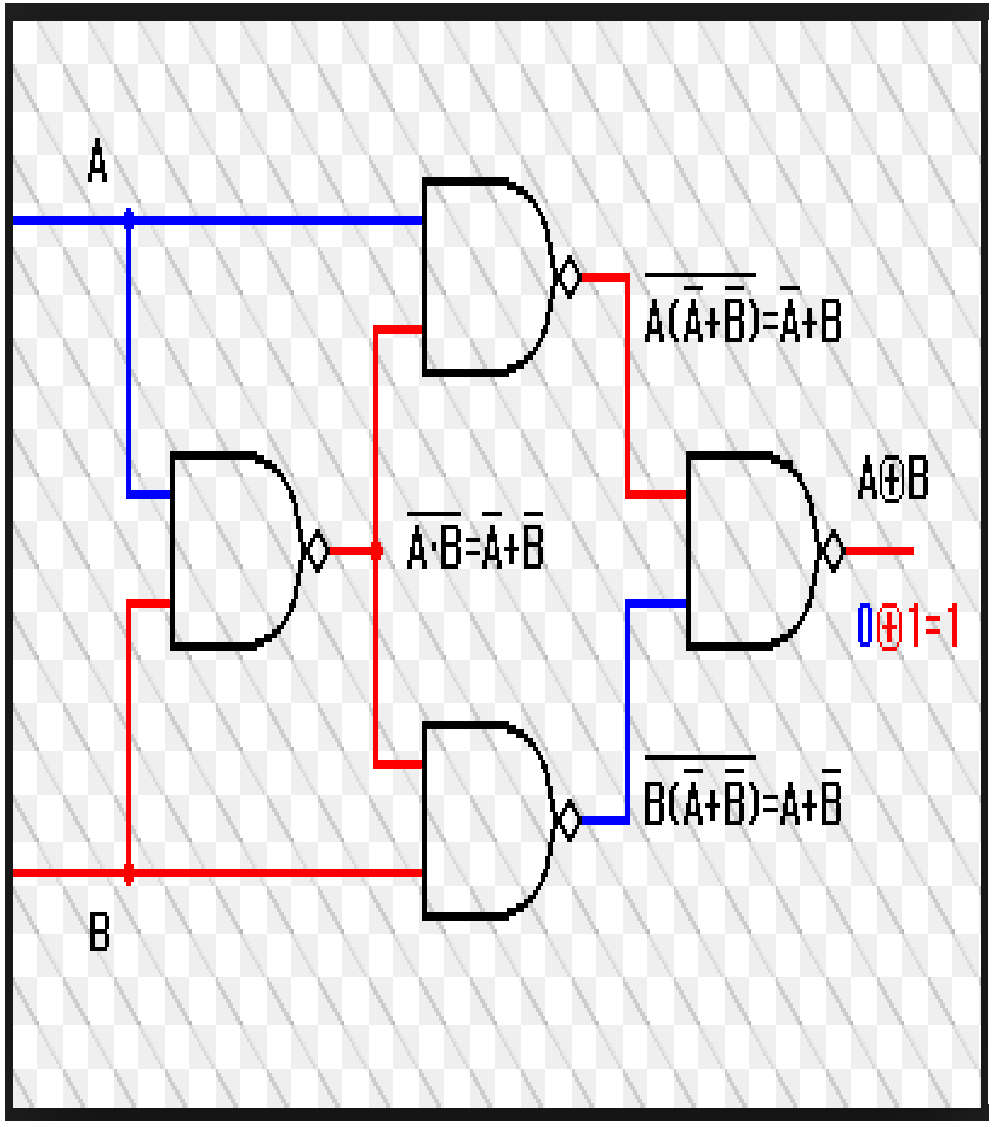
Law/Theorem	Law of Addition	Law of Multiplication
Identity Law	$x + 0 = x$	$x \cdot 1 = x$
Complement Law	$x + x' = 1$	$x \cdot x' = 0$
Idempotent Law	$x + x = x$	$x \cdot x = x$
Dominant Law	$x + 1 = 1$	$x \cdot 0 = 0$
Involution Law	$(x')' = x$	
Commutative Law	$x + y = y + x$	$x \cdot y = y \cdot x$
Associative Law	$x+(y+z) = (x+y)+z$	$x \cdot (y \cdot z) = (x \cdot y) \cdot z$
Distributive Law	$x \cdot (y+z) = x \cdot y+x \cdot z$	$x+y \cdot z = (x+y) \cdot (x+z)$
Demorgan's Law	$(x+y)' = x' \cdot y'$	$(x \cdot y)' = x' + y'$
Absorption Law	$x + (x \cdot y) = x$	$x \cdot (x + y) = x$

NAND AS A UNIVERSAL GATE





EXOR USING NAND



① $\overline{A\cdot B} = \bar{A}+\bar{B}$ { Demorgan's Law }

② $\overline{A(\bar{A}+\bar{B})} = \overline{A\cdot\bar{A} + A\cdot\bar{B}} \Rightarrow \overline{0+A\cdot\bar{B}} \Rightarrow \overline{A\cdot\bar{B}} \Rightarrow \bar{A}+B$

{ $A\cdot\bar{A} = 0$
$0 + A\bar{B} = A\bar{B}$ }

{ $\overline{A\cdot\bar{B}} = \bar{A}+\bar{\bar{B}} \Rightarrow \bar{A}+B$ }

$\overline{(\bar{A}+B)\cdot(A+\bar{B})} \Rightarrow \overline{(\bar{A}+B)}+\overline{(A+\bar{B})}$

$\Rightarrow \bar{\bar{A}}\cdot\bar{B} + \bar{A}\cdot\bar{\bar{B}}$

$\Rightarrow A\bar{B}+\bar{A}B$

$\Downarrow$

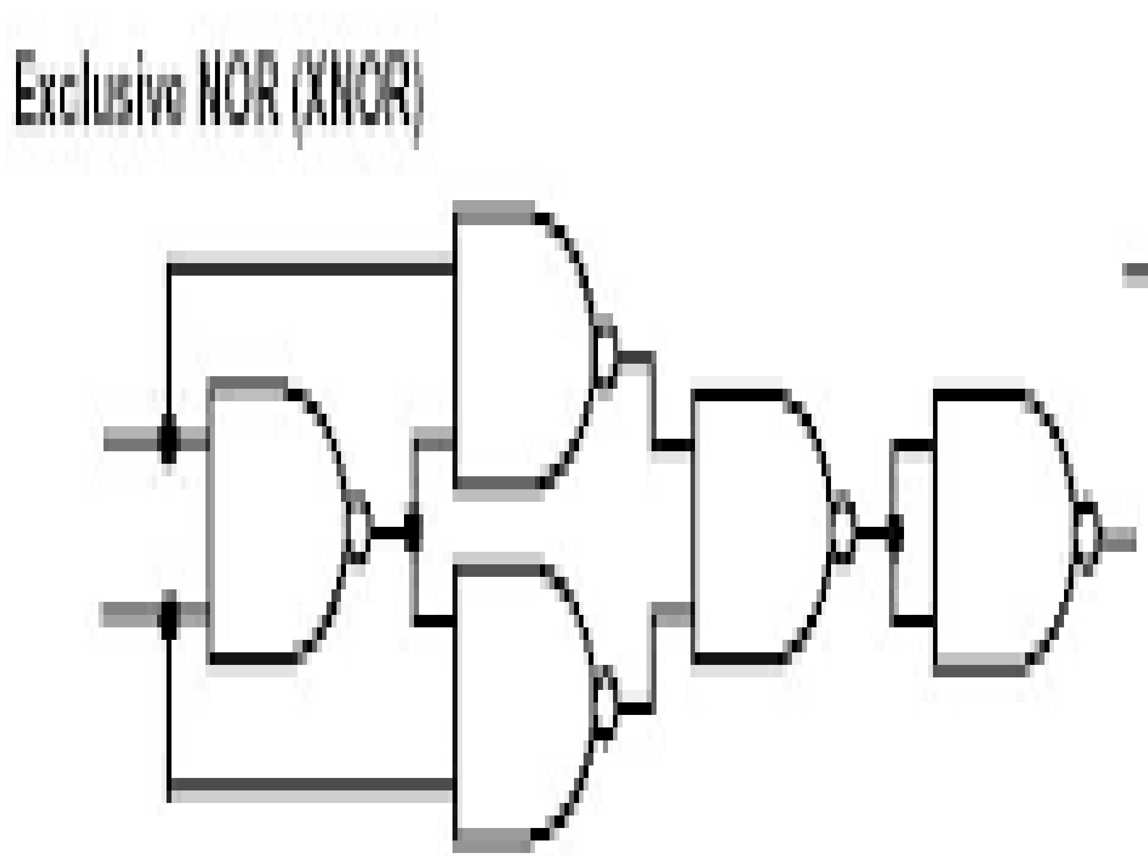
ExOR gate

③ $\overline{B(\bar{A}+\bar{B})} \Rightarrow \overline{\bar{A}\cdot B+\bar{B}\cdot B} \Rightarrow A+\bar{B}$

{ $\bar{B}\cdot B=0$
$\overline{\bar{A}\cdot B+0} \Rightarrow \overline{\bar{A}\cdot B}$ }

{ $\overline{\bar{A}\cdot B} \Rightarrow \bar{\bar{A}}+\bar{B} \Rightarrow A+\bar{B}$ }

Ex-NOR using NAND



Last question we got.

$A\bar{B}+\bar{A}B$ when you apply not gate $\Rightarrow \overline{A\bar{B}+\bar{A}B}$

$\Rightarrow (\overline{A\bar{B}})\cdot(\overline{\bar{A}B})$ { Demorgan theorem $\overline{A\cdot B} \Rightarrow \bar{A}+\bar{B}$ }

$\Rightarrow (\bar{A}+\bar{\bar{B}})(\bar{\bar{A}}+\bar{B})$

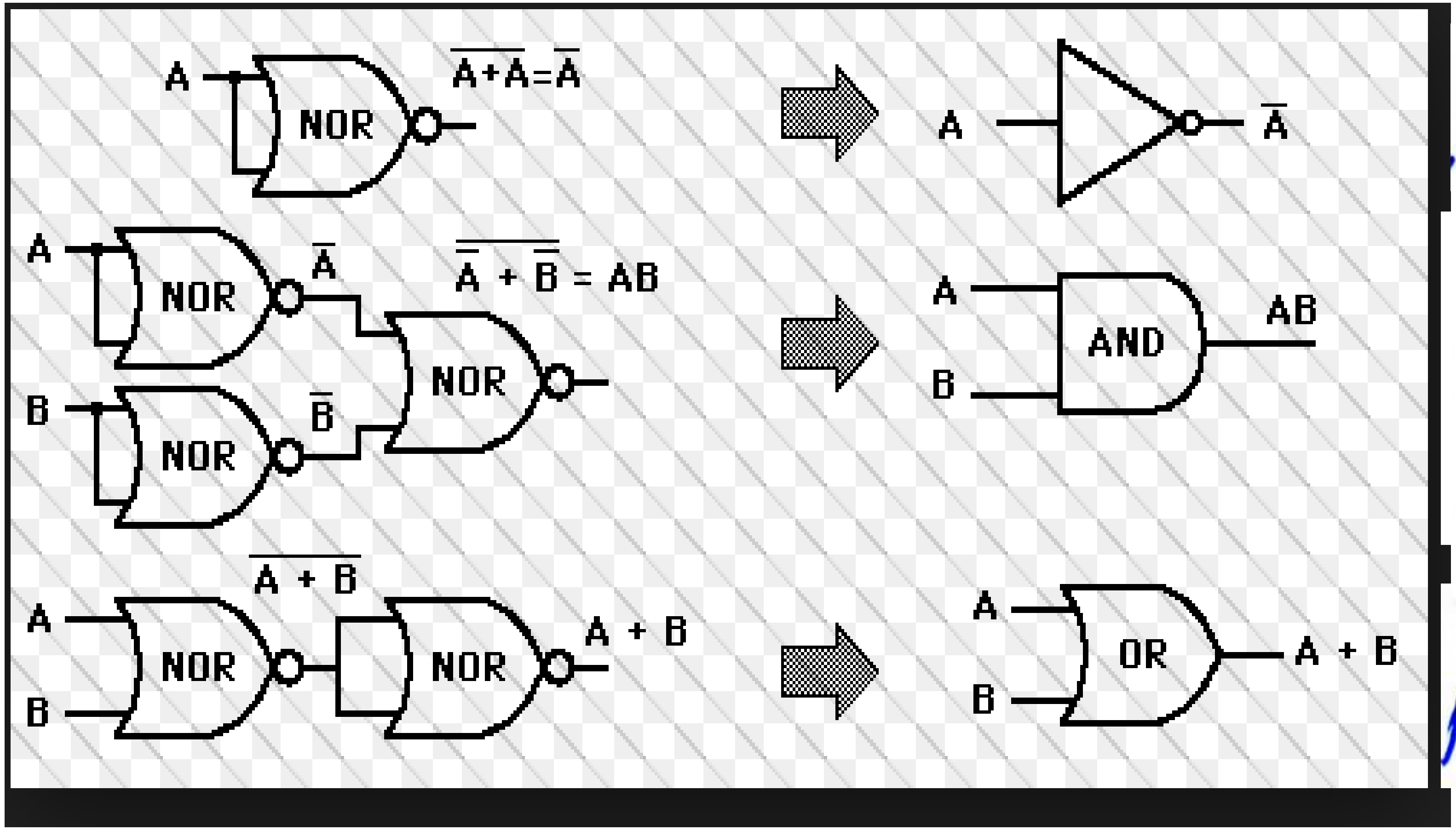
$\Rightarrow (\bar{A}+B)(A+\bar{B}) \Rightarrow \bar{A}A+\bar{A}\bar{B}+AB+B\bar{B}$

{ $x\cdot\bar{x}=0$ }

$\Rightarrow 0+\bar{A}\bar{B}+AB+0$

$\Rightarrow \bar{A}\bar{B}+AB \Rightarrow$ Ex-NOR

NOR AS A UNIVERSAL GATES



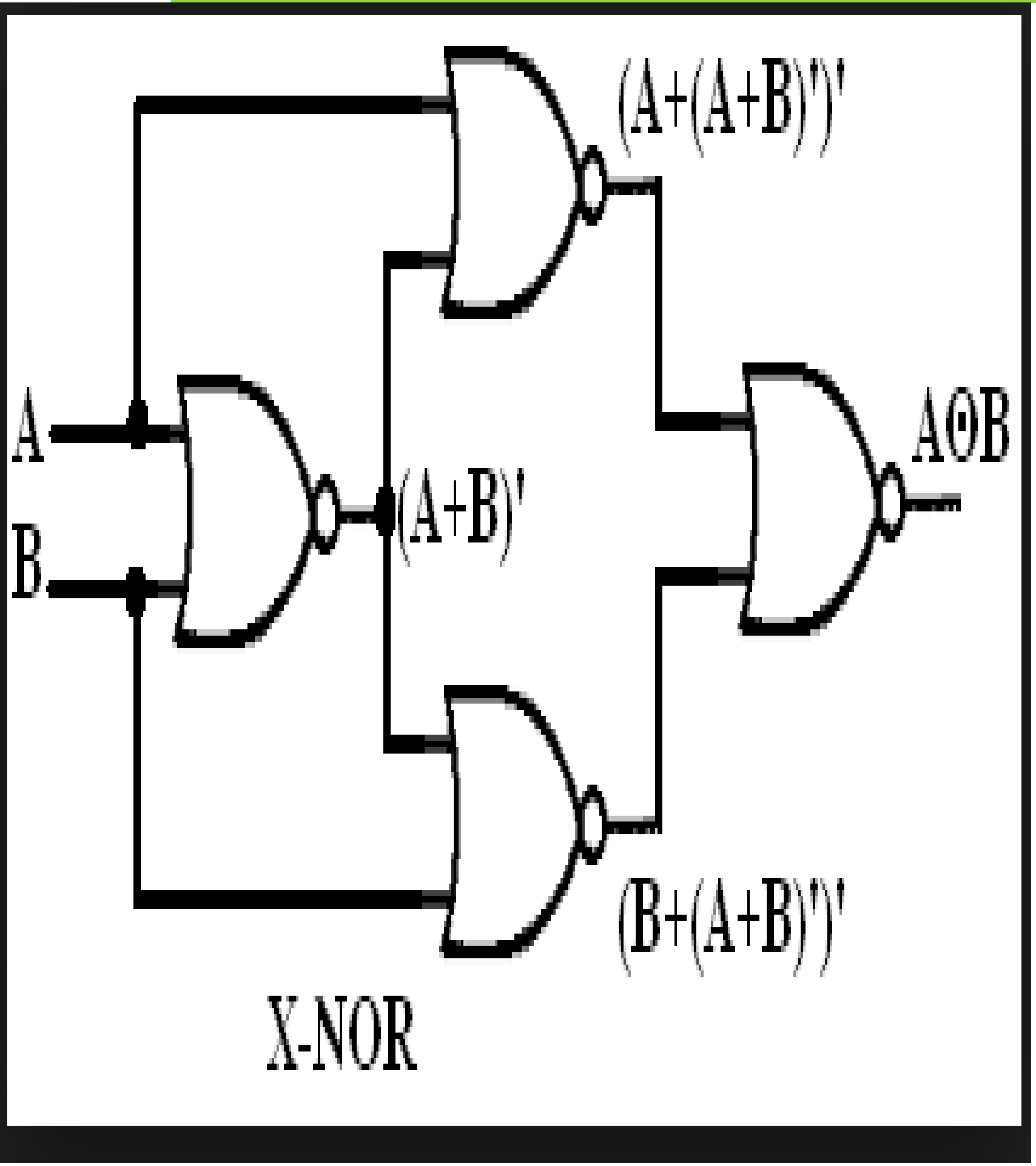
$\overline{A+A} \Rightarrow \bar{A}$ $\{A+A=A\}$

$\overline{\bar{A}+\bar{B}} \Rightarrow \bar{\bar{A}}\cdot\bar{\bar{B}}$ $\{\bar{\bar{A}}=A\}$

$\Rightarrow A\cdot B$

$\overline{A+B} \xRightarrow{NOR} \overline{\overline{A+B}} \Rightarrow A+B$

EX-NOR USING NOR



$$\overline{\overline{A}+\overline{B}} \Rightarrow \overline{\overline{A}}\cdot\overline{\overline{B}} \Rightarrow A\cdot B$$

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

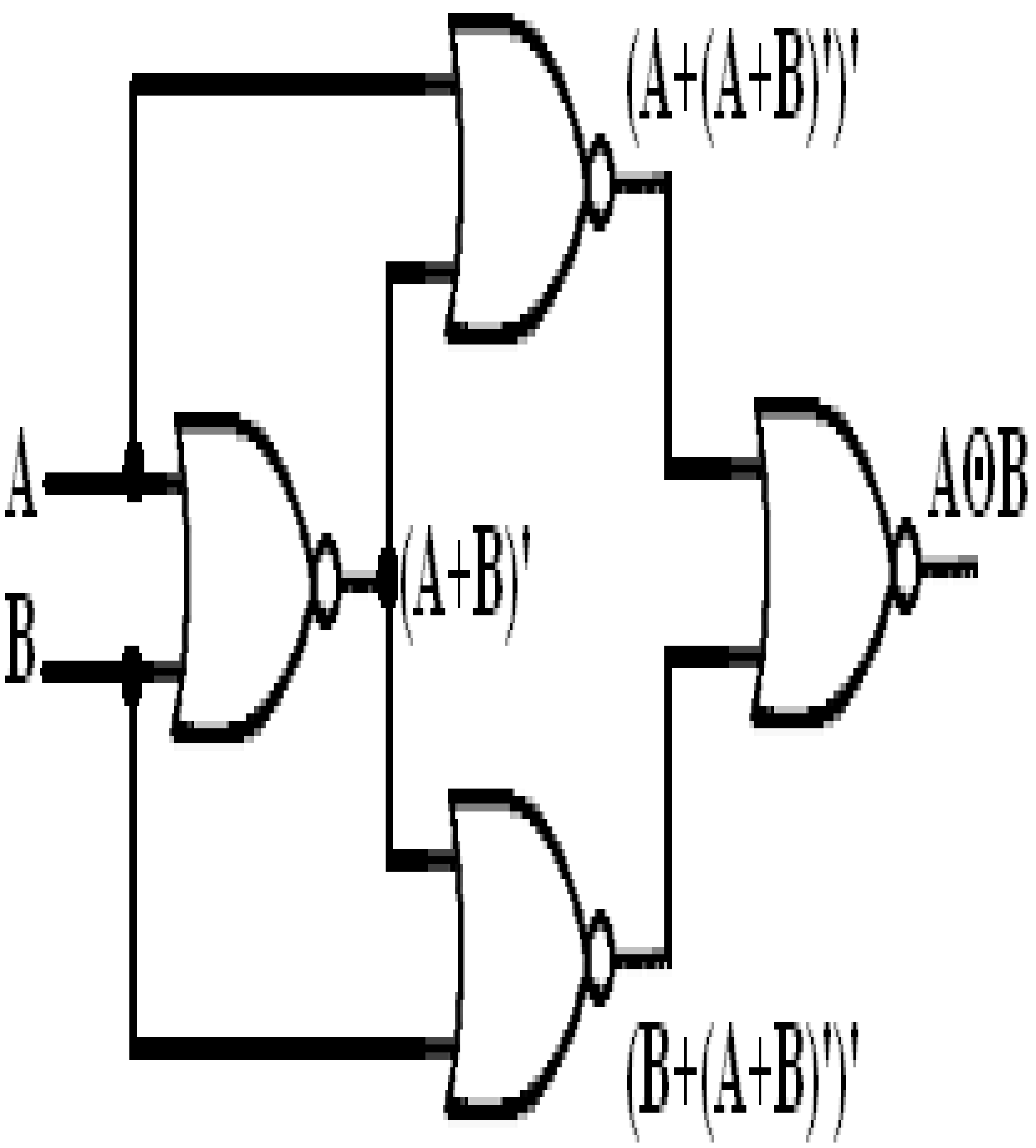
$$(A+(A+B)')' \Rightarrow \overline{A+\overline{(A+B)}} \Rightarrow \overline{A}\cdot(\overline{\overline{A+B}}) \quad \{\overline{A+B} = \overline{A}\cdot\overline{B}\}$$

$$\Rightarrow \overline{A}(A+B) \quad \{\overline{\overline{x}} \Rightarrow x\}$$

$$\Rightarrow \overline{A}\cdot A + \overline{A}B \quad \{\overline{x}\cdot x = 0\}$$

$$\Rightarrow 0+\overline{A}B \quad \{0+x=x\}$$

$$\Rightarrow \overline{A}B$$



X-NOR

$\overline{(B+(A+B)')} \Rightarrow \overline{(B+\overline{(A+B)})} \Rightarrow \overline{B}\cdot(\overline{\overline{A+B}}) \Rightarrow \overline{B}(A+B)$

$\Rightarrow A\cdot\overline{B} + \overline{B}\cdot B$

$\Rightarrow A\cdot\overline{B}$

Now $\Rightarrow \overline{(\overline{A}\cdot B + A\overline{B})} \Rightarrow (\overline{\overline{A}B})\cdot(\overline{A\overline{B}}) \Rightarrow (\overline{\overline{A}}+\overline{B})(\overline{A}+\overline{\overline{B}})$

$\Rightarrow (A+\overline{B})(\overline{A}+B)$

$\Rightarrow A\cdot\overline{A} + AB + \overline{A}\overline{B} + \overline{B}B$

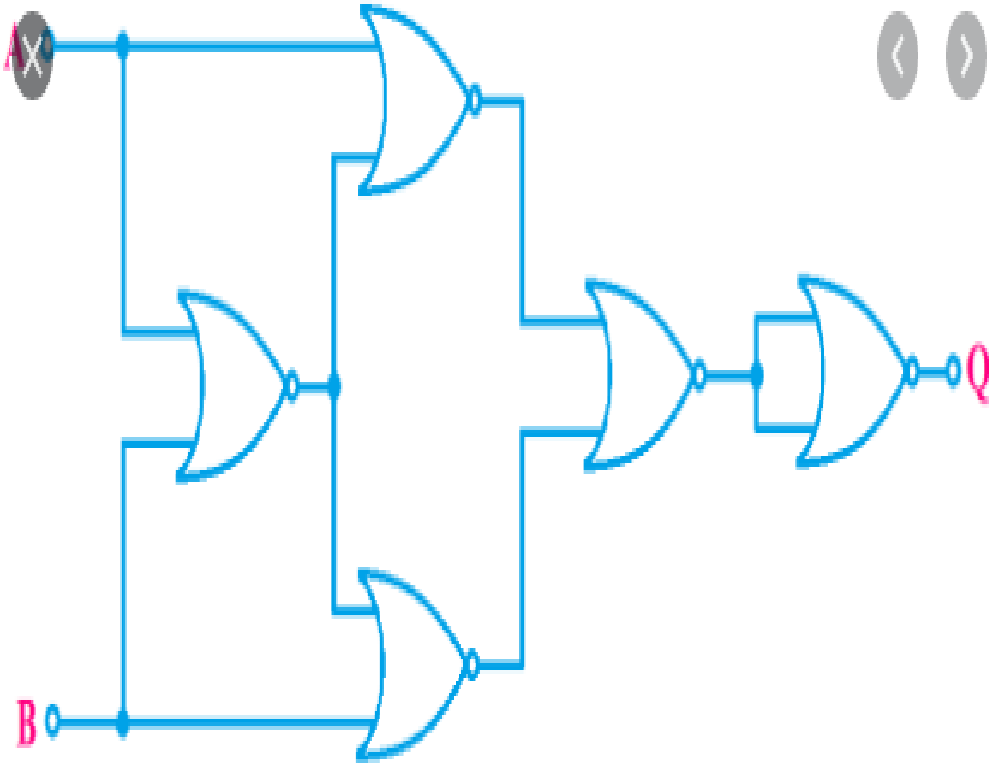
$\Rightarrow AB + \overline{A}\overline{B}$

$\Downarrow$

EXNOR

EX-OR USING NOR

- APPEND NOT GATE IN THE PREVIOUS EXAMPLE TO OBTAIN EX-OR GATE



We have obtained in previous diagram

$$\left(\overline{\bar{A}B + A\bar{B}}\right) \xrightarrow[\text{Not gate}]{\text{Apply}} \left(\overline{\overline{\bar{A}B + A\bar{B}}}\right) \Rightarrow \bar{A}B + A\bar{B}$$

$\Downarrow$

(ExOR gate)

$$\left\{\overline{\overline{x}} = x\right\}$$

POLL

5. The NOR gate output will be high if the two inputs are ________

a) 00

b) 01

c) 10

d) 11

Solution

5. The NOR gate output will be high if the two inputs are ________

a) 00

b) 01

c) 10

d) 11

^ View Answer

Answer: a

Explanation: In 01, 10 or 11 output is low if any of the I/P is high. So, the correct option will be 00.

Poll

7. A universal logic gate is one which can be used to generate any logic function. Which of the following is a universal logic gate?

a) OR

b) AND

c) XOR

d) NAND

Solutions

7. A universal logic gate is one which can be used to generate any logic function. Which of the following is a universal logic gate?

a) OR

b) AND

c) XOR

d) NAND

View Answer

Answer: d

Explanation: An Universal Logic Gate is one which can generate any logic function and also the three basic gates: AND, OR and NOT. Thus, NOR and NAND can generate any logic function and are thus Universal Logic Gates.

Poll

10. Which of the following are known as universal gates?

a) NAND & NOR

b) AND & OR

c) XOR & OR

d) EX-NOR & XOR

Solutions

10. Which of the following are known as universal gates?

a) NAND & NOR

b) AND & OR

c) XOR & OR

d) EX-NOR & XOR

^ View Answer

Answer: a

Explanation: The NAND & NOR gates are known as universal gates because any digital circuit can be realized completely by using either of these two gates, and also they can generate the 3 basic gates AND, OR and NOT.

Poll

Q3. The inputs of a NAND gate are connected together. The resulting circuit is ....

1. OR gate
2. AND gate
3. NOT gate
4. None of the above

Solu

Q3. The inputs of a NAND gate are connected together. The resulting circuit is ....

1. OR gate
2. AND gate
3. NOT gate
4. None of the above

Ans. 3

Discussions

$$\overline{A \cdot (A+C)}$$

$$= \overline{A} + \overline{(A+C)}$$

$$= \overline{A} + \overline{A} \cdot \overline{C}$$

$$= \overline{A}\,(1+\overline{C})$$

$$= \overline{A} \cdot 1$$

Questions

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

$$
\begin{aligned}
(A+B)(A+C) &= AA + AC + AB + BC \\
&= A + AC + AB + BC \\
&= A(1+C) + AB + BC \\
&= A \cdot 1 + AB + BC \\
&= A(1+B) + BC \\
&= A \cdot 1 + BC \\
&= A + BC
\end{aligned}
$$

Questions

Apply DeMorgan's theorems to the expressions $\overline{XYZ}$ and $\overline{X + Y + Z}$.

Solve and paste answer in LPULIVE

Solutions

Apply DeMorgan's theorems to the expressions $\overline{XYZ}$ and $\overline{X + Y + Z}$.

$$\overline{XYZ} = \overline{X} + \overline{Y} + \overline{Z}$$

$$\overline{X + Y + Z} = \overline{X}\,\overline{Y}\,\overline{Z}$$

Questions

Apply DeMorgan's theorems to the expressions $\overline{WXYZ}$ and $\overline{W + X + Y + Z}$.

Solutions

$$\overline{WXYZ} = \overline{W} + \overline{X} + \overline{Y} + \overline{Z}$$

$$\overline{W + X + Y + Z} = \overline{W}\,\overline{X}\,\overline{Y}\,\overline{Z}$$

Questions

Apply DeMorgan's theorems to each of the following expressions:

(a) $\overline{(A + B + C)D}$ (b) $\overline{ABC + DEF}$ (c) $\overline{A\overline{B} + \overline{C}D + EF}$

Solve b part now- share answer in lpulive students. ok

Solutions

Solution (a) Let $A + B + C = X$ and $D = Y$. The expression $\overline{(A + B + C)D}$ is of the form $\overline{XY} = \overline{X} + \overline{Y}$ and can be rewritten as

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

Next, apply DeMorgan's theorem to the term $\overline{A + B + C}$.

$$\overline{A + B + C} + \overline{D} = \overline{A}\,\overline{B}\,\overline{C} + \overline{D}$$

Solutions

Solution

(b) Let $ABC = X$ and $DEF = Y$. The expression $\overline{ABC + DEF}$ is of the form $\overline{X + Y} = \overline{X}\,\overline{Y}$ and can be rewritten as

$$\overline{ABC + DEF} = (\overline{ABC})(\overline{DEF})$$

Next, apply DeMorgan's theorem to each of the terms $\overline{ABC}$ and $\overline{DEF}$.

$$(\overline{ABC})(\overline{DEF}) = (\overline{A} + \overline{B} + \overline{C})(\overline{D} + \overline{E} + \overline{F})$$

Solutions

Solution

(c) Let $A\overline{B} = X$, $\overline{C}D = Y$, and $EF = Z$. The expression $\overline{A\overline{B} + \overline{C}D + EF}$ is of the form $\overline{X + Y + Z} = \overline{X}\,\overline{Y}\,\overline{Z}$ and can be rewritten as

$$\overline{A\overline{B} + \overline{C}D + EF} = (\overline{A\overline{B}})(\overline{\overline{C}D})(\overline{EF})$$

Next, apply DeMorgan's theorem to each of the terms $\overline{A\overline{B}}$, $\overline{\overline{C}D}$, and $\overline{EF}$.

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