Digital Logic Design

Department of Computer Science & IT

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Today’s Agenda

- OR Gate
- Universal Gates

The OR Gate

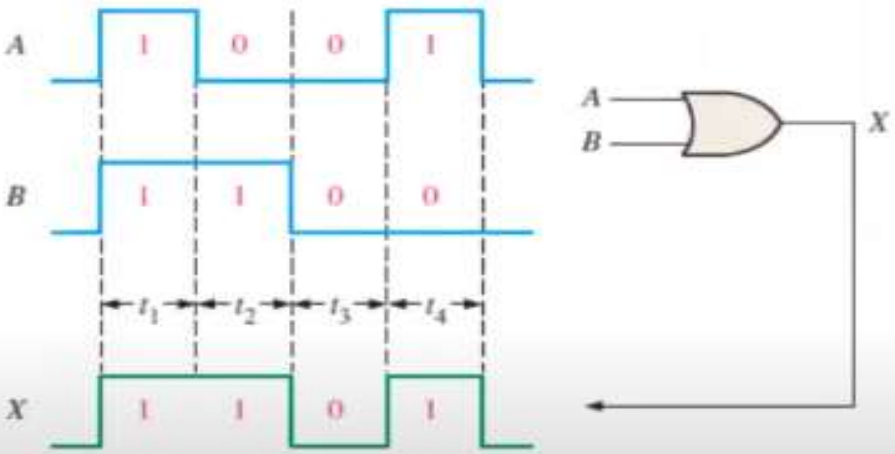
- An OR gate can have two or more inputs and performs what is known as logical addition.
- An OR gate produces a HIGH on the output when *any* of the inputs is HIGH.
- The output is LOW only when all of the inputs are LOW.
- Therefore, an OR gate determines when one or more of its inputs are HIGH and produces a HIGH on its output

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

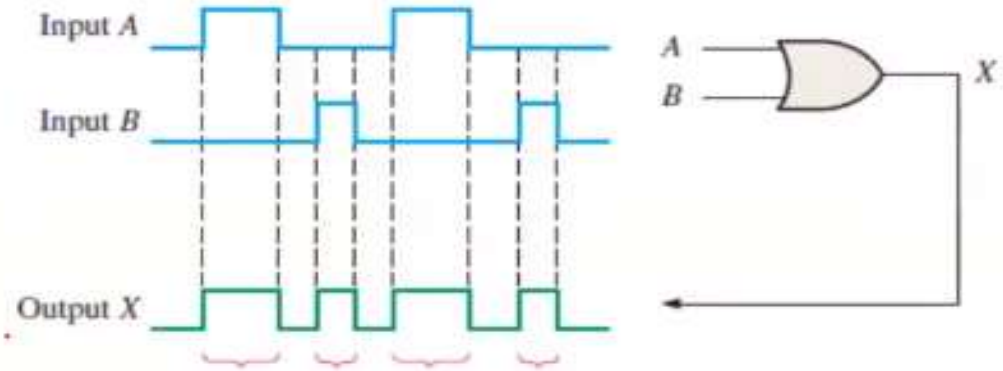
1 = HIGH, 0 = LOW

OR Gate Operation with Waveform Inputs



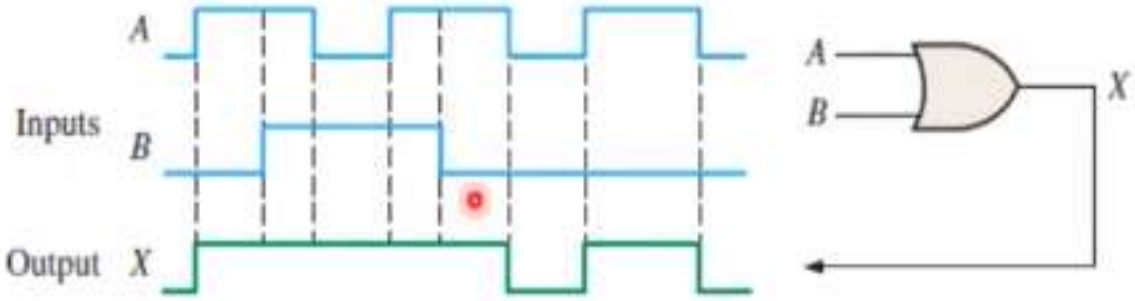
EXAMPLE 3–7

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



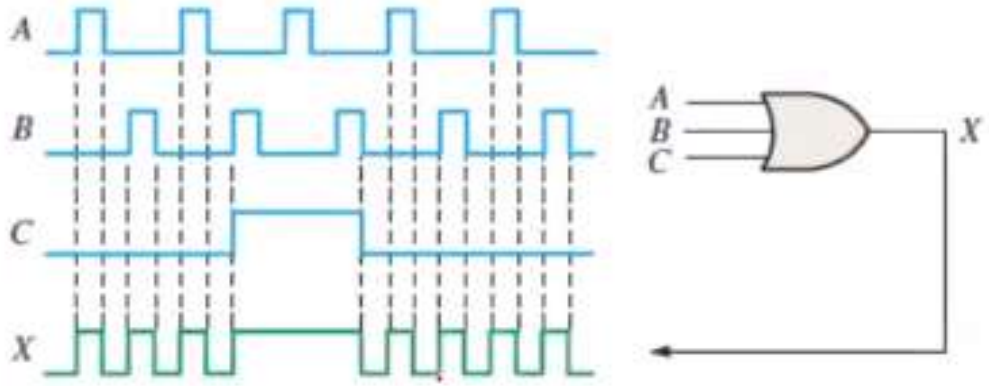
EXAMPLE 3–8

For the two input waveforms, *A* and *B*, in Figure 3–22, show the output waveform with its proper relation to the inputs.



EXAMPLE 3–9

For the 3-input OR gate in Figure 3–23, determine the output waveform in proper time relation to the inputs.

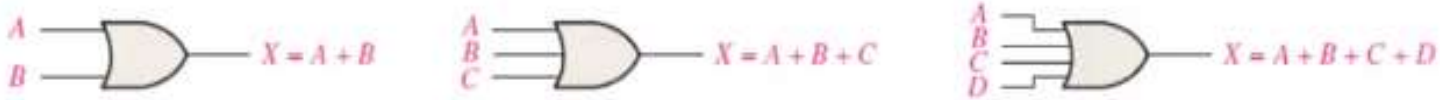


Logic Expressions for an OR Gate

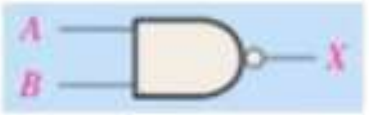
- If one input variable is *A*, if the other input variable is *B*, and if the output variable is *X*, then the Boolean (Logic) expression is;

$$X = A + B$$

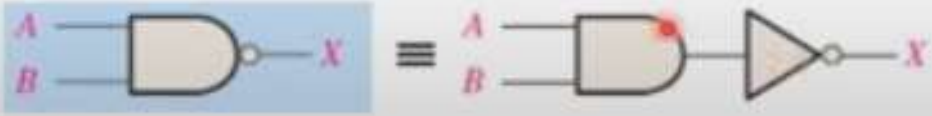
A	B	$A + B = X$
0	0	$0 + 0 = 0$
0	1	$0 + 1 = 1$
1	0	$1 + 0 = 1$
1	1	$1 + 1 = 1$



The NAND Gate



- The NAND gate is a popular logic element because it can be used as a universal gate; that is, NAND gates can be used in combination to perform the AND, OR, and inverter operations.
- The universal property of the NAND gate will be examined thoroughly later.
- The NAND gate is the same as the AND gate except the output is inverted.



Operation of a NAND Gate

- A **NAND gate** produces a LOW output only when all the inputs are HIGH.
- When any of the inputs is LOW, the output will be HIGH.

Truth table for a 2-input NAND gate.

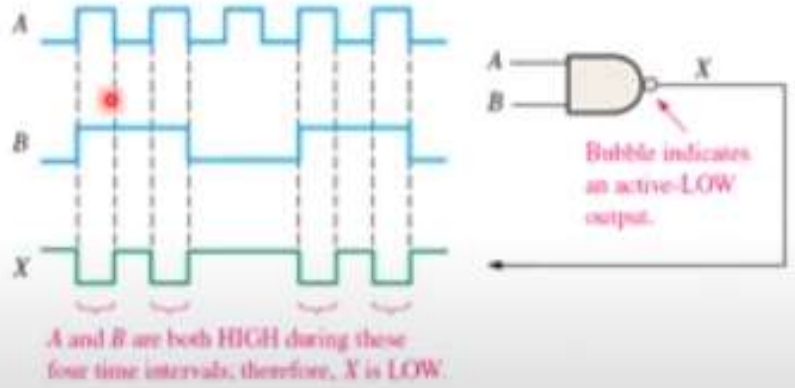
Inputs		Output
A	*B*	*X*
0	0	1
0	1	1
1	0	1
1	1	0

1 = HIGH, 0 = LOW.

NAND Gate Operation with Waveform Inputs

EXAMPLE 3–10

If the two waveforms *A* and *B* shown in Figure 3–28 are applied to the NAND gate inputs, determine the resulting output waveform.



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.

The output waveform X is LOW only when all three input waveforms are HIGH as shown in the timing diagram.

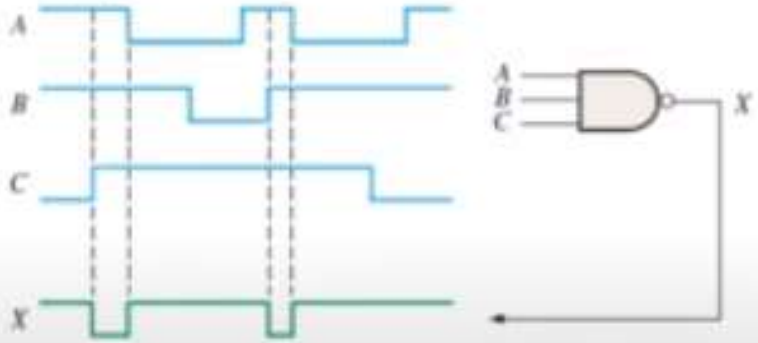


FIGURE 3–29

Logic Expressions for a NAND Gate

- The Boolean expression for the output of a 2-input NAND gate is:

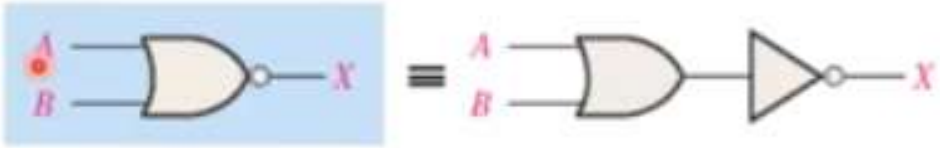
$$X = \overline{AB}$$

- This expression says that the two input variables, *A* and *B*, are first ANDed and then complemented, as indicated by the bar over the AND expression.

A	B	$\overline{AB} = X$
0	0	$\overline{0 \cdot 0} = \overline{0} = 1$
0	1	$\overline{0 \cdot 1} = \overline{0} = 1$
1	0	$\overline{1 \cdot 0} = \overline{0} = 1$
1	1	$\overline{1 \cdot 1} = \overline{1} = 0$

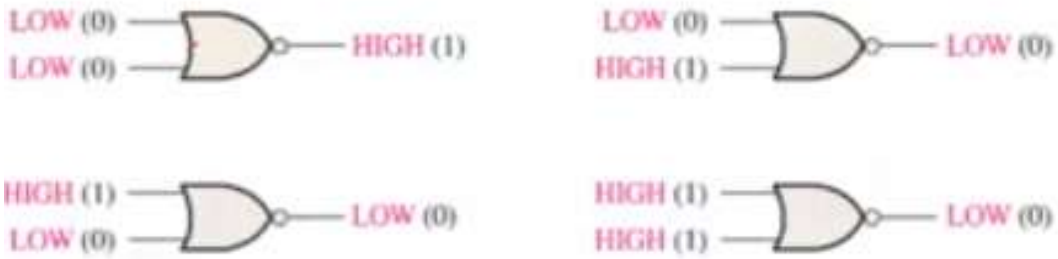
The NOR Gate

- The NOR gate, like the NAND gate, is a useful logic element because it can also be used as a universal gate; that is, NOR gates can be used in combination to perform the AND,OR, and inverter operations.
- The universal property of the NOR gate will be examined thoroughly later.
- The term *NOR* is a contraction of NOT-OR and implies an OR function with an inverted (complemented) output.



Operation of a NOR Gate

- A **NOR gate** produces a LOW output when *any* of its inputs is HIGH.
- Only when all of its inputs are LOW, the output is HIGH.



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.

NOR Gate Operation with Waveform Inputs

EXAMPLE 3–15

If the two waveforms shown in Figure 3–36 are applied to a NOR gate, what is the resulting output waveform?

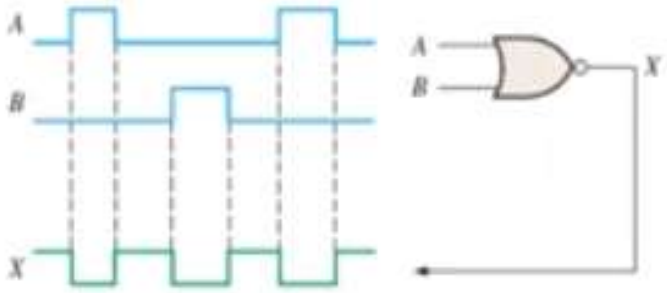


FIGURE 3–36

NOR Gate Operation with Waveform Inputs

EXAMPLE 3–16

Show the output waveform for the 3-input NOR gate in Figure 3–37 with the proper time relation to the inputs.

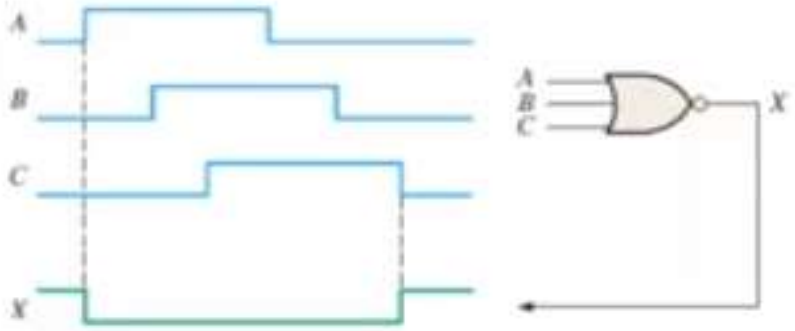


FIGURE 3–37

Logic Expressions for a NOR Gate

- The Boolean expression for the output of a 2-input NOR gate can be written as

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

- Above equation says that the two input variables are first ORed and then complemented, as indicated by the bar over the OR expression.

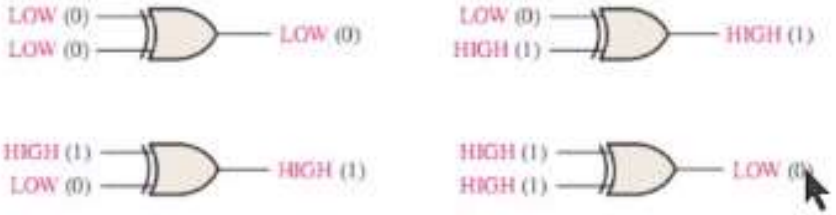
A	B	$\overline{A + B} = X$
0	0	$\overline{0 + 0} = \overline{0} = 1$
0	1	$\overline{0 + 1} = \overline{1} = 0$
1	0	$\overline{1 + 0} = \overline{1} = 0$
1	1	$\overline{1 + 1} = \overline{1} = 0$

The Exclusive-OR and Exclusive-NOR Gates

- Exclusive-OR and exclusive-NOR gates are formed by a combination of basic gates.
- However, because of their fundamental importance in many applications, these gates are often treated as basic logic elements with their own unique symbols.

The Exclusive-OR Gate

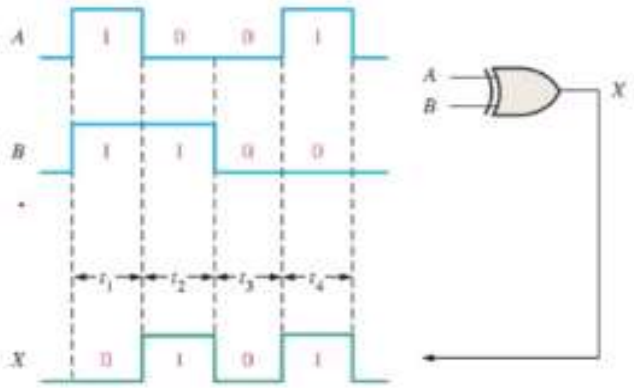
- The output of an exclusive-OR gate is HIGH only when the two inputs are at opposite logic levels.
- The XOR gate has only two inputs.



Truth table for an exclusive-OR gate.

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

Operation with Waveform Inputs



Application

EXAMPLE 3–20

A certain system contains two identical circuits operating in parallel. As long as both are operating properly, the outputs of both circuits are always the same. If one of the circuits fails, the outputs will be at opposite levels at some time. Devise a way to monitor and detect that a failure has occurred in one of the circuits.

Solution

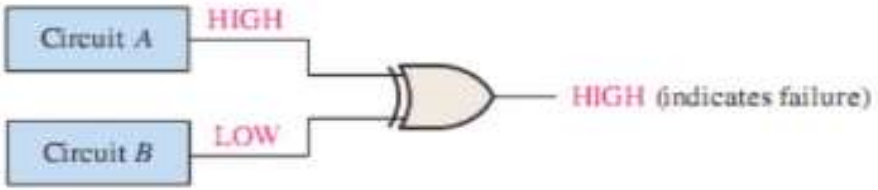


FIGURE 3–44

Related Problem

Will the exclusive-OR gate always detect simultaneous failures in both circuits of Figure 3–44?

The Exclusive-NOR Gate

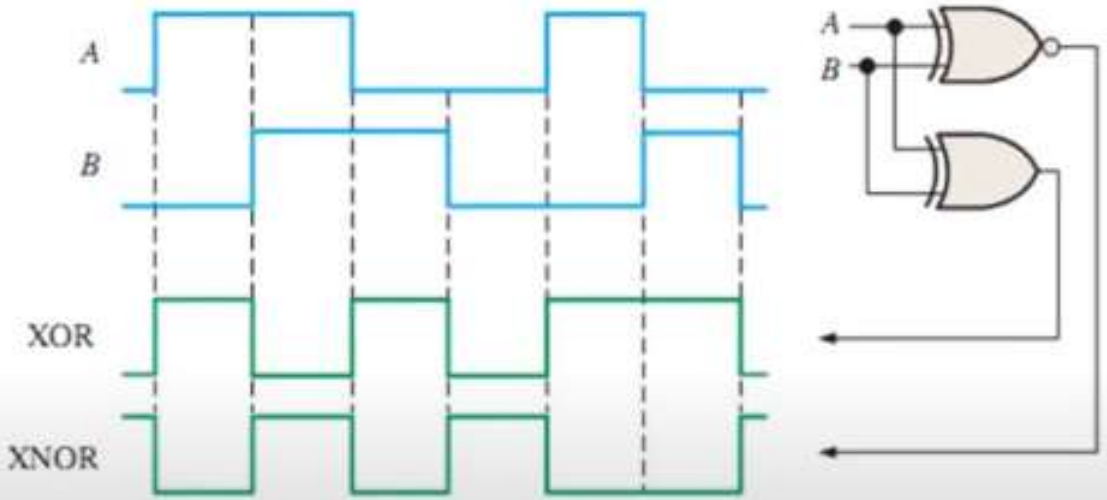
- Like the XOR gate, an XNOR has only two inputs.
- The bubble on the output of the XNOR symbol indicates that its output is opposite that of the XOR gate.
- When the two input logic levels are opposite, the output of the exclusive-NOR gate is LOW.
- The output is HIGH when the same level is on both inputs.

Truth table for an exclusive-NOR gate.

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

EXAMPLE 3–21

Determine the output waveforms for the XOR gate and for the XNOR gate, given the input waveforms, *A* and *B*, in Figure 3–48.



Logic Expression

XOR GATE

XNOR GATE

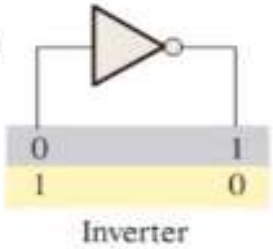
Summary

- What is Logic Gate?

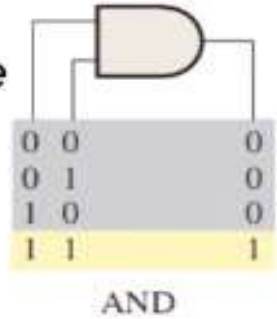
"A logic gate is an idealized or physical electronic device implementing a logical operation performed on one or more binary (digital)inputs that produces a single binary (digital) output"

Summary

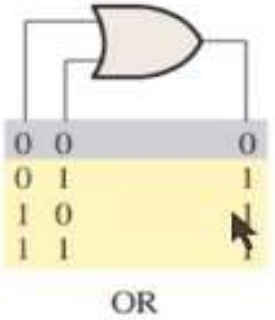
- *The inverter (NOT gate) output is the complement of the input.*



- *The AND gate output is HIGH only when all the inputs are HIGH.*

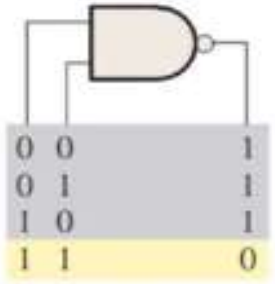


- *The OR gate output is HIGH when any of the inputs is HIGH.*



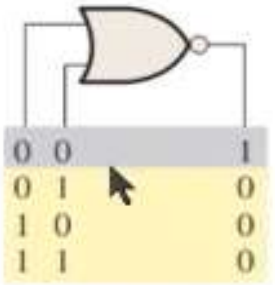
Summary

- The NAND gate output is LOW only when all the inputs are HIGH.



NAND

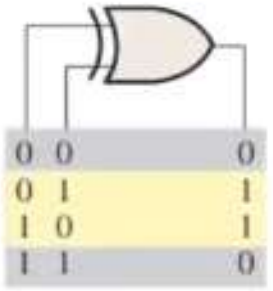
- The NOR gate output is LOW when any of the inputs is HIGH.



NOR

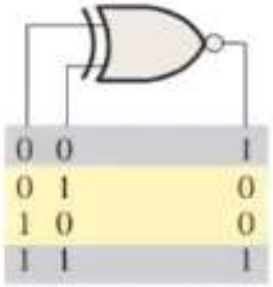
Summary

- The Exclusive-OR gate output is HIGH when the inputs are not the same.



Exclusive-OR

- The Exclusive-NOR gate output is LOW when the inputs are not the same.



Exclusive-NOR

- Download Proteus
- Labcenter.com