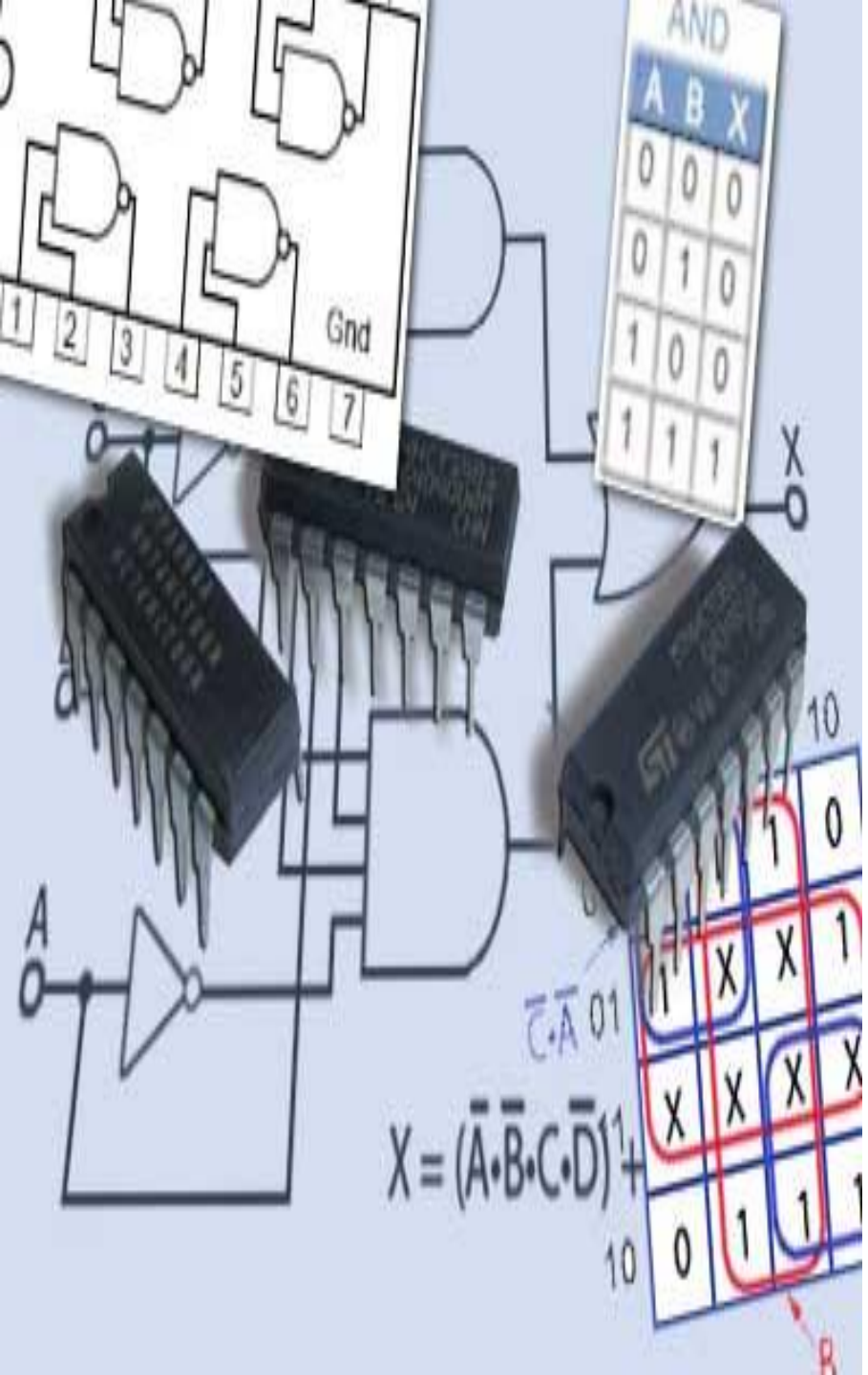

Medical Instrumentations Techniques Engineering
Al-Rasheed University College
Second Level

Digital Techniques

Lecture 04

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LOGIC GATES

This lecture presents the basics of logic gates which are used in implementing the integrated circuits (ICs). The ICs are used in many digital techniques applications therefore it is necessary to understand the basics of its components. Logic gates are primarily implemented electronically using diodes or transistors, but can also be constructed using electromagnetic relays (relay logic), fluidic logic, pneumatic logic, optics, molecules, or even mechanical elements.

Lecture objectives

At the end of this lecture, the student should be able to:

1- Know the NOT, AND, and OR gates.

2- Know the NAND and NOR gates.

3- Know the EX-OR and EX-NOR gates.

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, as shown at the outputs. The symbol, truth table, equation, and operation are shown below.

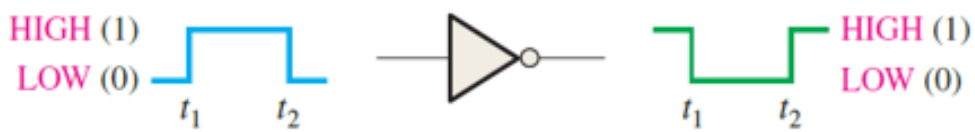
Symbol

$X = \overline{A}$

Output equation

Inverter truth table.

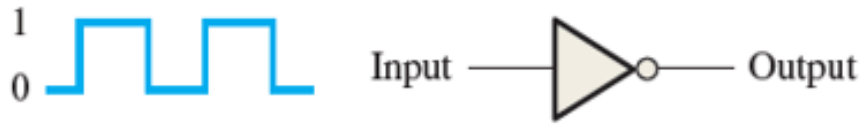
Input	Output
LOW (0)	HIGH (1)
HIGH (1)	LOW (0)



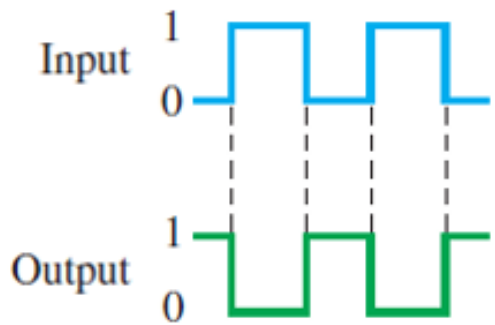
Input pulse

Output pulse

Example: Determine the output of the invertor for the input waveform shown below.



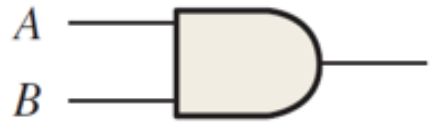
Solution:



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. The symbol, truth table, equation, and operation are shown below.

Symbol

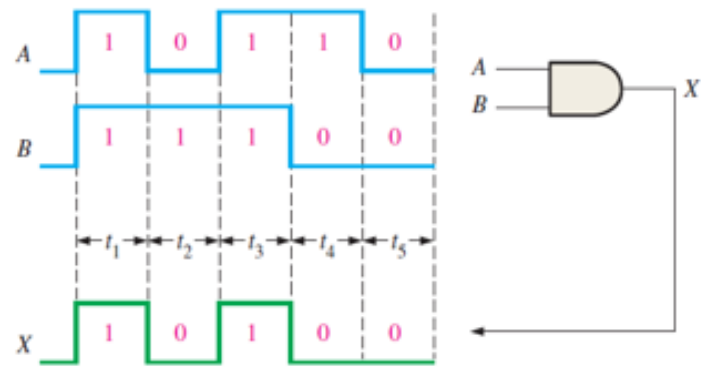


$X = A \cdot B$

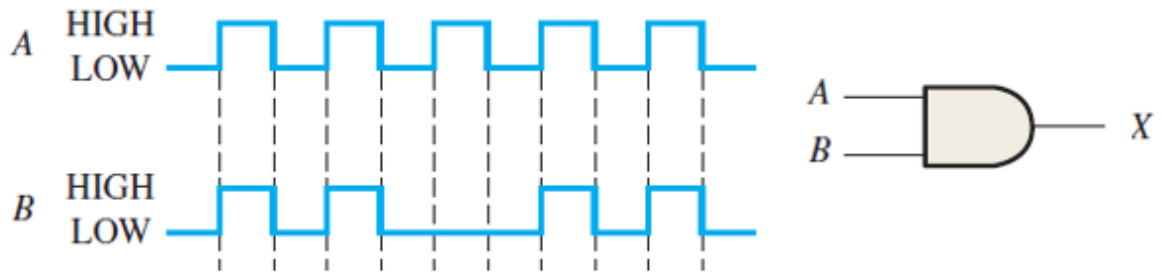
Output equation

Truth table for a 2-input AND gate.

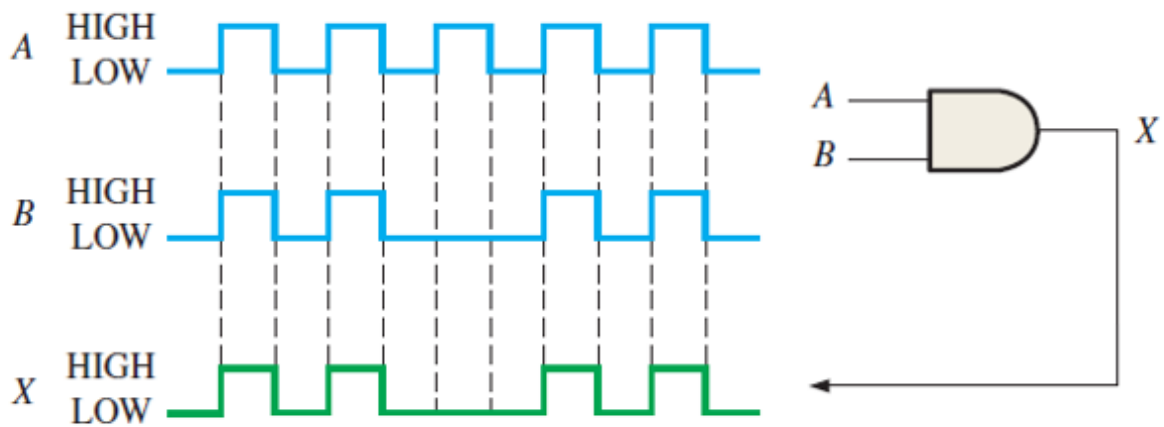
Inputs		Output
A	*B*	*X*
0	0	0
0	1	0
1	0	0
1	1	1



Example: Determine the output of the AND gate for the input waveforms shown below.



Solution:



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. The symbol, truth table, equation, and operation are shown below.

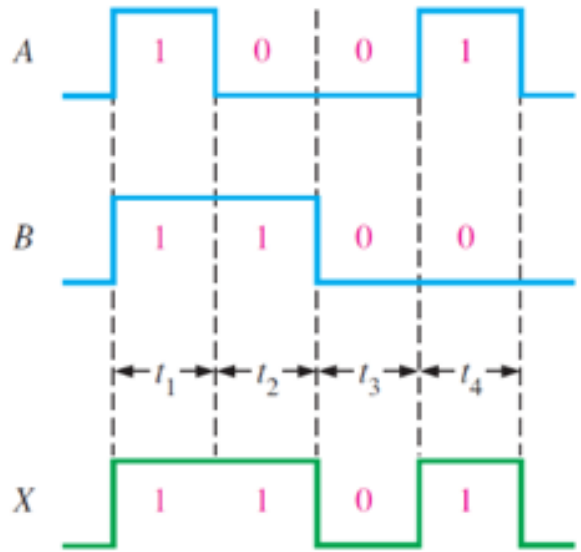
Symbol

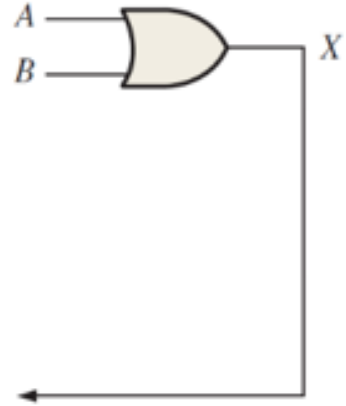
$X = A + B$

Output equation

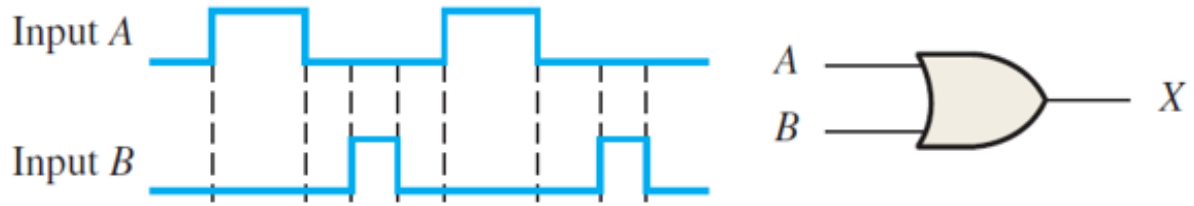
Truth table for a 2-input OR gate.

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

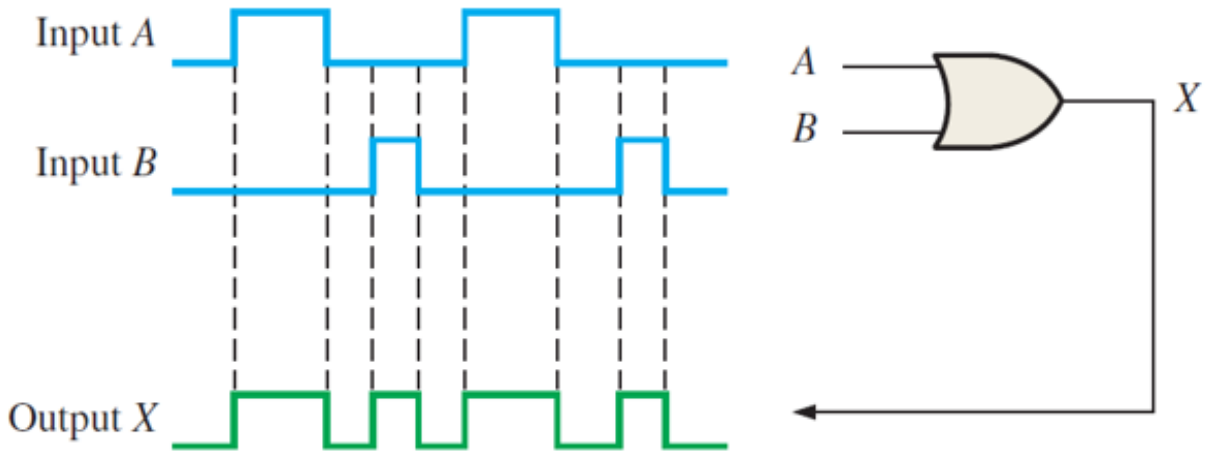




Example: Determine the output of the OR gate for the input waveforms shown below.



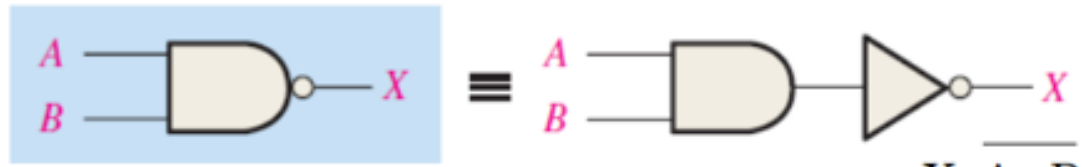
Solution:



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. The symbol, truth table, and equation are shown below.

Symbol

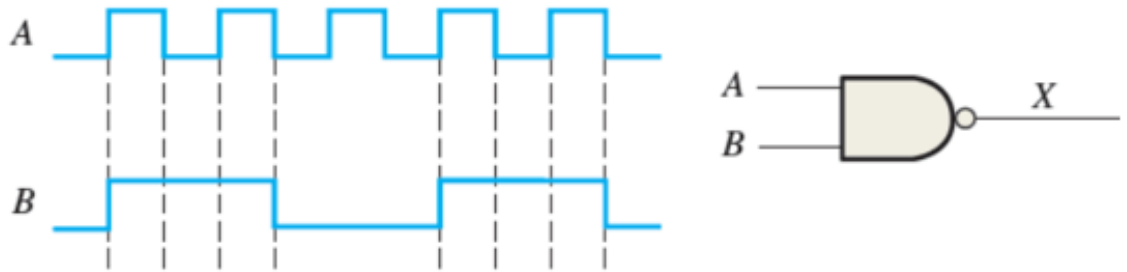


$X = \overline{A \cdot B}$

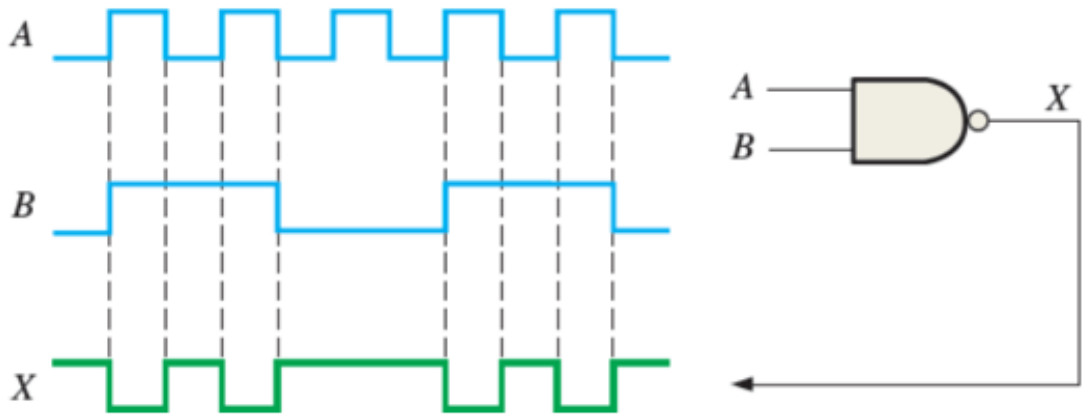
Truth table for a 2-input NAND gate.

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

Example: Determine the output of the NAND gate for the input waveforms shown below.



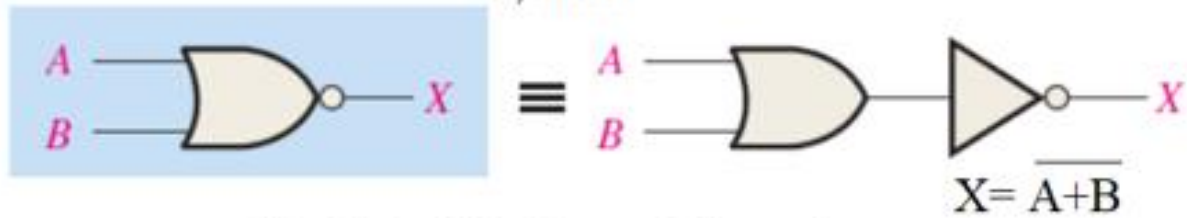
Solution:



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. The symbol, truth table, and equation are shown below.

Symbol

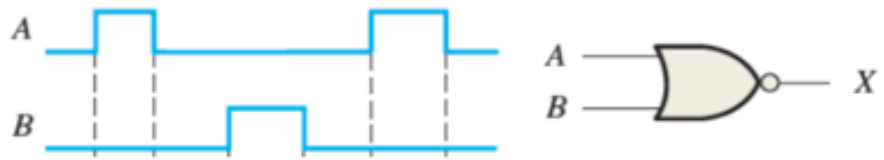


$X = \overline{A+B}$

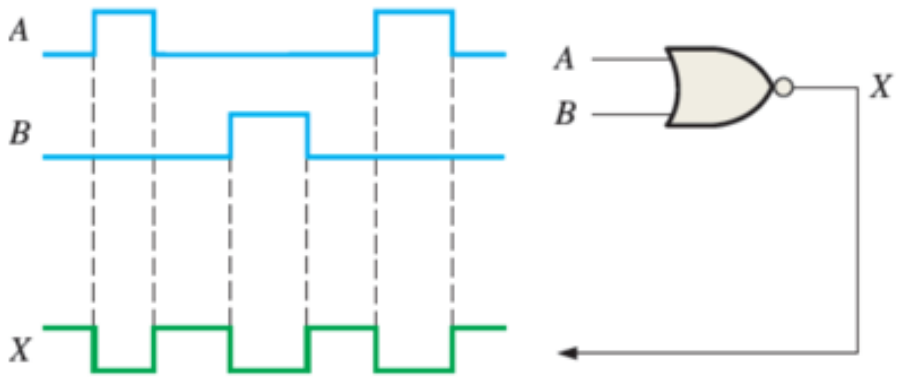
Truth table for a 2-input NOR gate.

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

Example: Determine the output of the NOR gate for the input waveforms shown below.



Solution:



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. The symbol, truth table, and equation are shown below.

Symbol

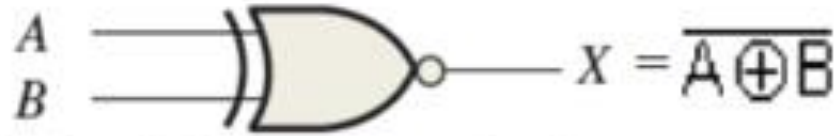
Truth table for an exclusive-OR gate.

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

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 EX-OR gate with a small circle on the output. The small circle represents inversion.

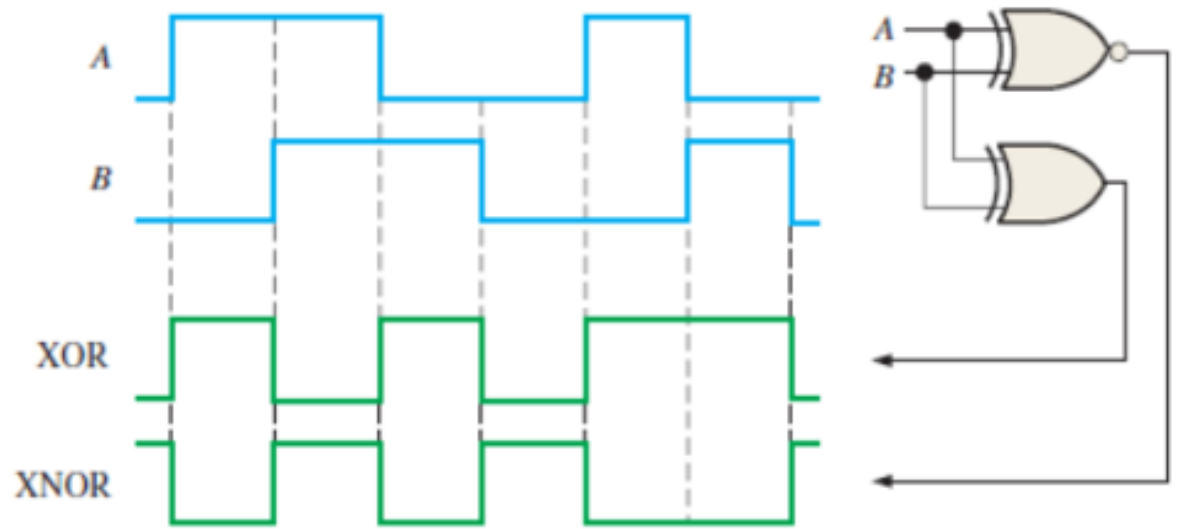
Symbol



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: Determine the output waveforms for the EX-OR gate and for the XE-NOR gate, given the input waveforms, A and B as shown below.



Exercise (Lecture 04)

Answer the following questions:

1- When 1 is on the input of an inverter, what is the output?
2- When is the output of an AND gate HIGH?
3- Describe the truth table for a 5-input AND gate.
4- When is the output of an OR gate LOW?
5- Describe the truth table for a 3-input OR gate.
6- When is the output of a NAND gate HIGH?
7- When is the output of a NOR gate LOW?
8- What are the logic gates that can be used to detect when the two bits are different?