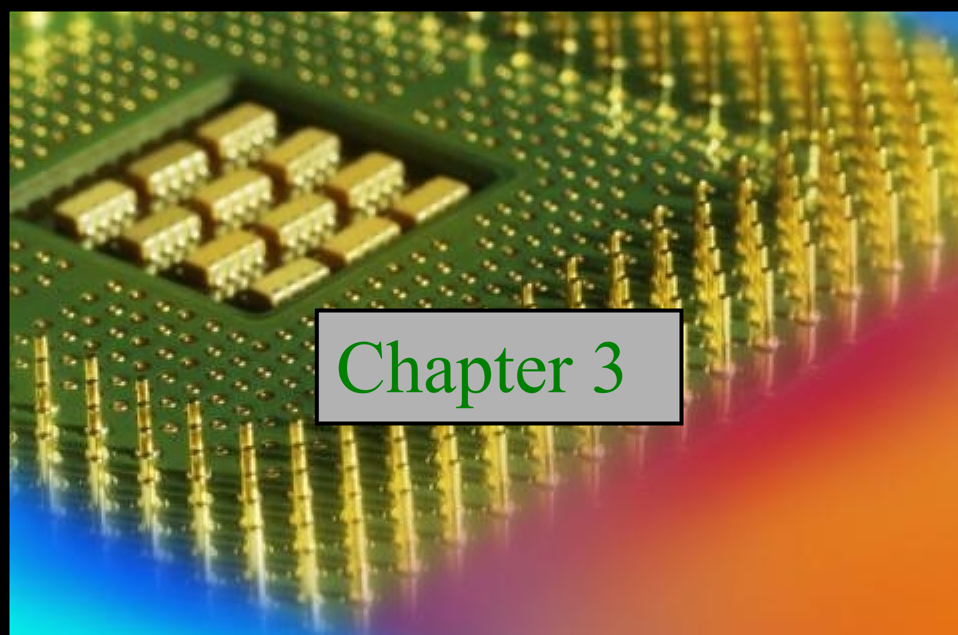
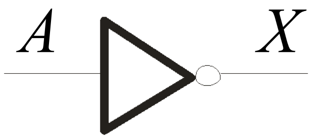
Digital Fundamentals

Tenth Edition

Floyd



The Inverter



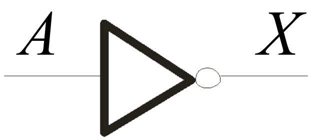
The inverter performs the Boolean **NOT** operation. When the input is LOW, the output is HIGH; when the input is HIGH, the output is LOW.

Input	Output
A	*X*
LOW (0)	HIGH (1)
HIGH (1)	LOW(0)

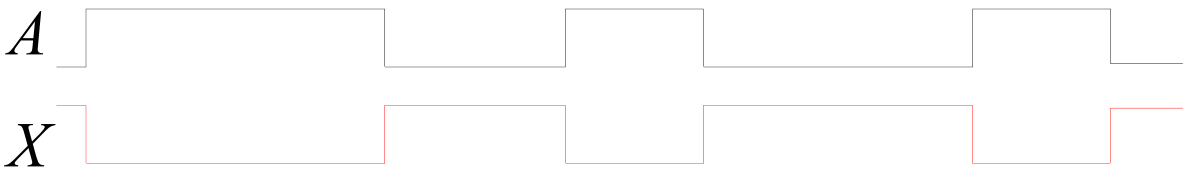
The **NOT** operation (complement) is shown with an overbar. Thus, the Boolean expression for an inverter is $X = \overline{A}$.

Summary

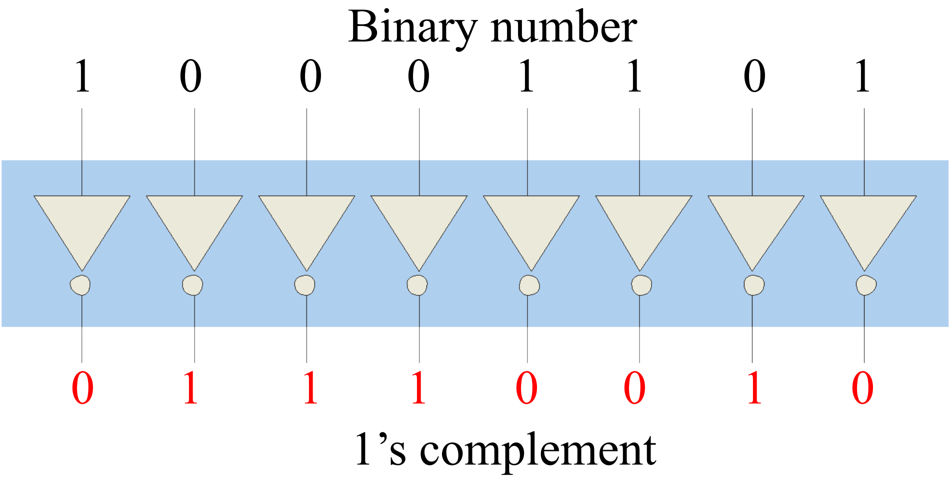
The Inverter



Example waveforms:

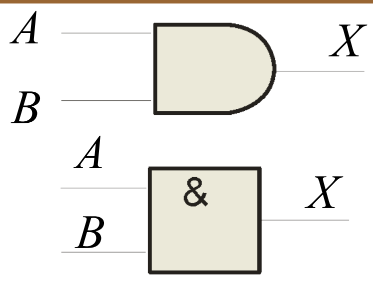


A group of inverters can be used to form the 1's complement of a binary number:



Summary

The AND Gate



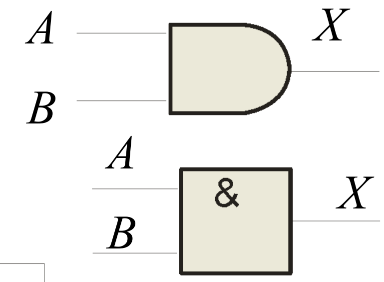
The **AND gate** produces a HIGH output when all inputs are HIGH; otherwise, the output is LOW. For a 2-input gate, the truth table is

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

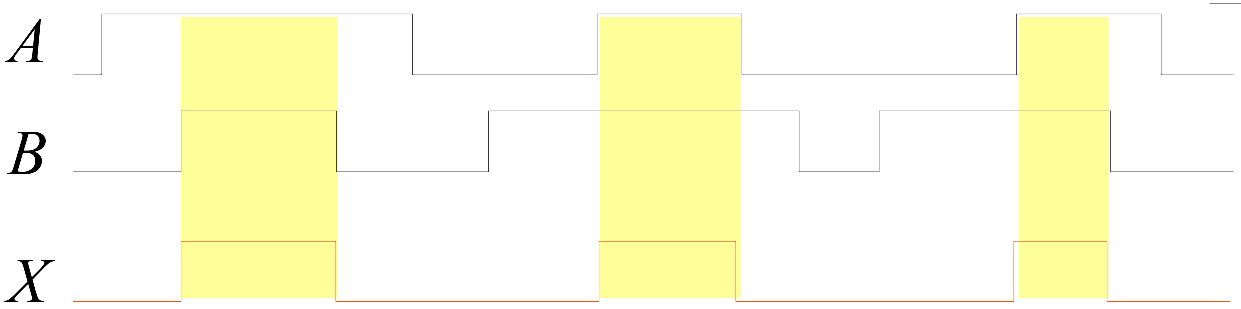
The **AND** operation is usually shown with a dot between the variables but it may be implied (no dot). Thus, the AND operation is written as $X = A \cdot B$ or $X = AB$.

Summary

The AND Gate



Example waveforms:



The AND operation is used in computer programming as a selective mask. If you want to retain certain bits of a binary number but reset the other bits to 0, you could set a mask with 1's in the position of the retained bits.

Summary

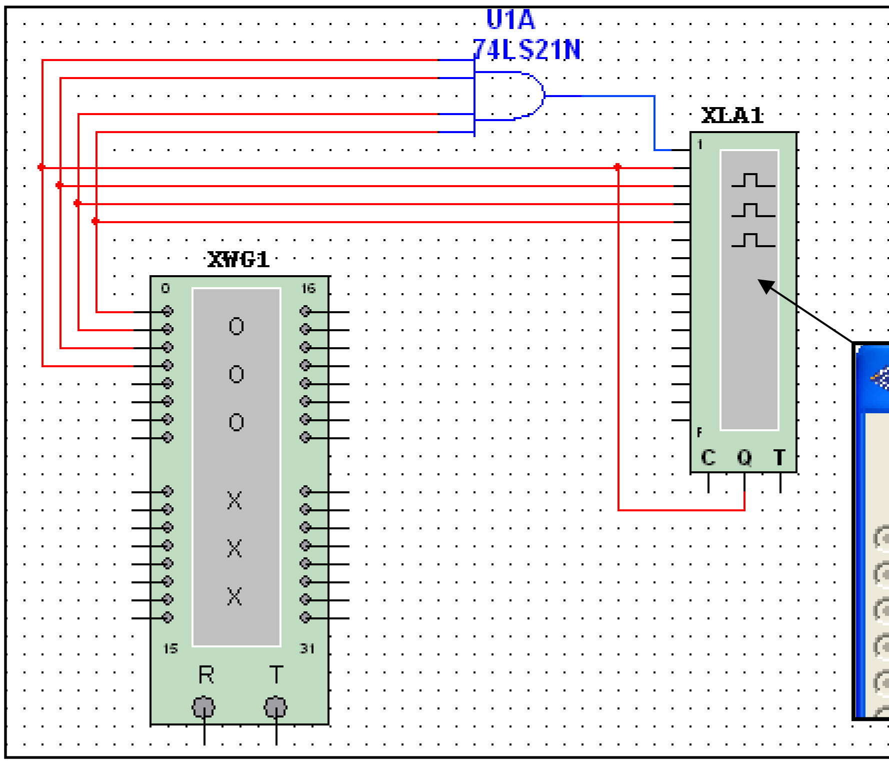
Example

If the binary number 10100011 is ANDed with the mask 00001111, what is the result? 00000011

Summary

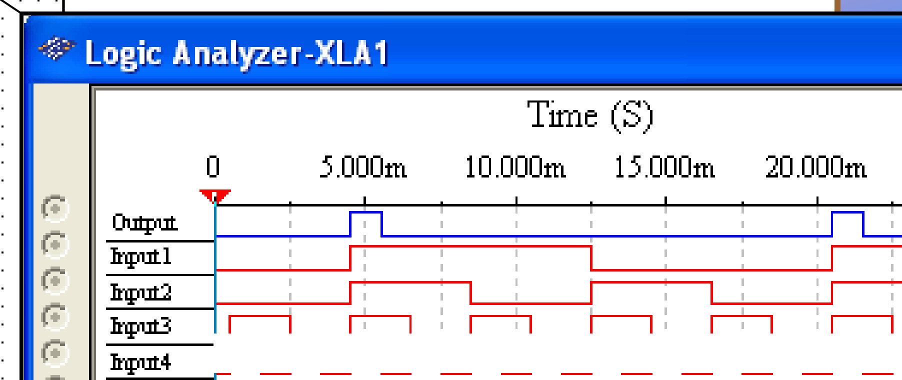
Example

A Multisim circuit is shown. XWG1 is a word generator set in the count down mode. XLA1 is a logic analyzer with the output of the AND gate connected to first (upper) line of the analyzer. What signal do you expect to on this line?



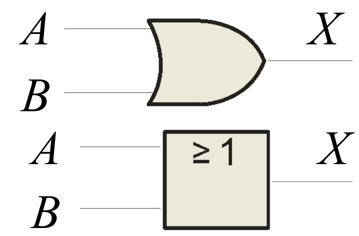
Solution

The output (line 1) will be HIGH only when all of the inputs are HIGH.



Summary

The OR Gate



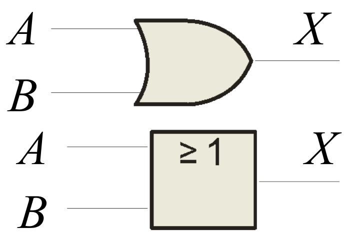
The **OR gate** produces a HIGH output if any input is HIGH; if all inputs are LOW, the output is LOW. For a 2-input gate, the truth table is

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

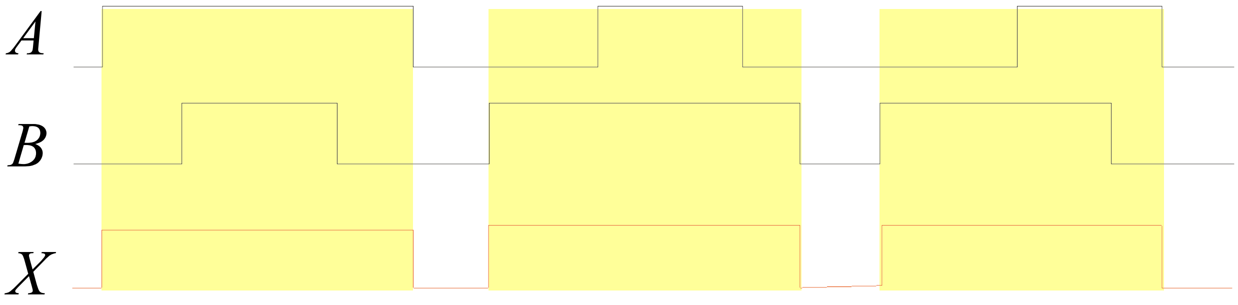
The **OR** operation is shown with a plus sign (+) between the variables. Thus, the OR operation is written as $X = A + B$.

Summary

The OR Gate



Example waveforms:



The OR operation can be used in computer programming to set certain bits of a binary number to 1.

Summary

Example

ASCII letters have a 1 in the bit 5 position for lower case letters and a 0 in this position for capitals. (Bit positions are numbered from right to left starting with 0.) What will be the result if you OR an ASCII letter with the 8-bit mask 00100000?

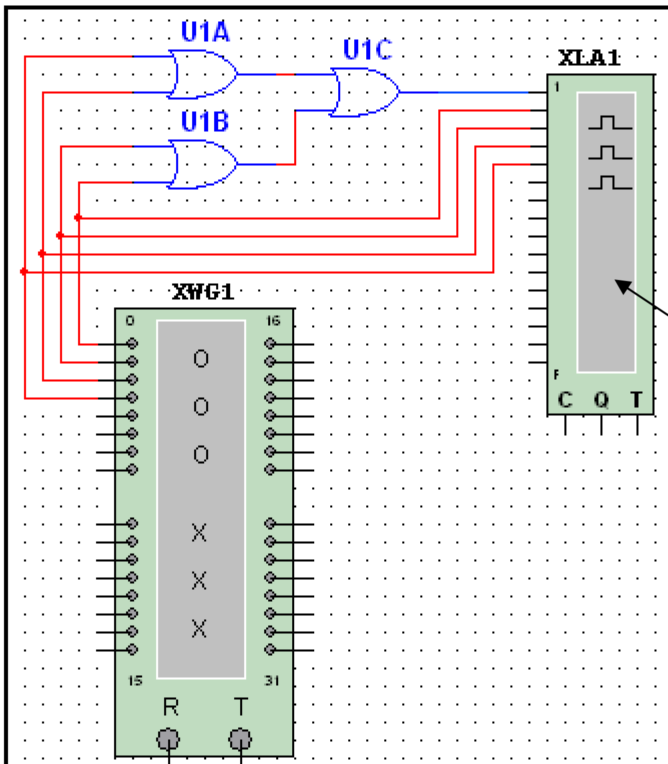
Solution

The resulting letter will be lower case.

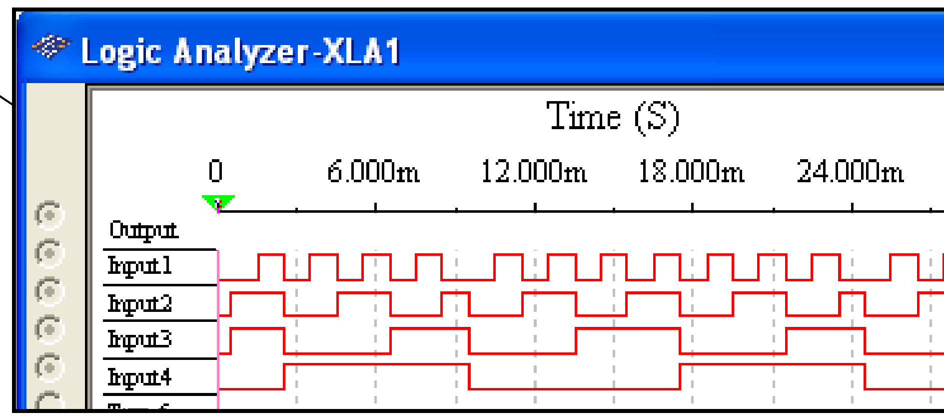
Summary

The OR Gate

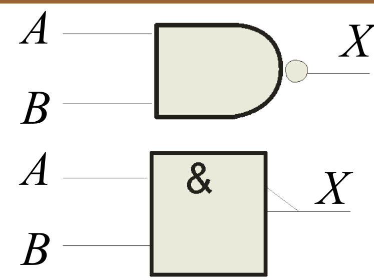
Example A Multisim circuit is shown. XWG1 is a word generator set to count down. XLA1 is a logic analyzer with the output connected to first (top) line of the analyzer. The three 2-input OR gates act as a single 4-input gate. What signal do you expect on the output line?



Solution The output (line 1) will be HIGH if any input is HIGH; otherwise it will be LOW.



The NAND Gate



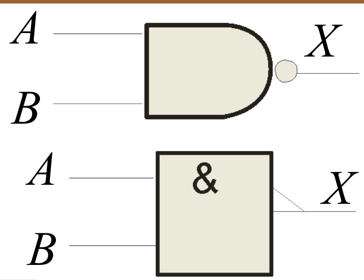
The **NAND gate** produces a LOW output when all inputs are HIGH; otherwise, the output is HIGH. For a 2-input gate, the truth table is

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

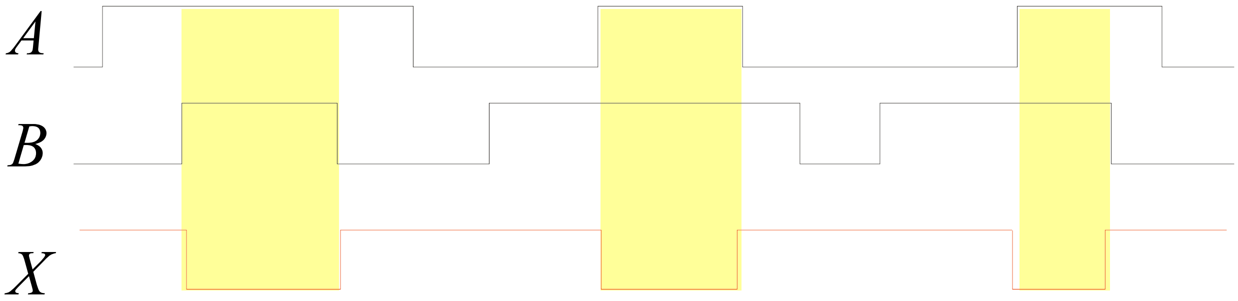
The **NAND** operation is shown with a dot between the variables and an overbar covering them. Thus, the NAND operation is written as $X = \overline{A \cdot B}$ (Alternatively, $X = \overline{AB}$.)

Summary

The NAND Gate



Example waveforms:



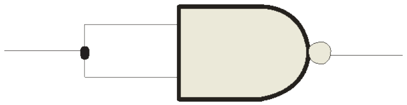
The NAND gate is particularly useful because it is a "universal" gate – all other basic gates can be constructed from NAND gates.

Summary

The NAND Gate

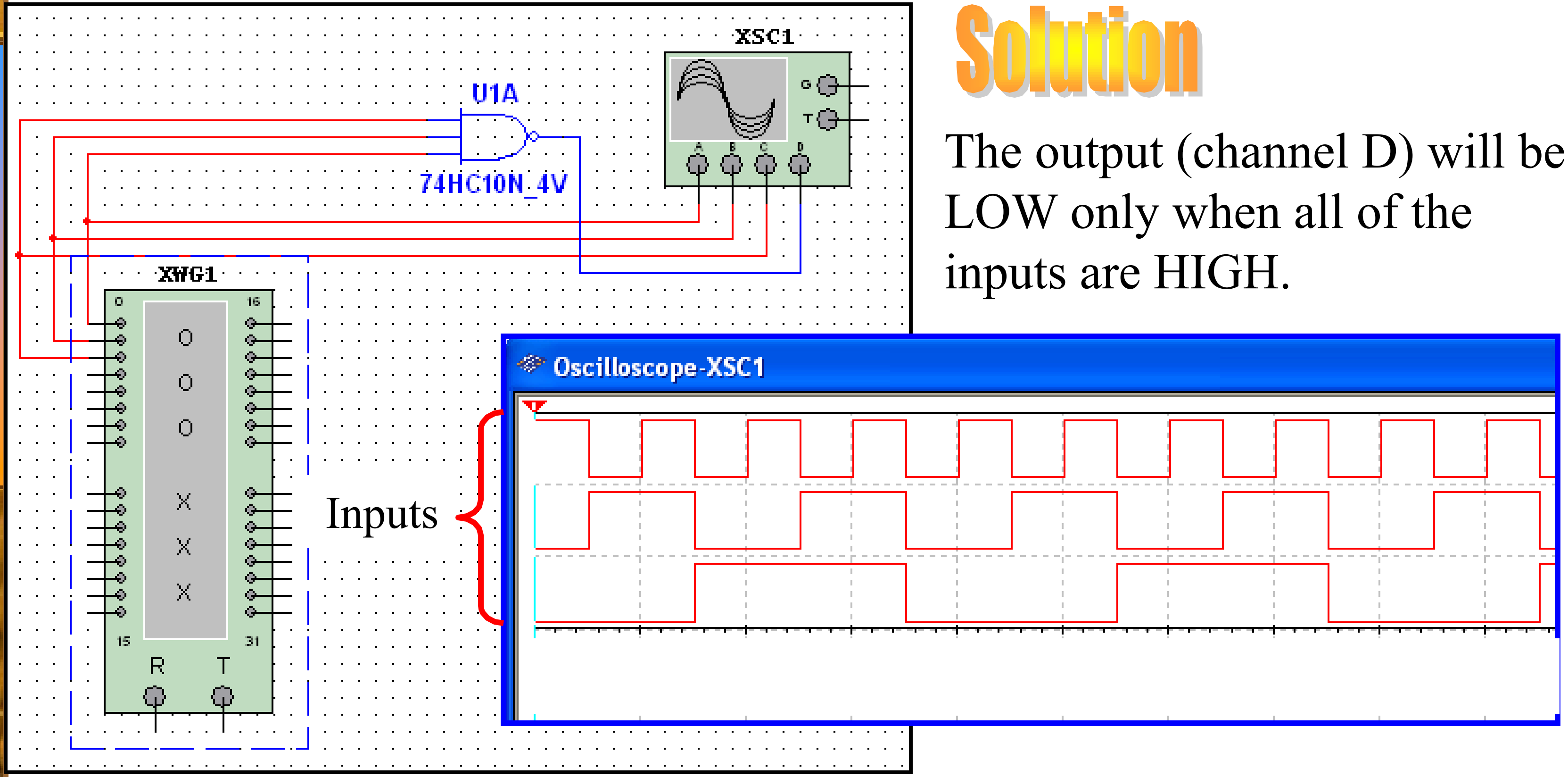
Question

How would you connect a 2-input NAND gate to form a basic inverter?



Example

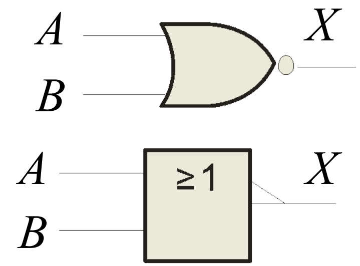
A Multisim circuit is shown. XWG1 is a word generator set in the count up mode. A four-channel oscilloscope monitors the inputs and output. What output signal do you expect to see?



Solution

The output (channel D) will be LOW only when all of the inputs are HIGH.

The NOR Gate



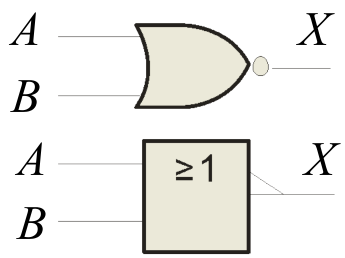
The **NOR gate** produces a LOW output if any input is HIGH; if all inputs are HIGH, the output is LOW. For a 2-input gate, the truth table is

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

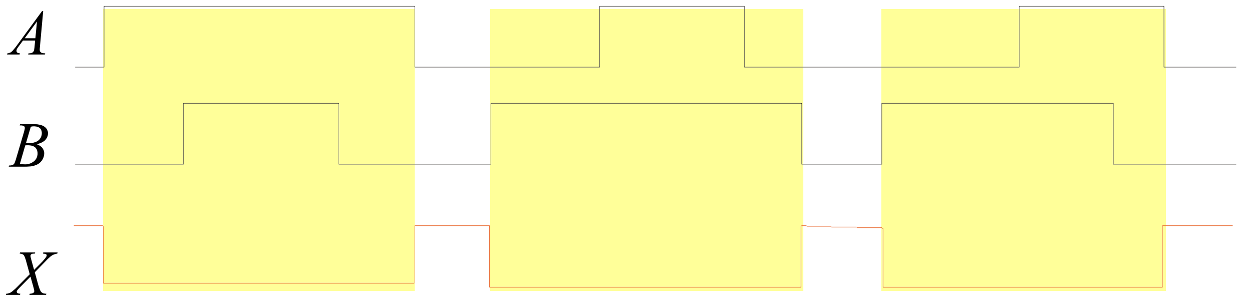
The **NOR** operation is shown with a plus sign (+) between the variables and an overbar covering them. Thus, the NOR operation is written as $X = \overline{A + B}$.

Summary

The NOR Gate



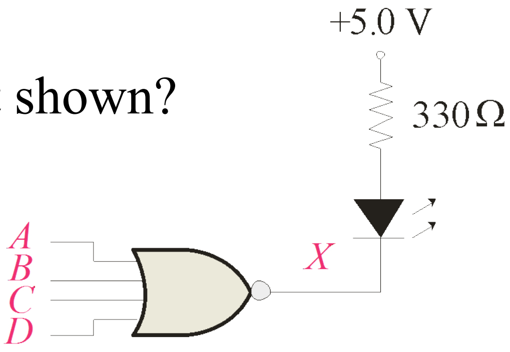
Example waveforms:



The NOR operation will produce a LOW if any input is HIGH.

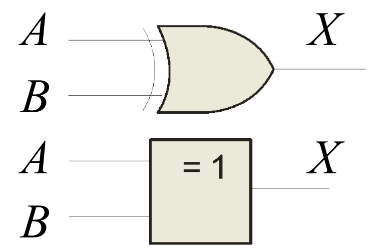
Summary

Example When is the LED is ON for the circuit shown?



Solution The LED will be on when any of the four inputs are HIGH.

The XOR Gate



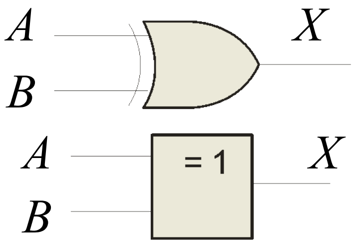
The **XOR gate** produces a HIGH output only when both inputs are at opposite logic levels. The truth table is

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

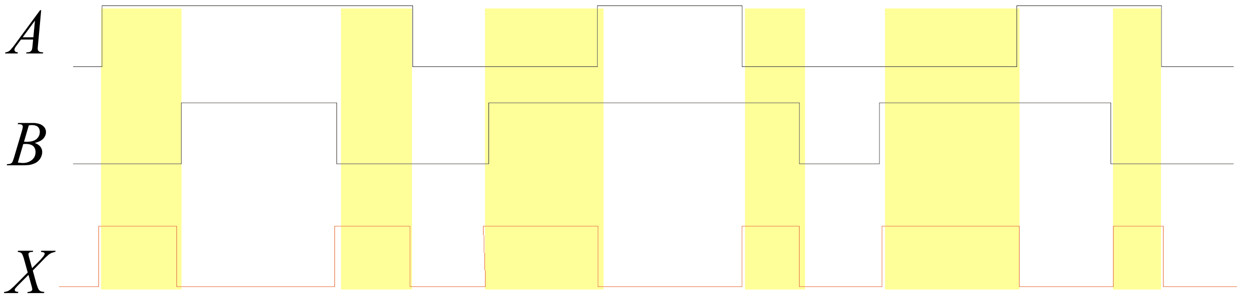
The **XOR** operation is written as $X = \overline{A}B + A\overline{B}$. Alternatively, it can be written with a circled plus sign between the variables as $X = A \oplus B$.

Summary

The XOR Gate



Example waveforms:



Notice that the XOR gate will produce a HIGH only when exactly one input is HIGH.

Summary

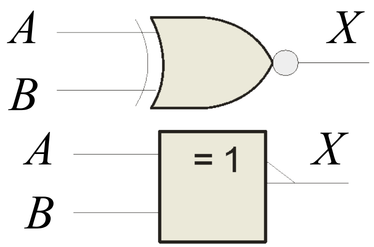
Question

If the *A* and *B* waveforms are both inverted for the above waveforms, how is the output affected?

There is no change in the output.

Summary

The XNOR Gate



The **XNOR gate** produces a HIGH output only when both inputs are at the same logic level. The truth table is

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

The **XNOR** operation shown as $X = \overline{A}\overline{B} + AB$. Alternatively, the XNOR operation can be shown with a circled dot between the variables. Thus, it can be shown as $X = A \odot B$.