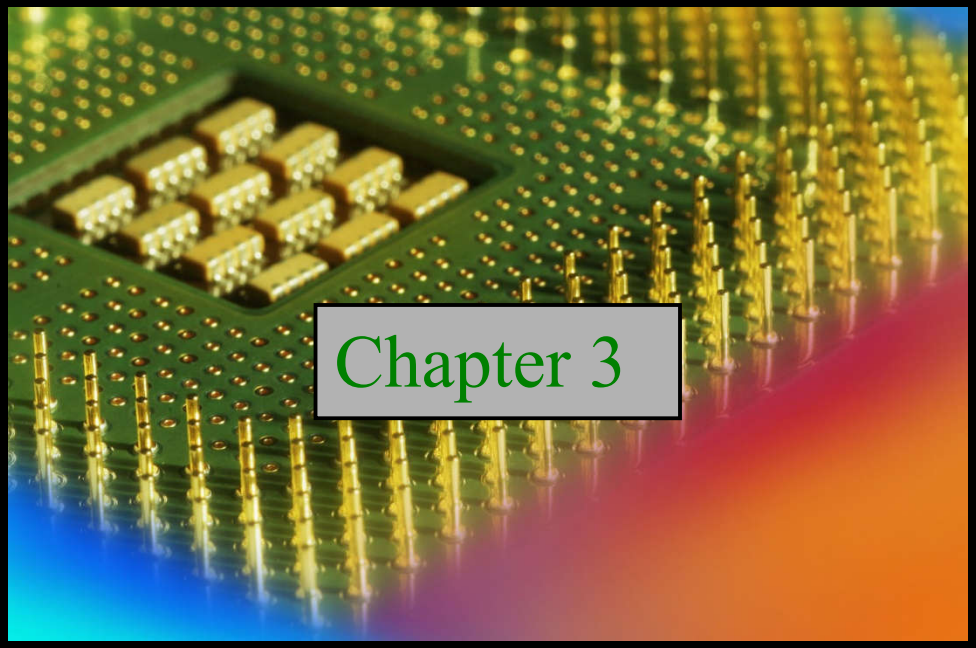
Digital Fundamentals

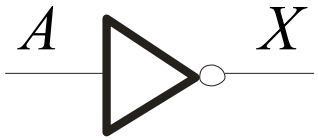
Tenth Edition

Floyd



Summary

The Inverter



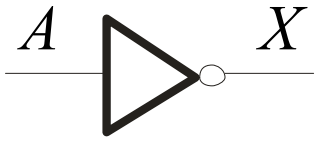
The inverter performs the Boolean **NOT** operation. When the input is LOW, the output is HIGH; when the input is HIGH, the output is LOW.

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

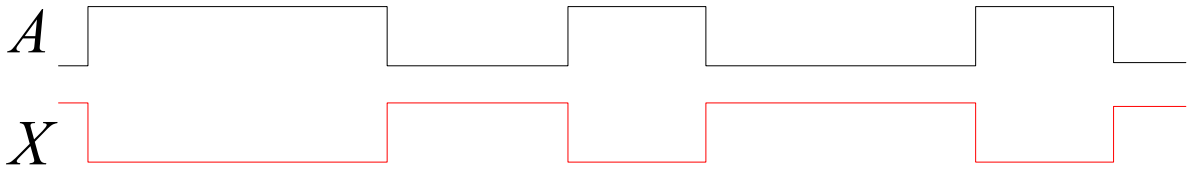
The **NOT** operation (complement) is shown with an overbar. Thus, the Boolean expression for an inverter is $X = \overline{A}$.

Summary

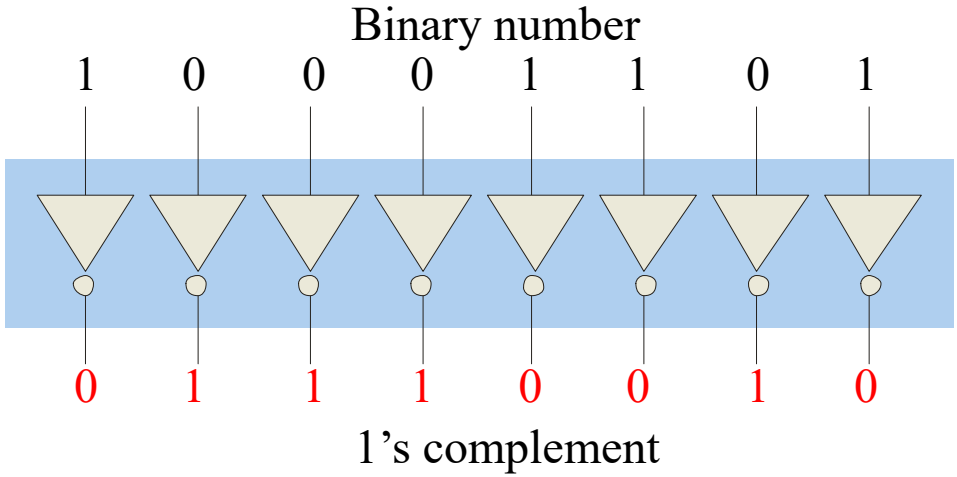
The Inverter



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

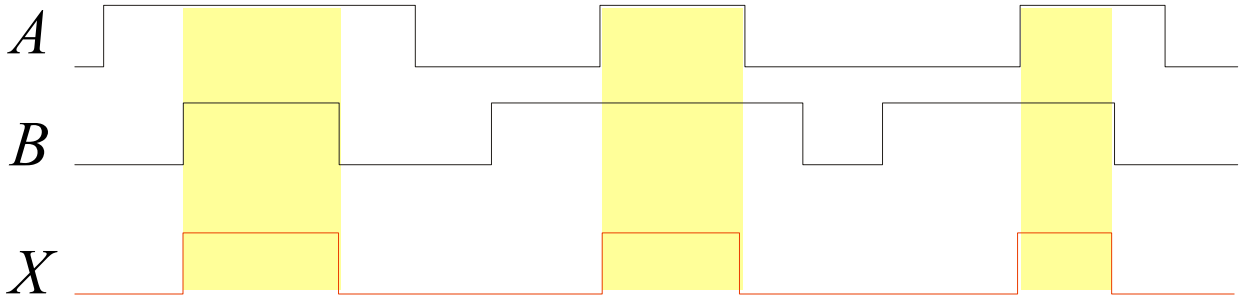
Inputs		Output
A	*B*	*X*
0	0	0
0	1	0
1	0	0
1	1	1

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:

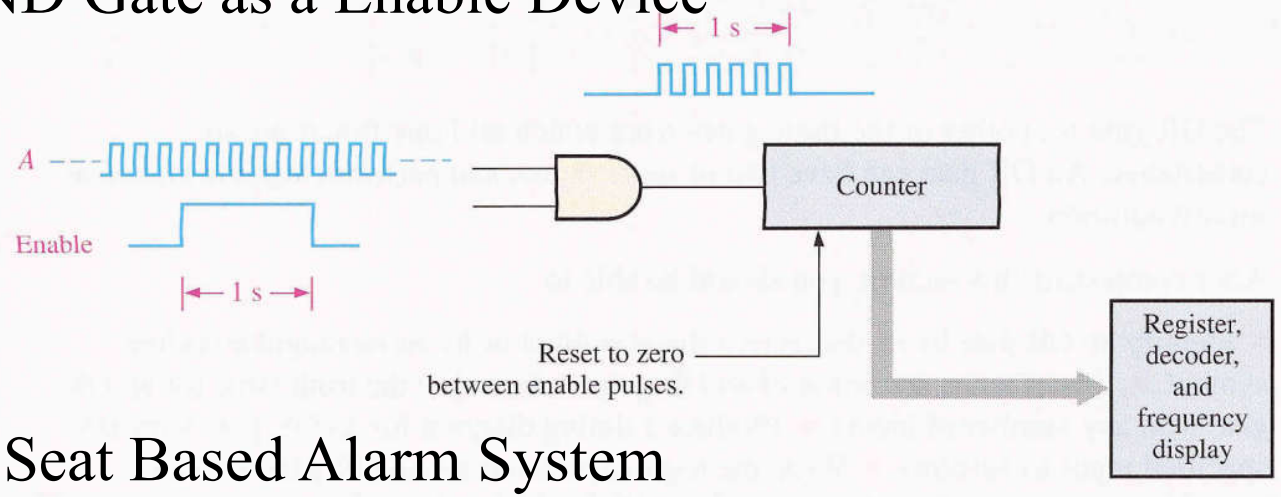


The AND operation is used in computer programming as a selective mask. If you want to retain certain bits of a binary number but reset the other bits to 0, you could set a mask with 1's in the position of the retained bits.

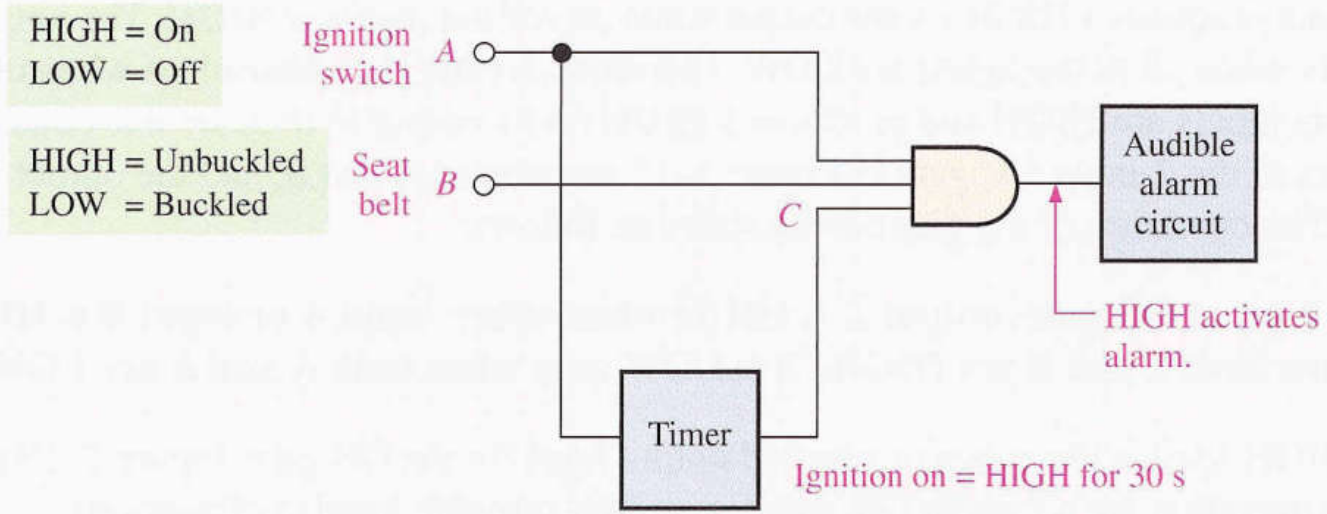
Example If the binary number 10100011 is ANDed with the mask 00001111, what is the result?

Applications

1. AND Gate as a Enable Device



2. A Seat Based Alarm System



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

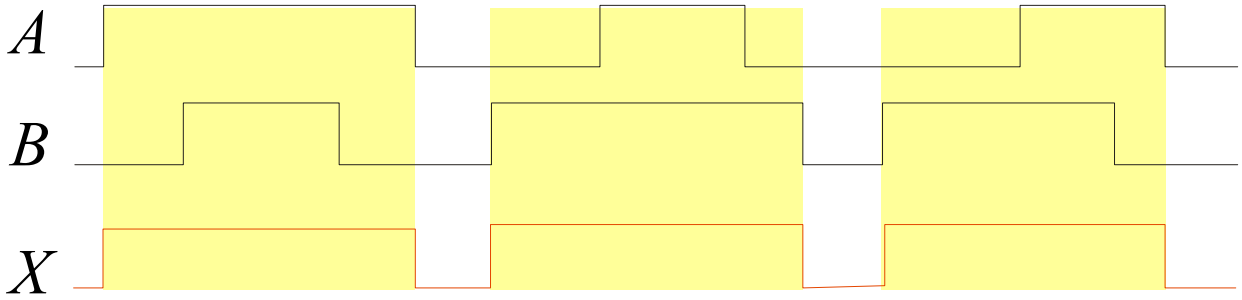
Inputs		Output
A	*B*	*X*
0	0	0
0	1	1
1	0	1
1	1	1

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.

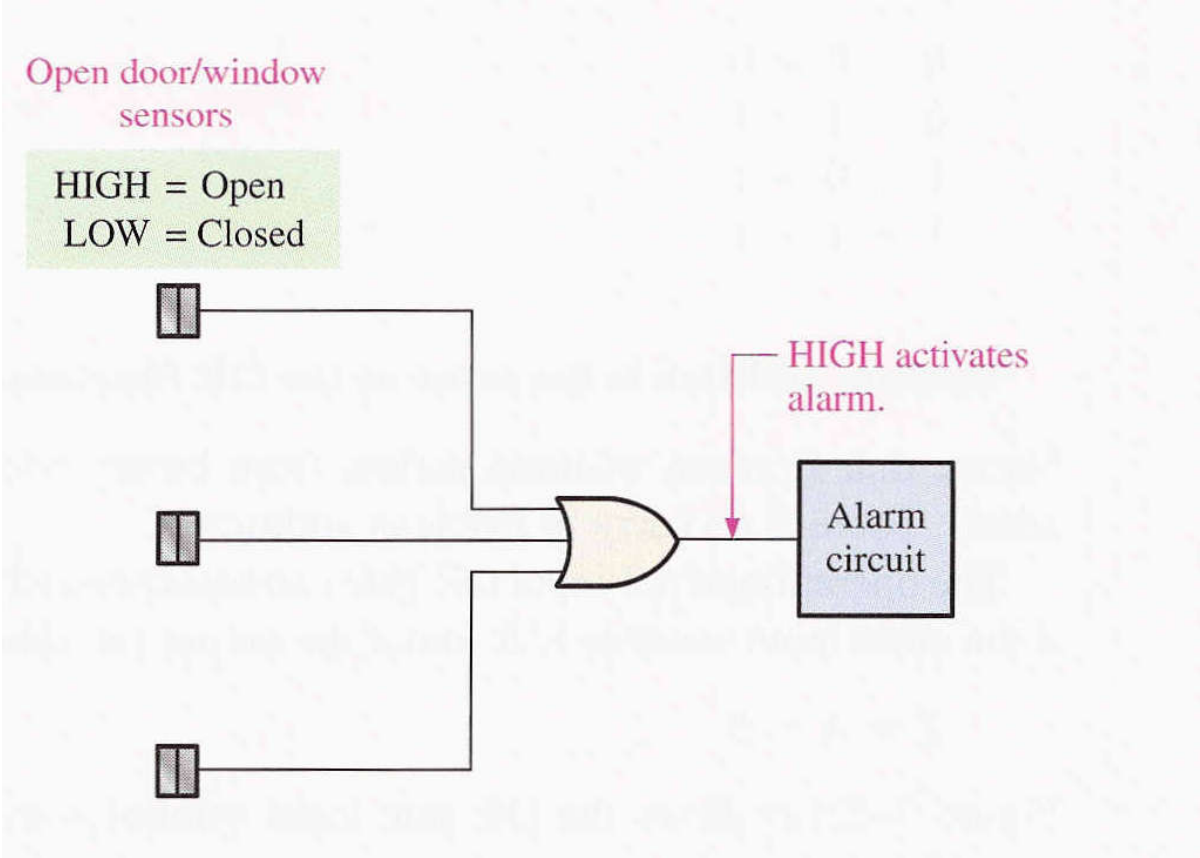
Example

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 a lower case ASCII letter with the 8-bit mask 00100000?

Solution

Applications

1. Intrusion Detection



Summary

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

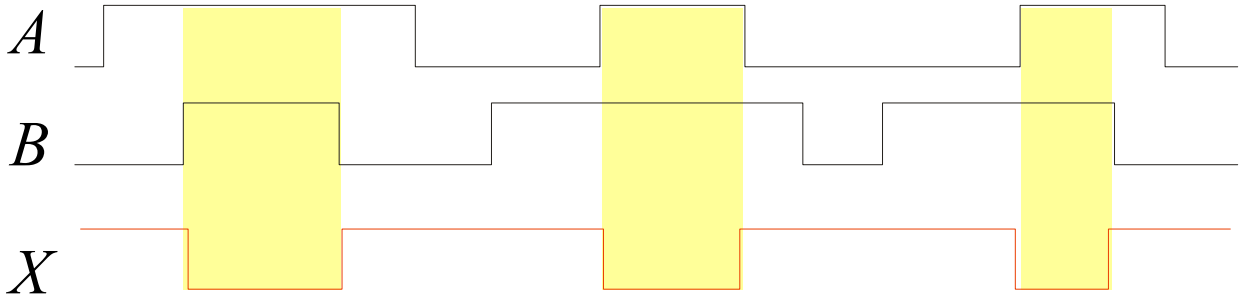
Inputs		Output
A	*B*	*X*
0	0	1
0	1	1
1	0	1
1	1	0

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:

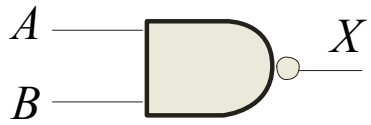


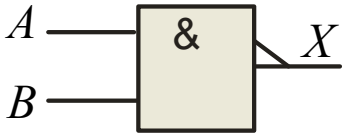
The NAND gate is particularly useful because it is a "universal" gate – all other basic gates can be constructed from NAND gates.

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

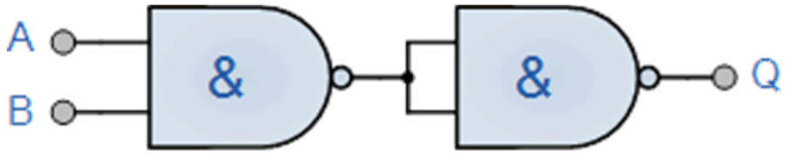
Summary

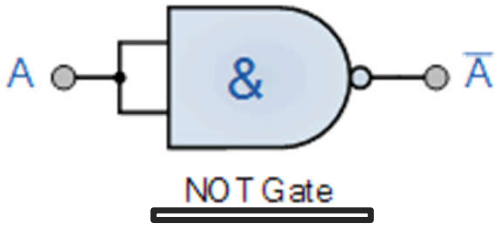
The NAND Gate

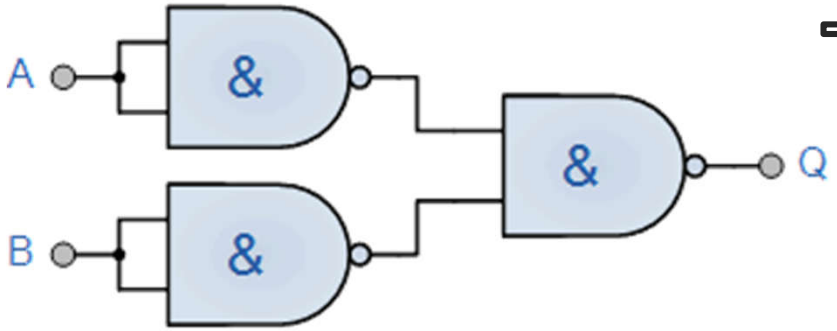




Universality of NAND Gate:





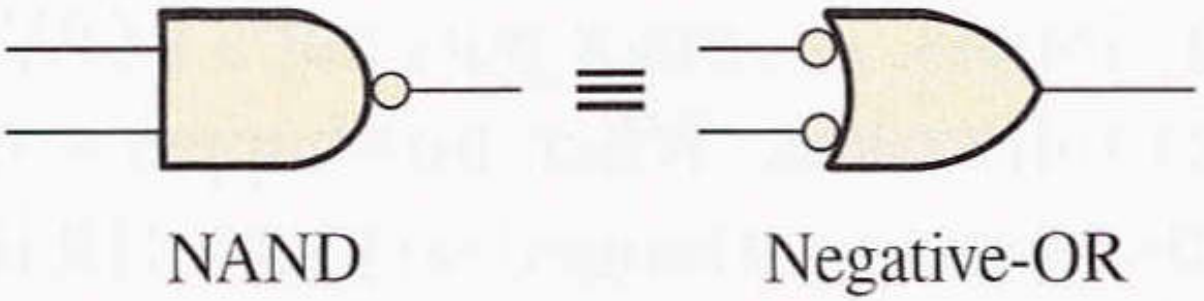


Summary

Negative OR Equivalent operation NAND Gate

For a 2-input NAND gate performing a negative-OR operation, output *X* is HIGH when either input *A* or input *B* is LOW, or when both *A* and *B* are LOW.

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

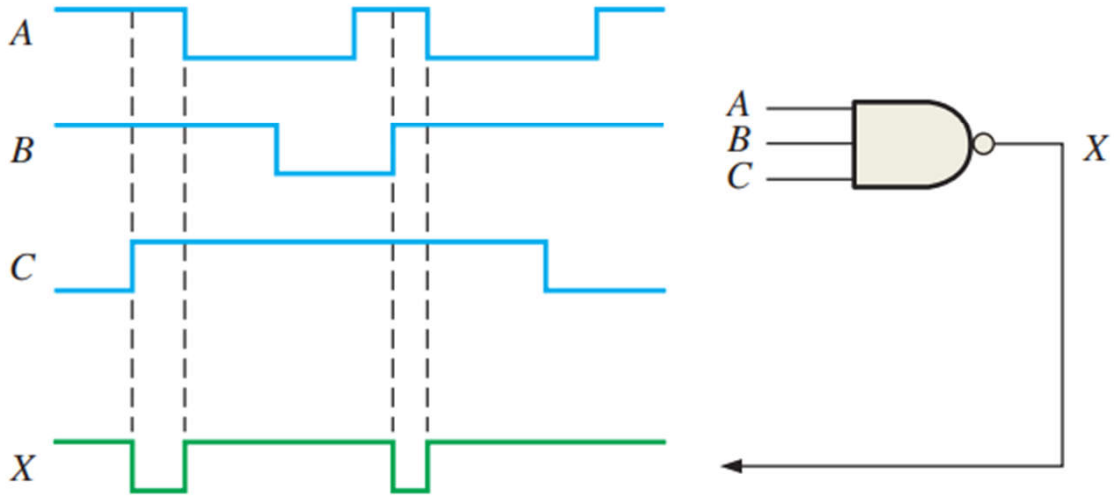


Summary

Negative OR Equivalent operation NAND Gate

EXAMPLE 3–11

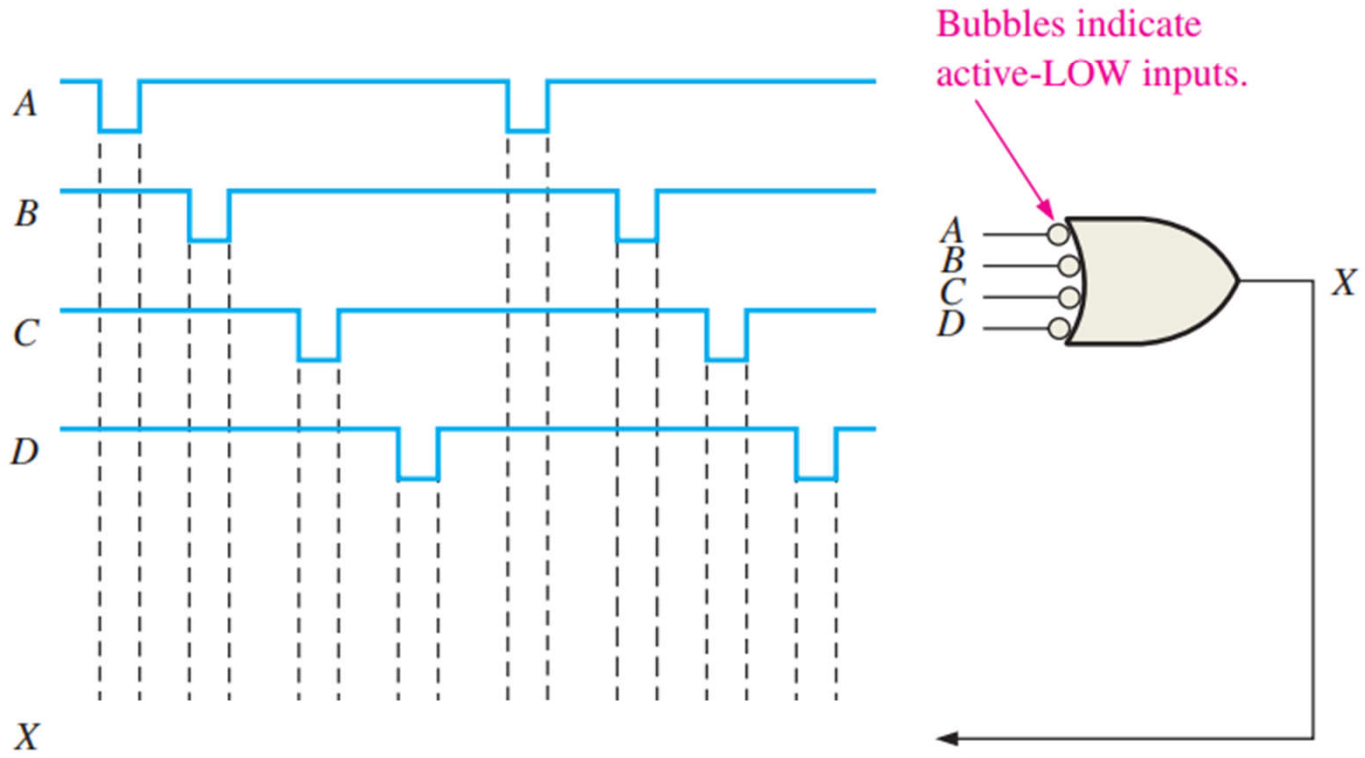
Show the output waveform for the 3-input NAND gate in Figure 3–29 with its proper time relationship to the inputs.



Summary

EXAMPLE 3–14

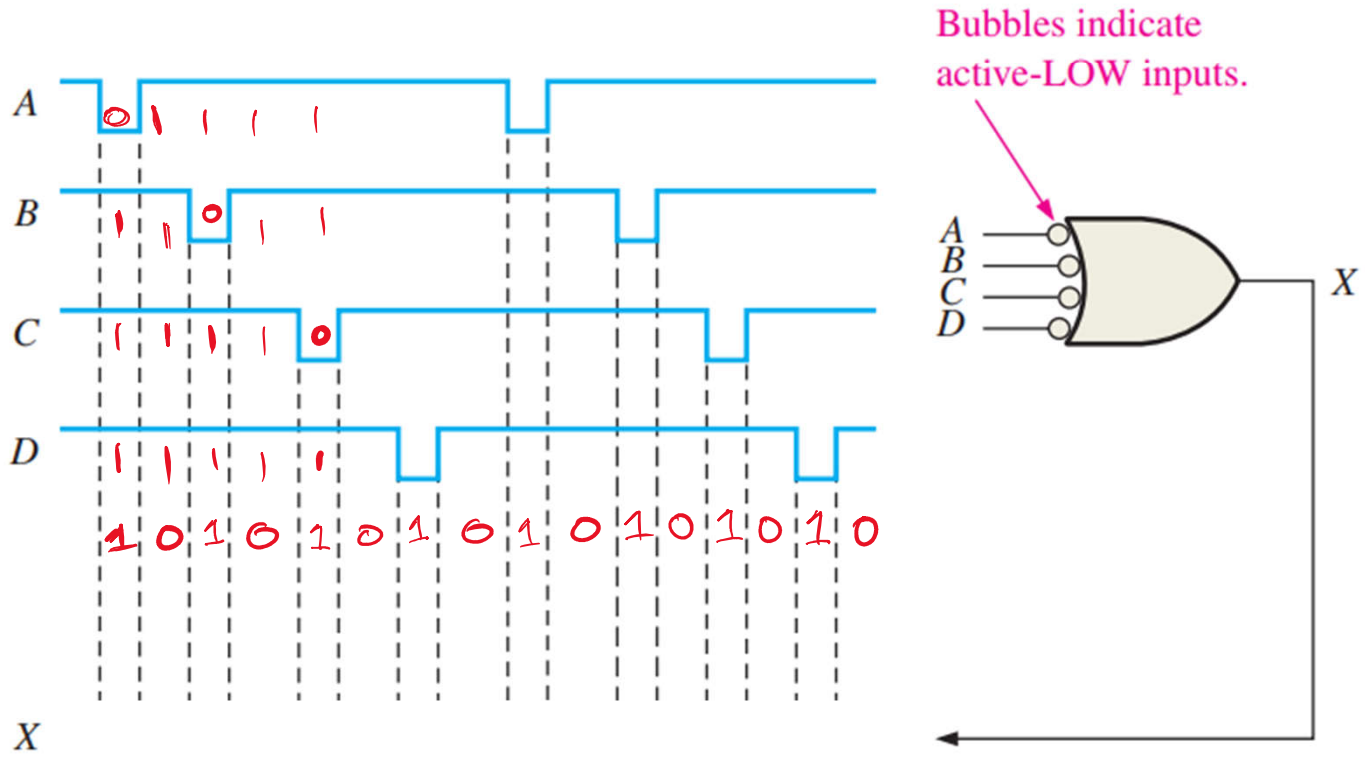
For the 4-input NAND gate in Figure 3–33, operating as a negative-OR gate, determine the output with respect to the inputs.



Summary

EXAMPLE 3–14

For the 4-input NAND gate in Figure 3–33, operating as a negative-OR gate, determine the output with respect to the inputs.



Summary

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

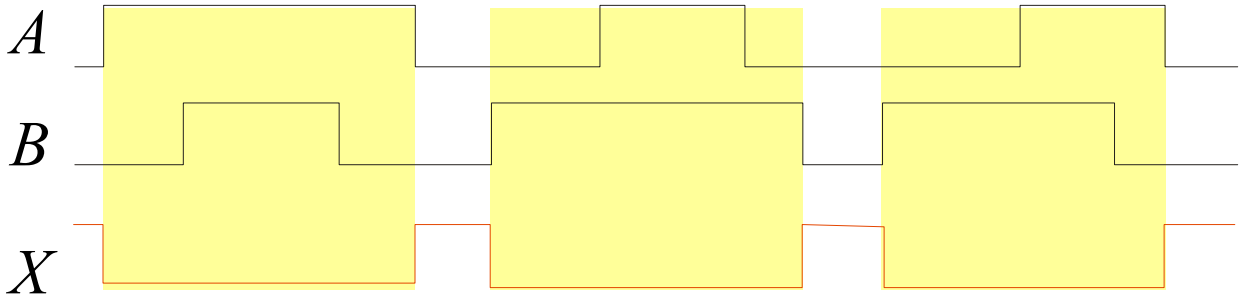
Inputs		Output
A	*B*	*X*
0	0	1
0	1	0
1	0	0
1	1	0

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

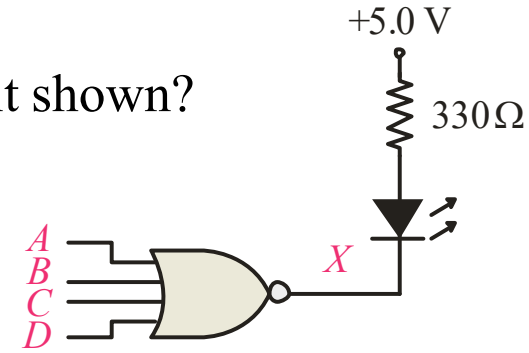
The NOR Gate

Example waveforms:



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

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

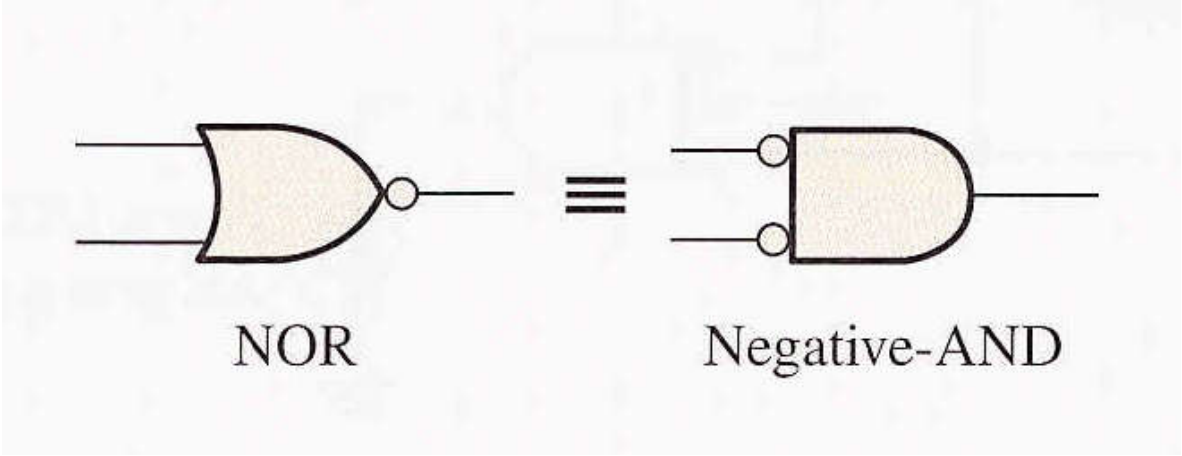


Solution

Summary

Negative AND Equivalent operation NOR Gate

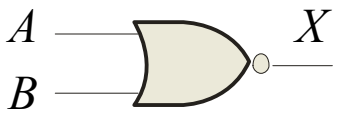
For a 2-input NOR gate performing a negative-AND operation, output *X* is HIGH only when both inputs *A* and *B* are LOW.

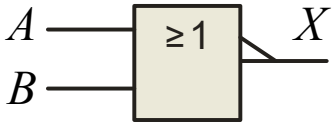


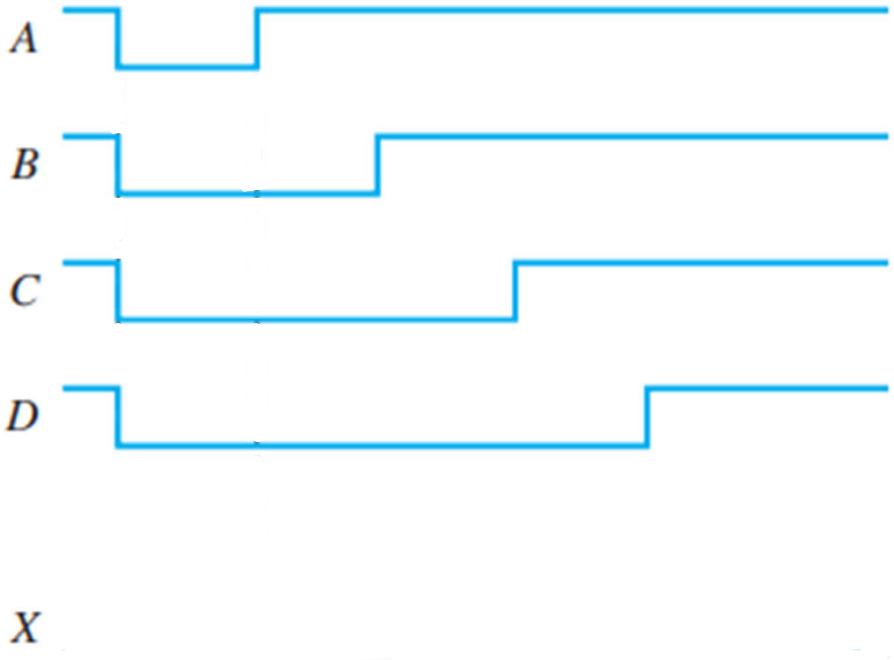
$$X = \overline{A + B} = \overline{A}.\overline{B}$$

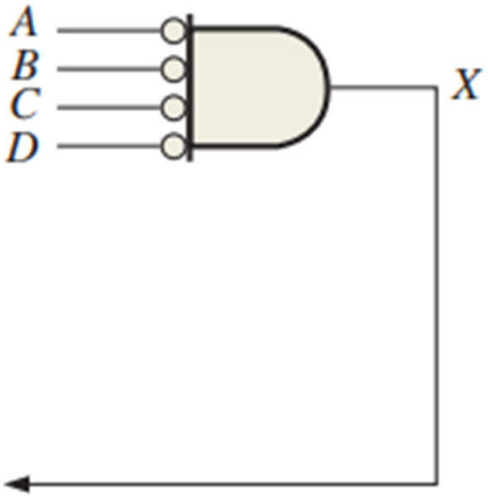
Summary

The NOR Gate



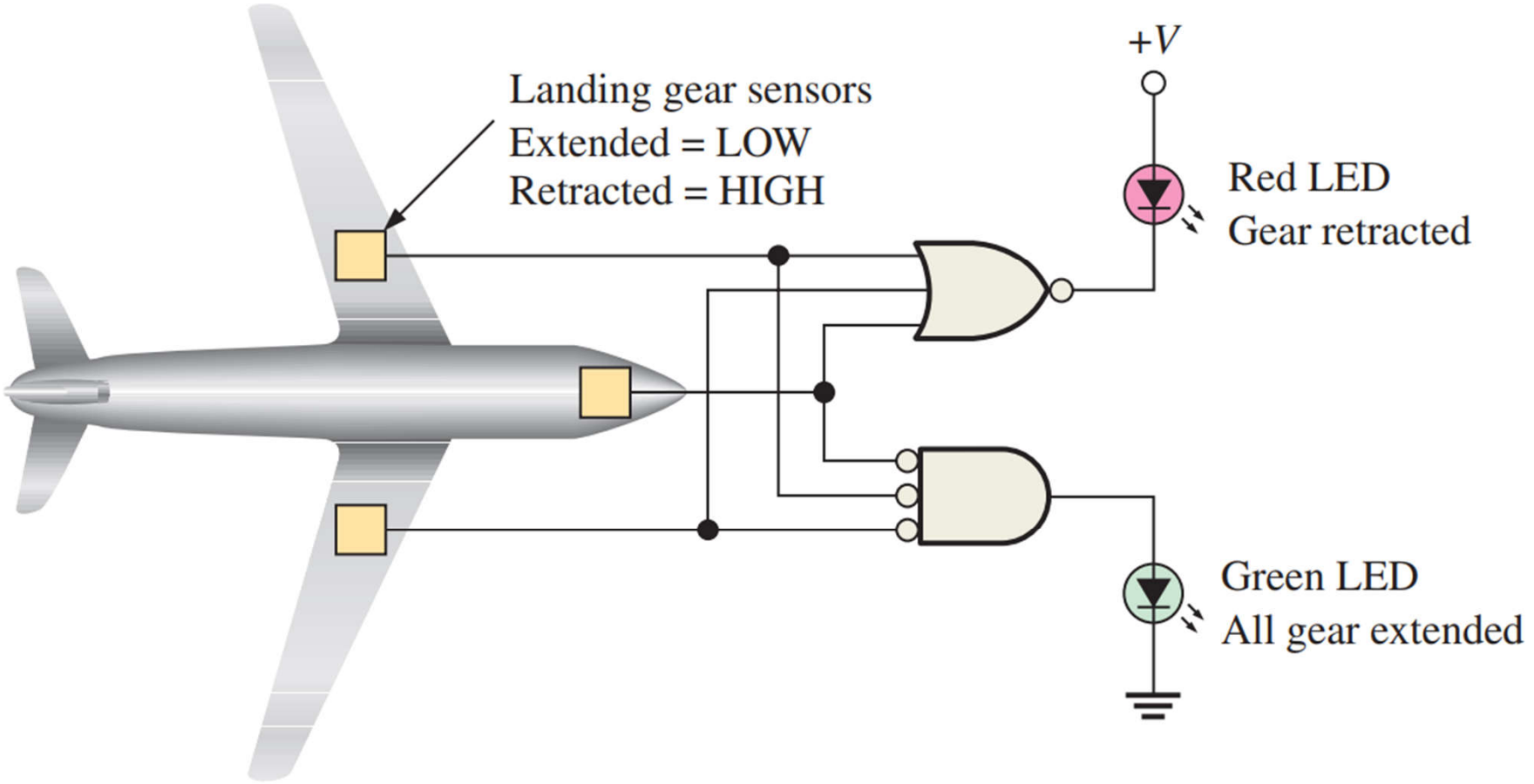


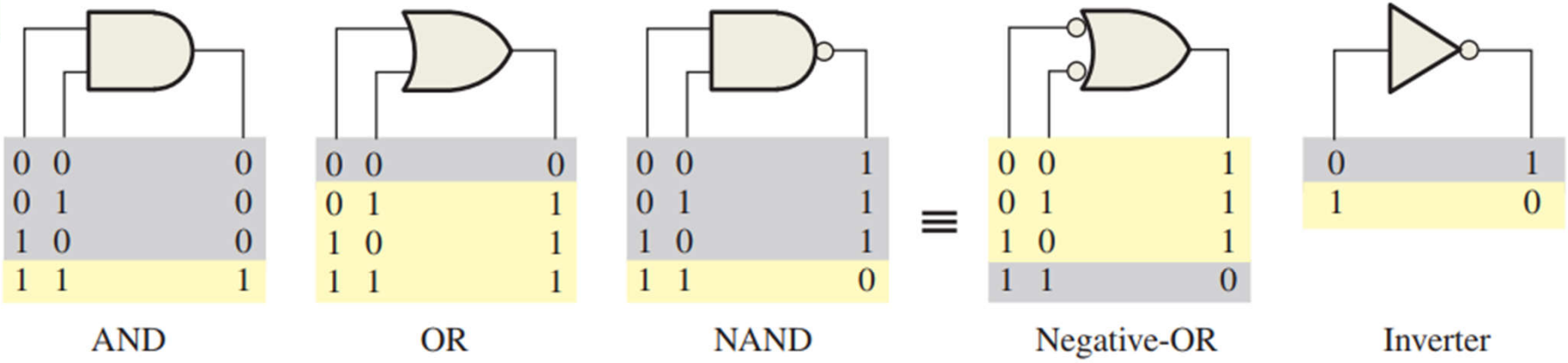


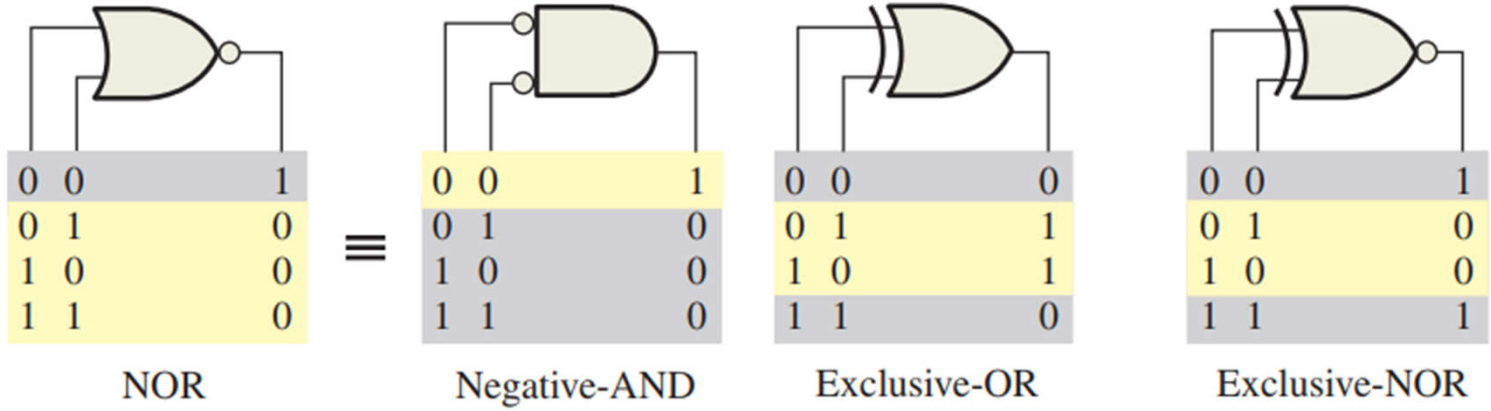


Summary

EXAMPLE 3–18







Note: Active states are shown in yellow.

Homework:

Problems from digital fundamentals by Floyd

2,3,6,18