DLD
Digital Logic Design

Department of Computer Science & IT

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Today Agenda

- Logic Gates

Digital and Analog Quantities

- The term digital is derived from the way operations are performed, by counting digits.
- Digital electronics involves quantities with discrete values, and analog electronics involves quantities with continuous values.

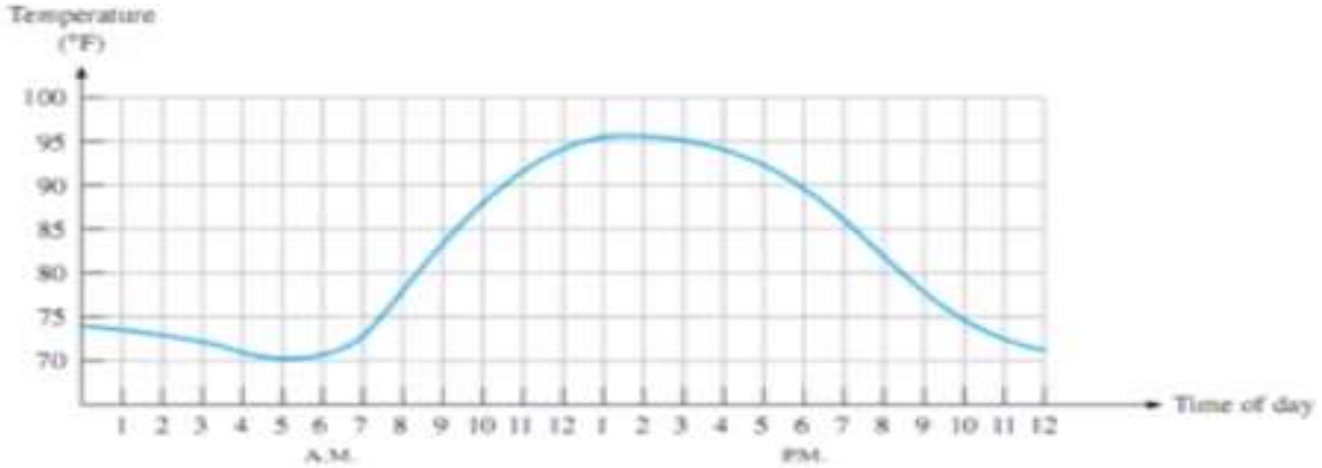


FIGURE 1–1 Graph of an analog quantity (temperature versus time).

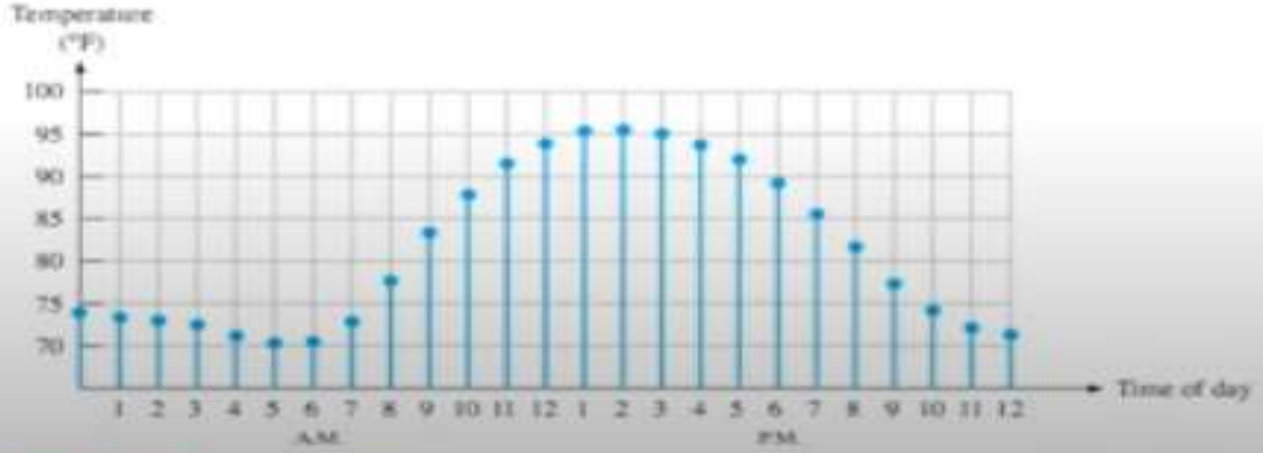


FIGURE 1–2 Sampled-value representation (quantization) of the analog quantity in Figure 1–1. Each value represented by a dot can be digitized by representing it as a digital code that consists of a series of 1s and 0s.

The Digital Advantage

- Digital representation has certain advantages over analog representation in electronics applications:
- Digital data can be processed and transmitted more efficiently and reliably than analog data.
- Digital data has a great advantage when storage is necessary. For example, music when converted to digital form can be stored more compactly and reproduced with greater accuracy and clarity than is possible when it is in analog form.
- Noise (unwanted voltage fluctuations) does not affect digital data nearly as much as it does analog signals.

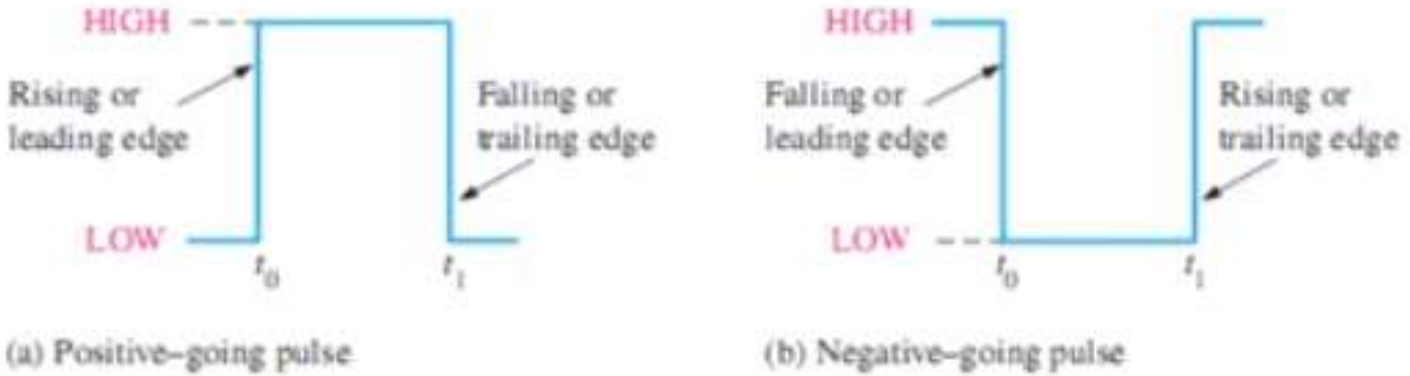
Binary Digits

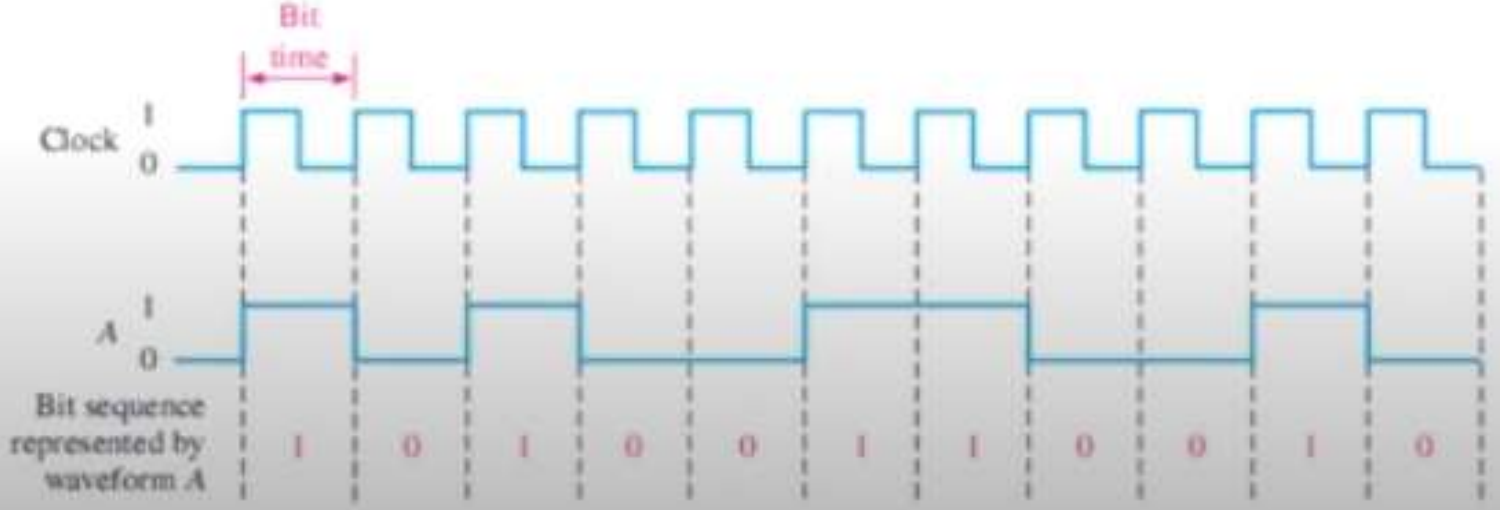
- Digital electronics involves circuits and systems in which there are only two possible states.
- These states are represented by two different voltage levels (or can also be represented by current levels): A HIGH and a LOW.
- In digital systems such as computers, combinations of states, called codes, are used to represent numbers, symbols, alphabetic characters, and other types of information.
- The two-state number system is called binary, and its two digits are 0 and 1. A binary digit is called a bit.

Logic Levels

- The voltages used to represent a 1 and a 0 are called logic levels.
- Ideally, one voltage level represents a HIGH and another voltage level represents a LOW.
- In a practical digital circuit, however, a HIGH can be any voltage between a specified minimum value and a specified maximum value. Likewise, a LOW can be any voltage between a specified minimum and a specified maximum.
- There can be no overlap between the accepted range of HIGH levels and the accepted range of LOW levels.

Digital Waveforms

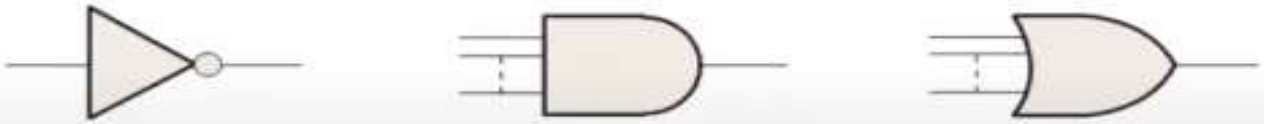




Logic Gates

Logic Gates / Logic Function

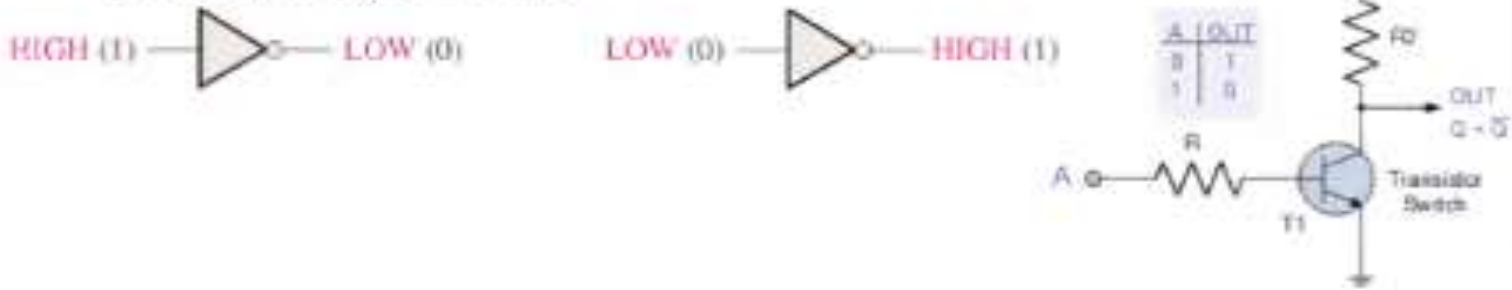
- The term logic is applied to digital circuits used to implement logic functions.
- Several kinds of digital logic circuits are the basic elements that form the building blocks for such complex digital systems as the computer.
- Three basic logic functions are:



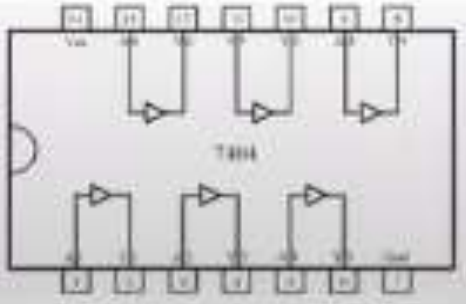
- Each of the three basic logic functions produces a unique response to a given set of conditions, Either a High (1) or Low (0).

Logic Gates / Logic Function

- **NOT:** The NOT function changes one logic level to the opposite logic level.

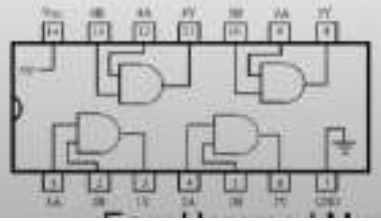


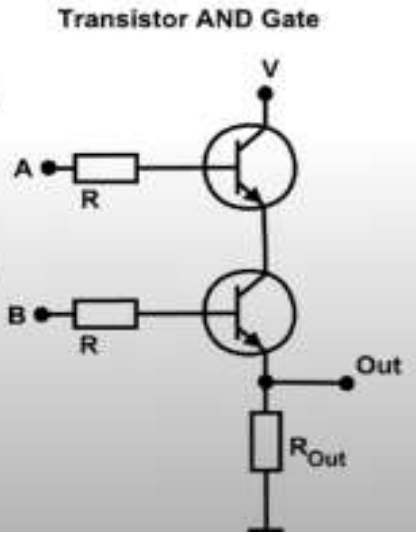
- The NOT function is implemented by a logic circuit known as an "inverter".



Logic Gates / Logic Function

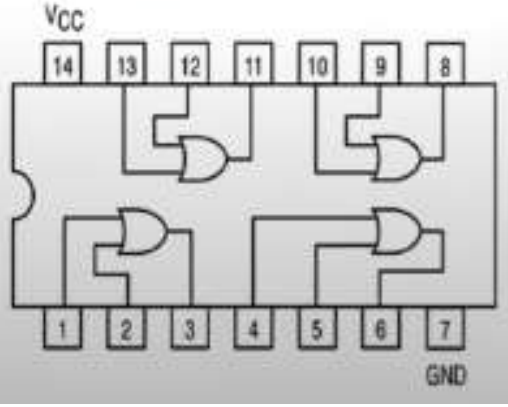
- **AND:** The AND function produces a HIGH output only when all the inputs are HIGH.
- When any or all inputs are LOW, the output is LOW.

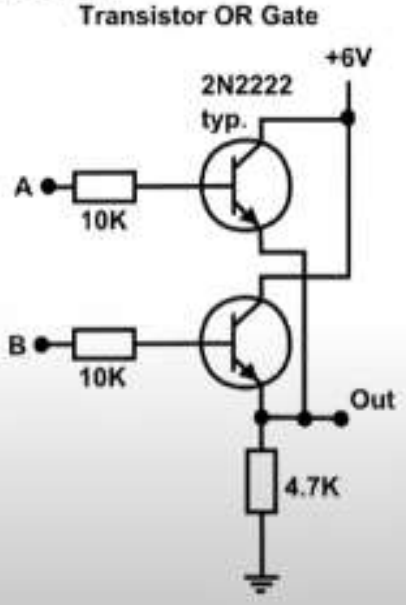




Logic Gates / Logic Function

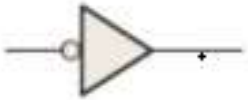
- **OR:** The OR function produces a HIGH output when one or more inputs are HIGH.
- When both inputs are LOW, the output is LOW.



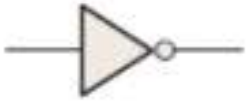


Review Questions

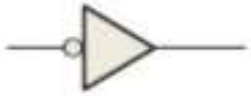
- What is the difference between digital and analog quantities?
- State the advantages of digital over analog.
- Define binary.
- Define bit.
- How voltage levels are used to represent bits?
- What is a logic gate?



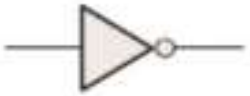
The Inverter



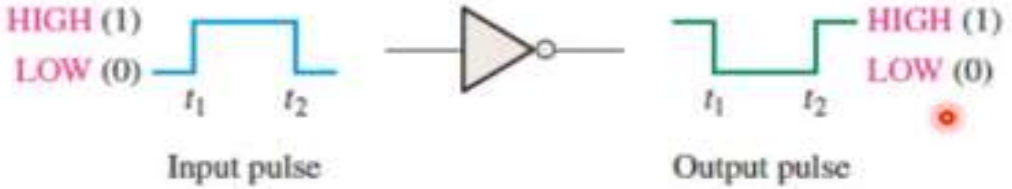
- The inverter (NOT circuit) performs the operation called *inversion* or *complementation*.
- The inverter changes one logic level to the opposite level.
- In terms of bits, it changes a 1 to a 0 and a 0 to a 1.
- The negation indicator is a “bubble” (O) that indicates **inversion** or *complementation* when it appears on the input or output of any logic element, for the inverter.
- Generally, inputs are on the left of a logic symbol and the output is on the right.



The Inverter

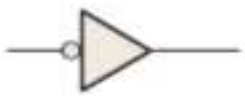


- When appearing on the output, the bubble means that a 0 is the active or asserted output state, and the output is called an active-LOW output.
- The absence of a bubble on the input or output means that a 1 is the active or asserted state, and in this case, the input or output is called active-HIGH.
- When the input is LOW, the output is HIGH; when the input is HIGH, the output is LOW, thereby producing an inverted output pulse.

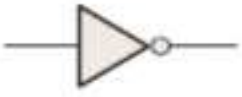


Inverter truth table.

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

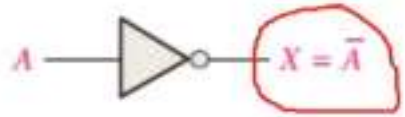


The Inverter



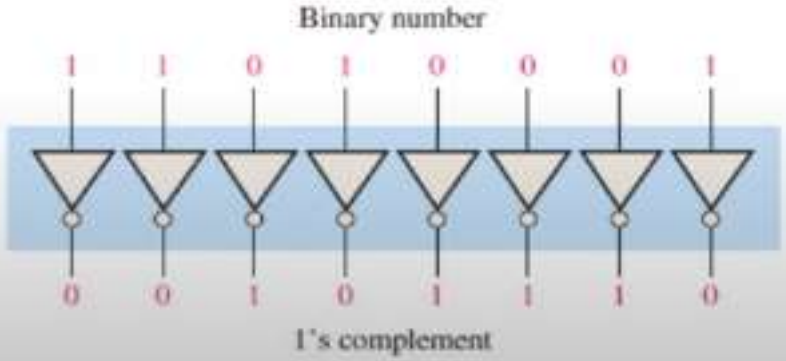
- Logic Expression for an Inverter:

$$X = \overline{A}$$



- Where, the input variable is called *A* and the output variable is called *X*,

An Application

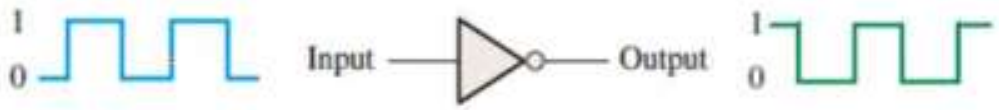


Example of a 1's complement circuit using inverters.

Example

EXAMPLE 3–1

A waveform is applied to an inverter in Figure 3–4. Determine the output waveform corresponding to the input and show the timing diagram. According to the placement of the bubble, what is the active output state?



The AND Gate

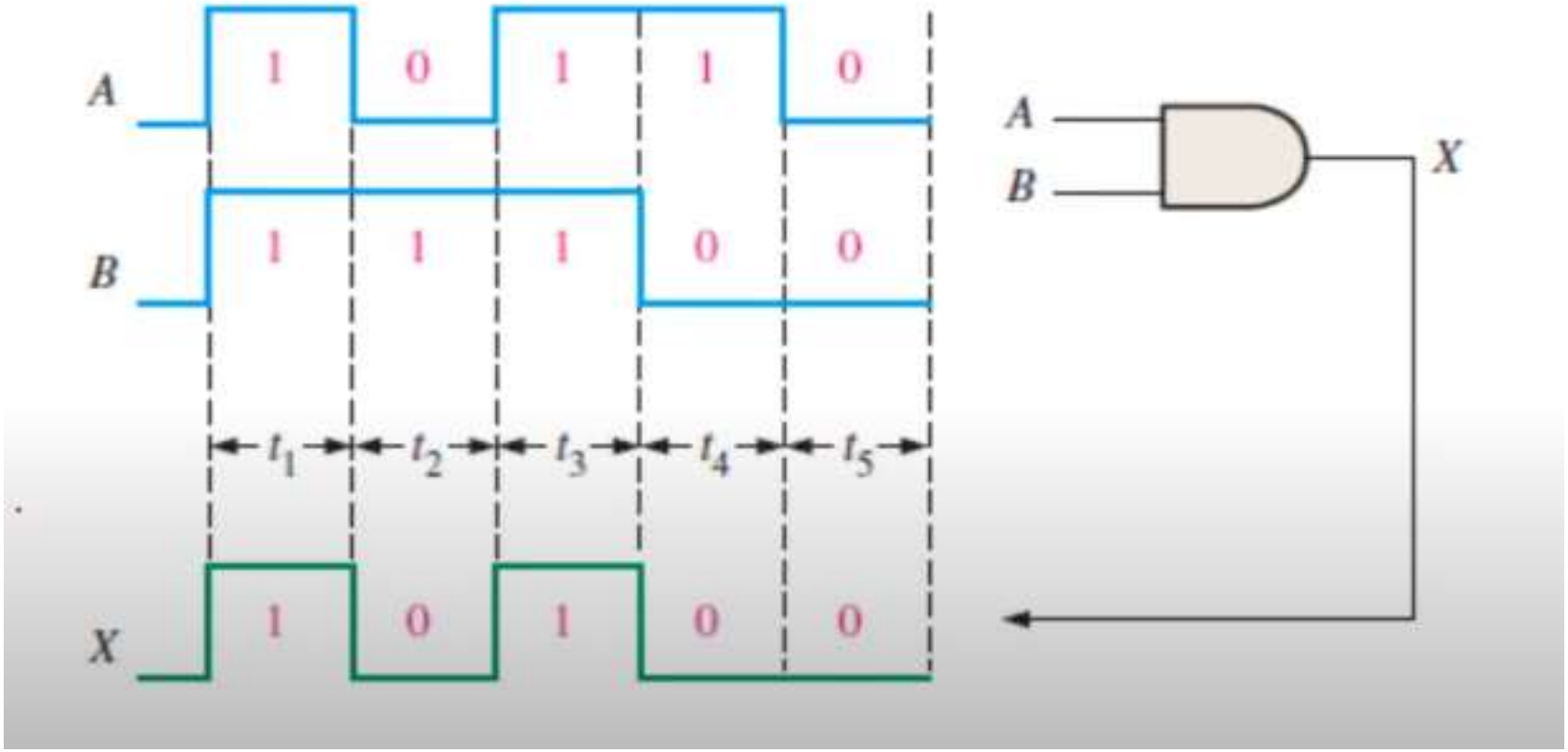
- An AND gate can have two or more inputs and performs what is known as logical multiplication.
- An **AND gate** produces a HIGH output *only* when *all* of the inputs are HIGH.
- When any of the inputs is LOW, the output is LOW.
- Therefore, the basic purpose of an AND gate is to determine when certain conditions are simultaneously true.

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

1 = HIGH, 0 = LOW

AND Gate Operation with Waveform Inputs (Timing Diagram)



EXAMPLE 3–3

If two waveforms, *A* and *B*, are applied to the AND gate inputs as in Figure 3–11, what is the resulting output waveform?

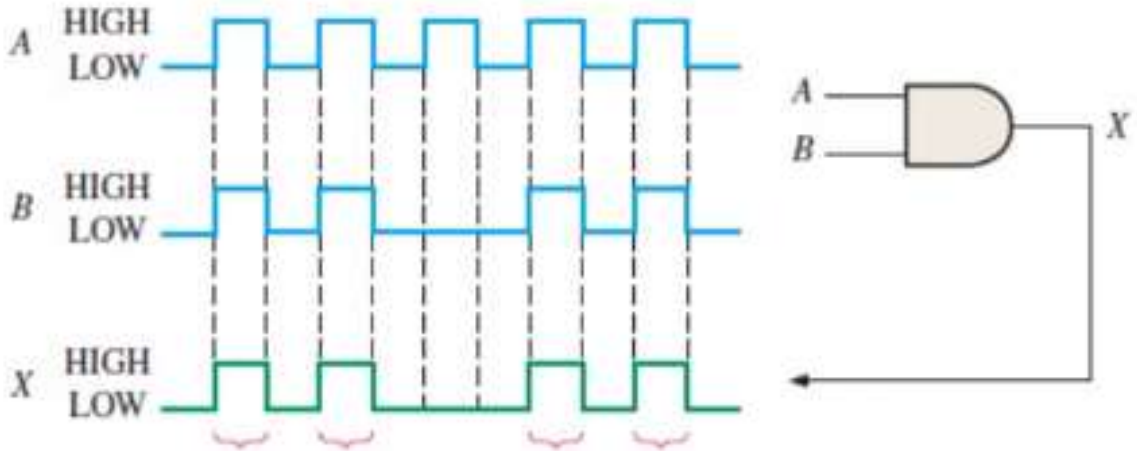


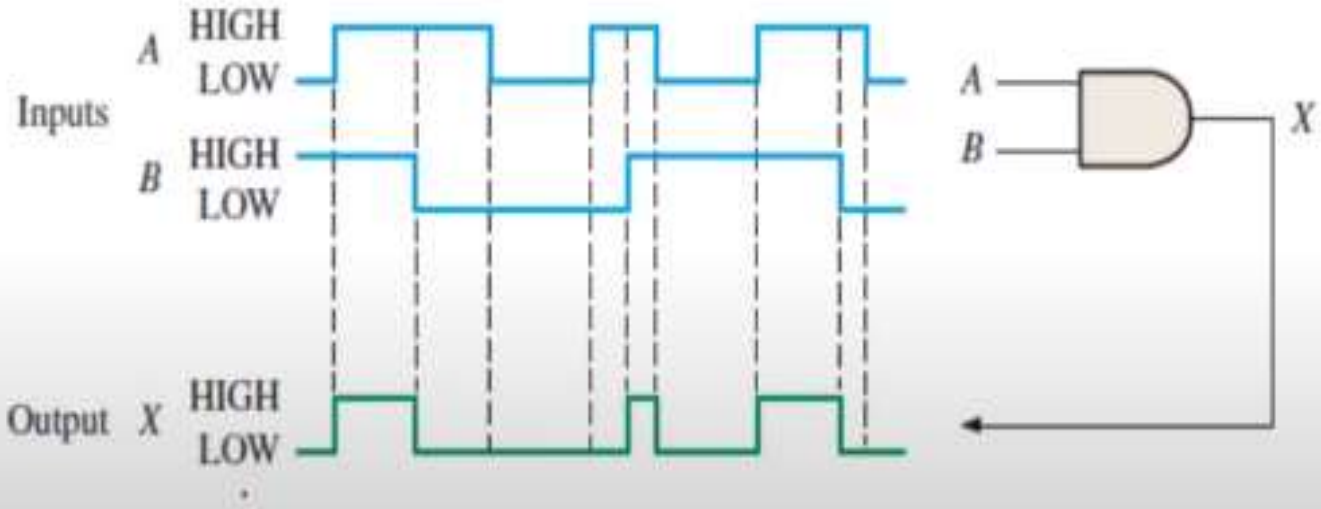
FIGURE 3–11

Solution

The output waveform *X* is HIGH only when both *A* and *B* waveforms are HIGH as shown in the timing diagram in Figure 3–11.

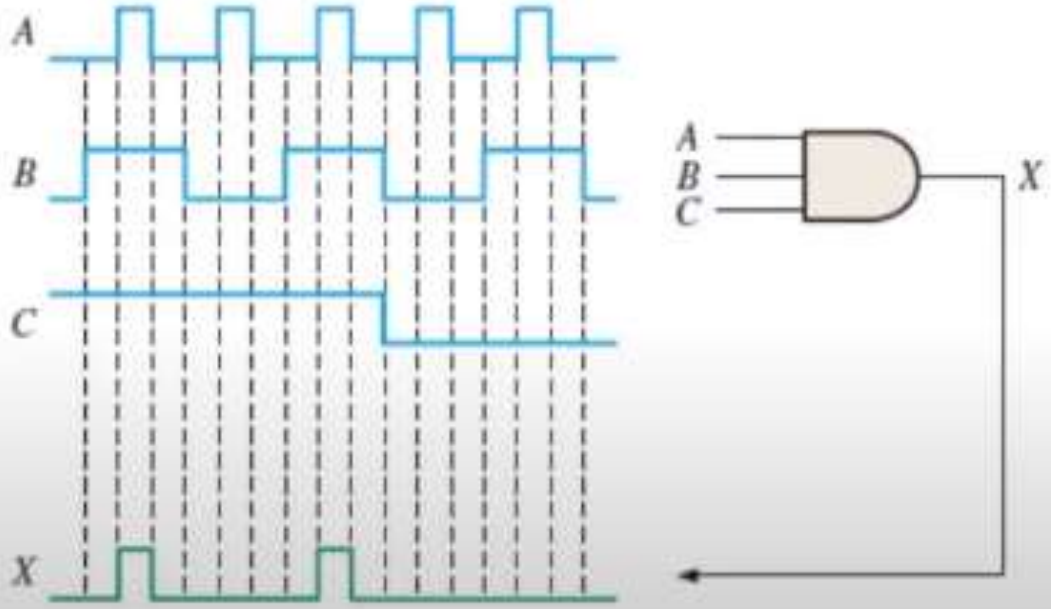
EXAMPLE 3–4

For the two input waveforms, *A* and *B*, in Figure 3–12, show the output waveform with its proper relation to the inputs.



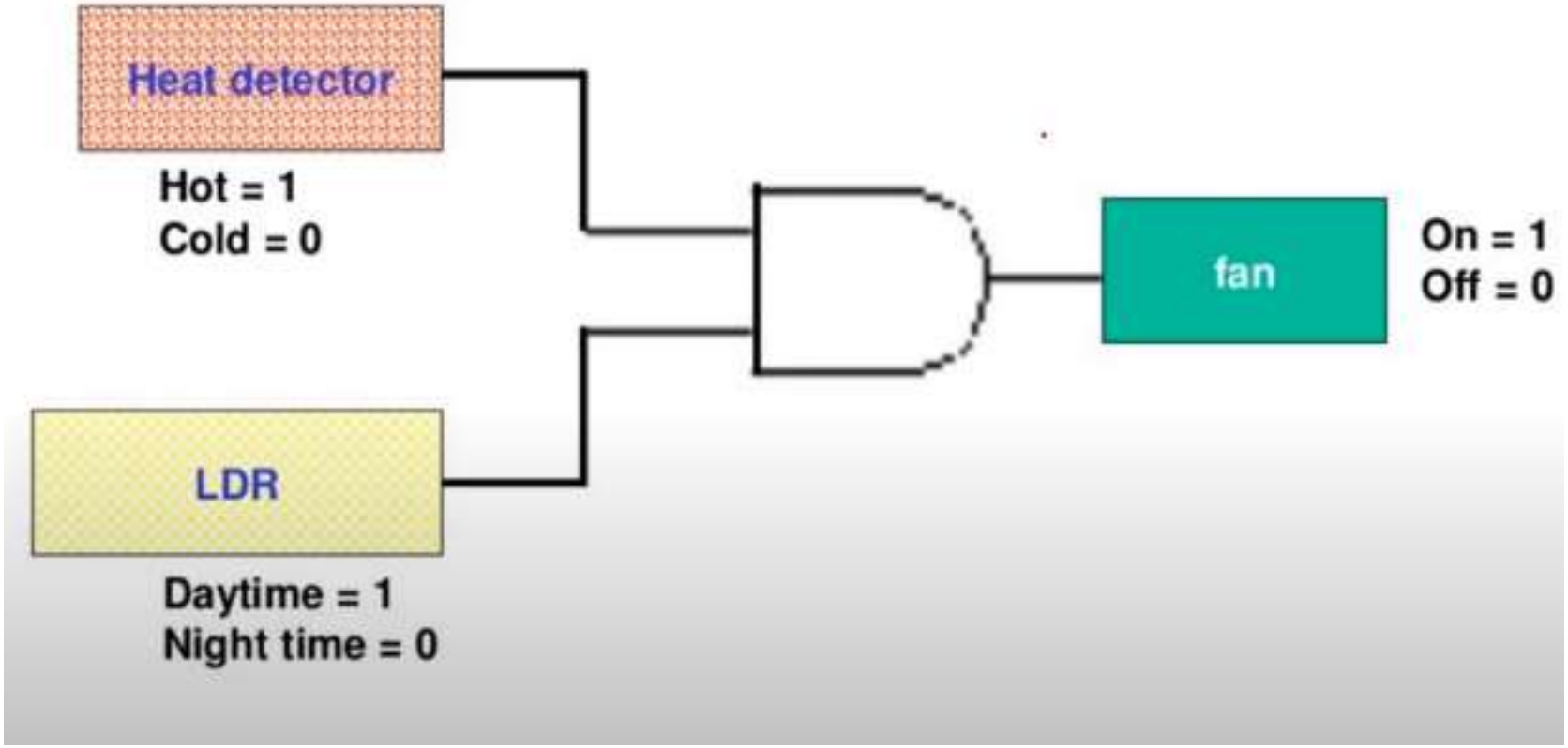
EXAMPLE 3–5

For the 3-input AND gate in Figure 3–13, determine the output waveform in relation to the inputs.



Application of AND Gate

Automatic fan control system



Logic Expressions for an AND 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:

$$X = AB \quad or \quad X = A \bullet B$$

A	*B*	*AB* = *X*
0	0	$0 \cdot 0 = 0$
0	1	$0 \cdot 1 = 0$
1	0	$1 \cdot 0 = 0$
1	1	$1 \cdot 1 = 1$