

XMUT 202

Digital Electronics

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*Te Whare Wānanga
o te Ūpoko o te Ika a Māui*



CAPITAL CITY UNIVERSITY

Review of Logic Gates

- What is a **logic gate**?

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 - An electronic component that can be used to conduct electricity based on a rule.

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 - An electronic component that can be used to conduct electricity based on a rule.
 - The output of the logic gate is the result of applying this rule to one or more inputs.

Review of Logic Gates

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- Boolean algebra is an important tool in describing, analyzing, designing, and implementing digital circuits.

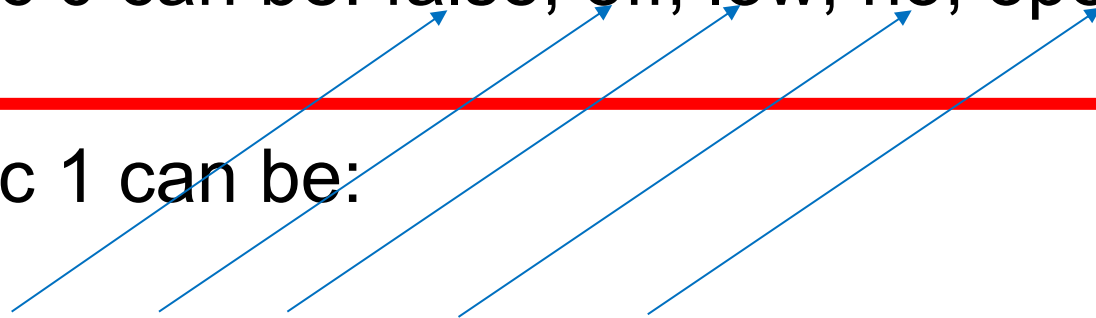
Boolean Constants and Variables

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Boolean Constants and Variables

- Boolean algebra allows only two values; 0 and 1.
- Logic 0 can be: false, off, low, no, open switch.
- Logic 1 can be: true, on, high, yes, closed switch.
- Three basic logic operations: **OR**, **AND**, and **NOT**.

Truth Tables

- A truth table describes the relationship between the inputs and output of a logic circuit.

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Inputs

Output

A	B	X
0	0	1
0	1	0
1	0	1
1	1	0

Truth Tables

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Number of inputs = 2

Number
of
entries
= $2^2 = 4$

A	B	X
0	0	1
0	1	0
1	0	1
1	1	0

Truth Tables

- The number of entries corresponds to the number of inputs.
 - A 3 inputs table will have 2^3 or 8 entries.

Number of inputs = 3

Number
of
entries
= $2^3 = 8$

A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Truth Tables

- Truth table with 4 inputs.

Number of inputs = 4

Number
of
entries
= $2^4 = 16$

A	B	C	D	x
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

1) OR operation with OR Gate

- The Boolean expression for the

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- Truth table for a two inputs OR gate.

OR

A	B	$x = A + B$
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1	0	1
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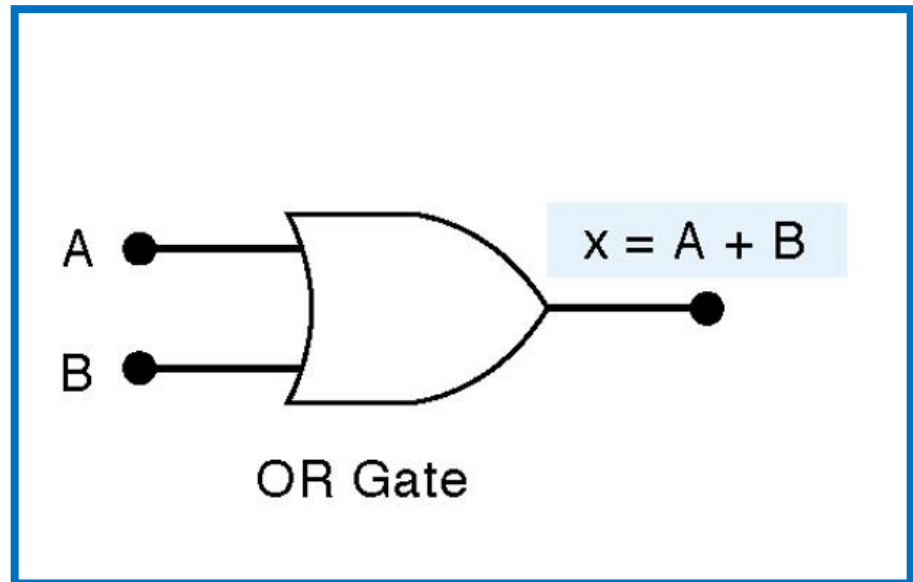
A	B	$X = A + B$
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0	1	$X = 0 + 1 = 1$
1	0	$X = 1 + 0 = 1$
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1) OR operation with OR Gate

- Truth table and circuit symbol for a two input OR gate.

OR

A	B	$x = A + B$
0	0	0
0	1	1
1	0	1
1	1	1



1) OR Operation With OR Gates

- The OR operation is similar to addition but when A and B are 1, the OR operation produces $1 + 1 = 1$.

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- The OR operation is similar to addition but where A and B are 1, the OR operation produces $1 + 1 = 1$.

- In the Boolean expression

$$X = 1 + 1 + 1 = 1$$

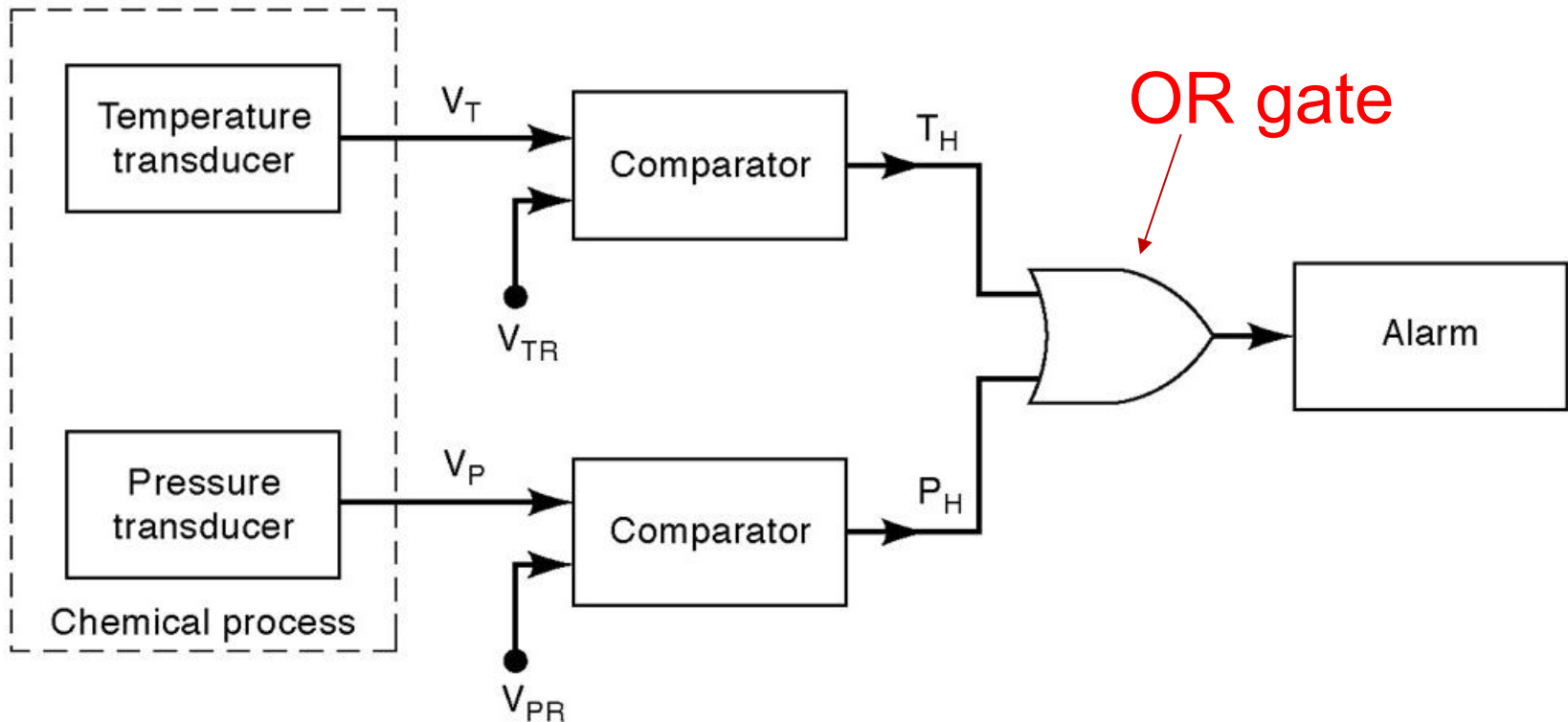
We could say that x is true (1) when A is true (1) OR B is true (1) OR C is true (1).

1) OR Operation With OR Gates

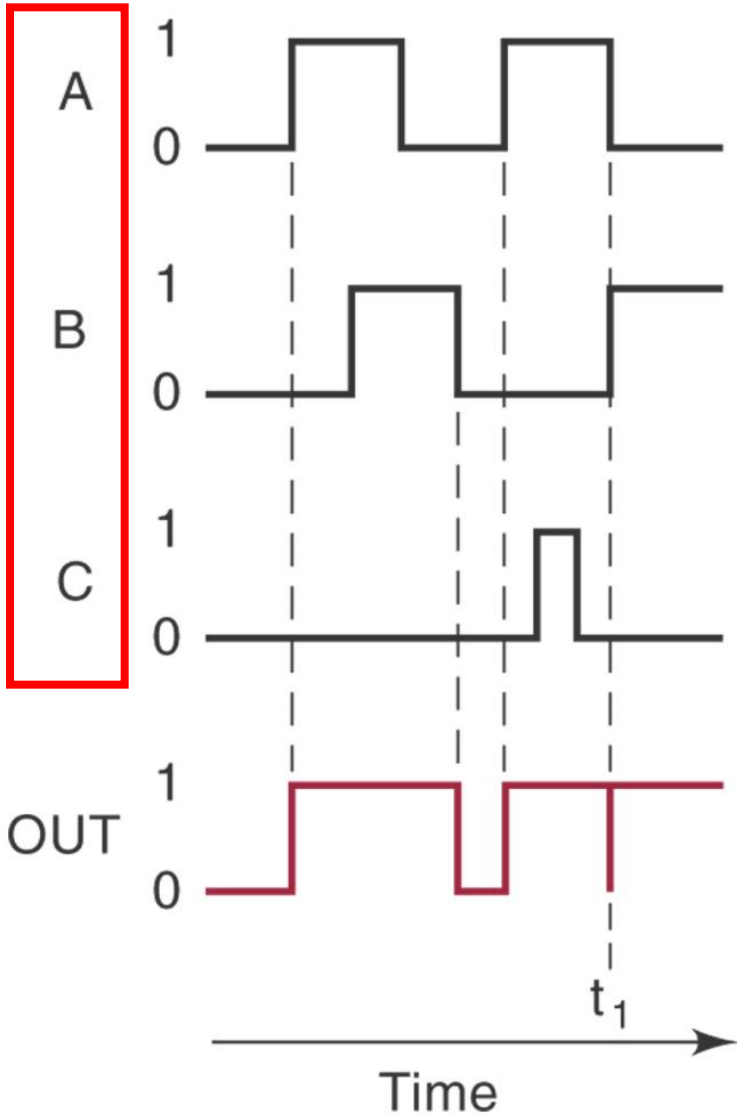
- There are many examples of applications where an output function is desired when one of multiple inputs is activated.

1) OR Operation With OR Gates

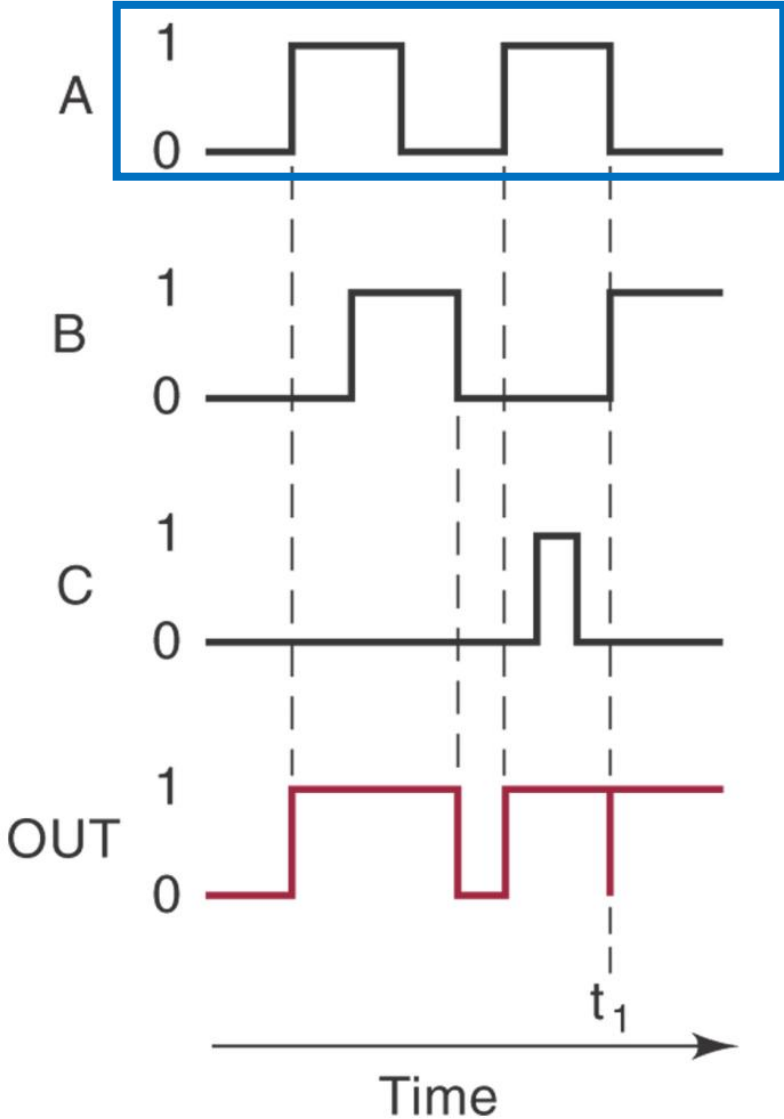
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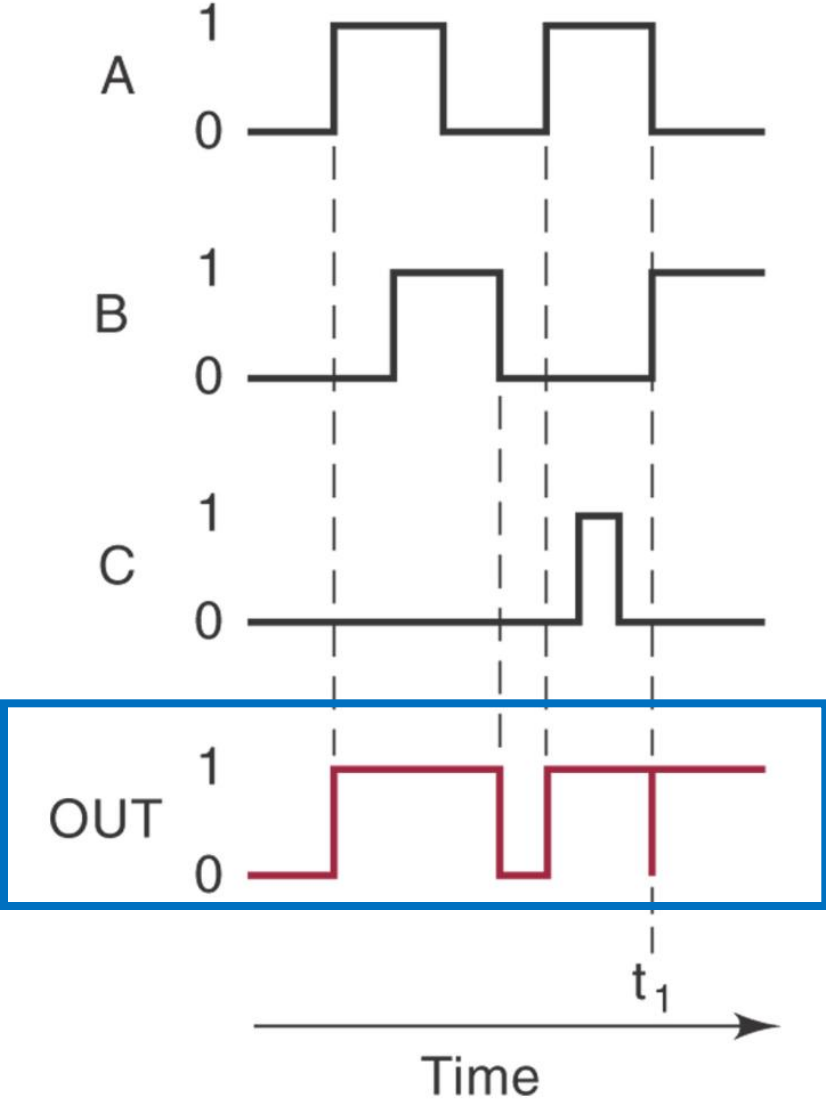
Representing Logic Functions by Timing Diagrams



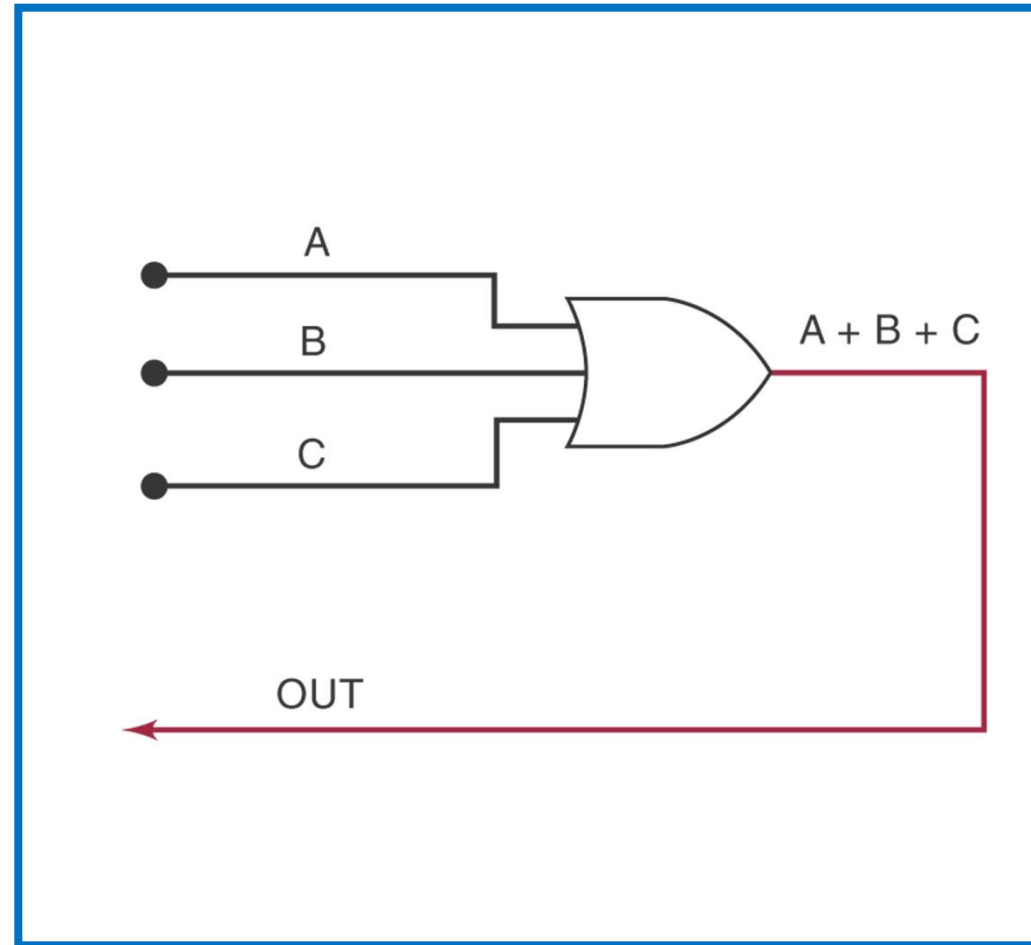
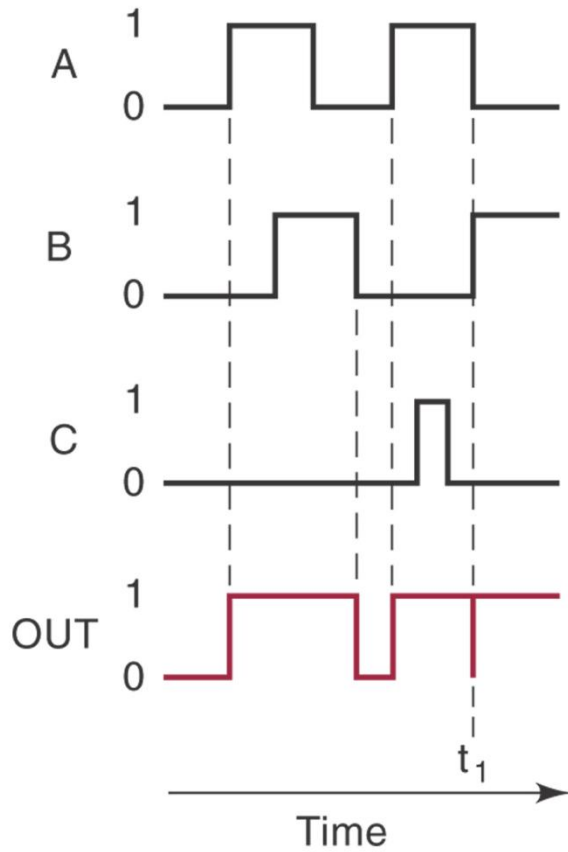
Representing Logic Functions by Timing Diagrams



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Representing Logic Functions by Timing Diagrams



2) AND Operations with AND gate

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- Truth table for a two inputs AND gate. Note the difference between OR and AND gates.

AND

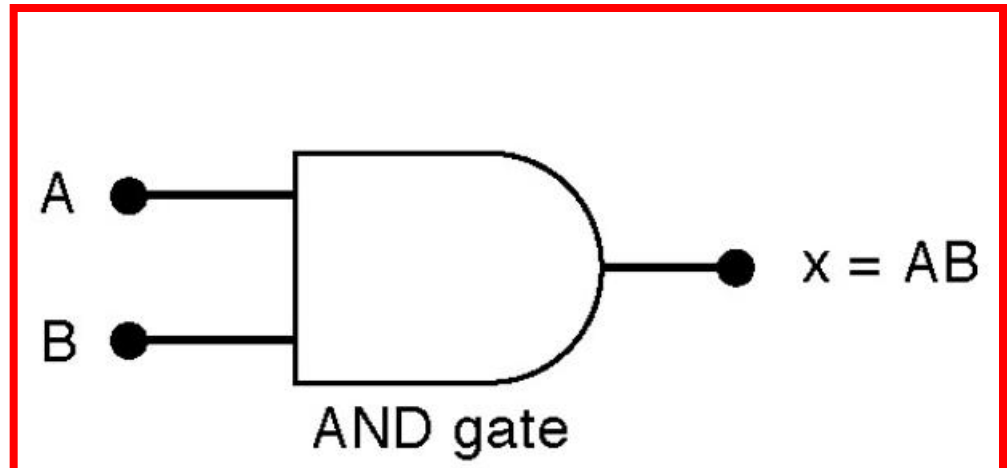
A	B	$x = A \cdot B$
0	0	0
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2) AND Operations with AND gate

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AND

A	B	$x = A \cdot B$
0	0	0
0	1	0
1	0	0
1	1	1



2) AND Operation With AND Gates

- The AND operation is similar to multiplication.
- In the Boolean expression

$$X = A \cdot B \cdot C$$

x will equal 1 only when A, B, and C are all 1.

3) NOT Operation

- The Boolean expression for the NOT operation is

$$x = \bar{A}$$

3) NOT Operation

- The Boolean expression for the NOT operation is

$$x = \overline{A}$$

- This is read as:
 - x equals NOT A, or
 - x equals the inverse of A, or
 - x equals the complement of A

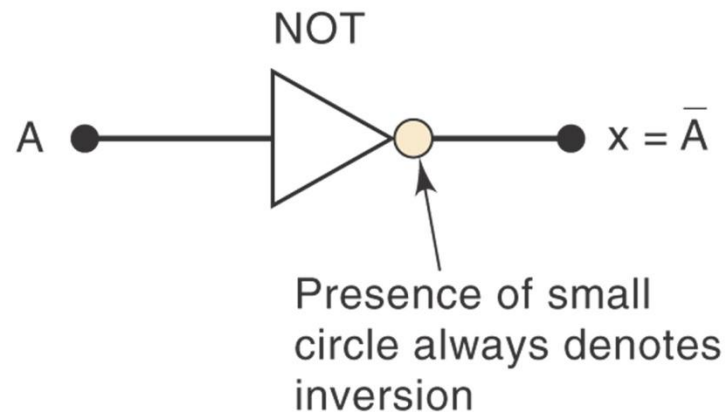
3) NOT Operation

- Truth table, symbol, and sample waveform for the NOT circuit.

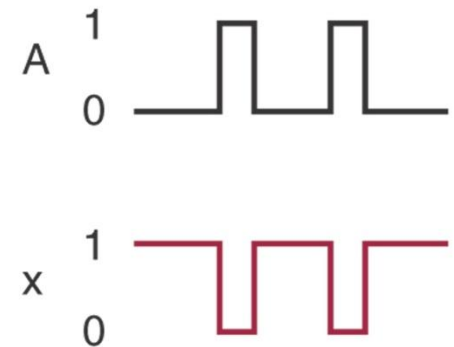
NOT

A	$x = \bar{A}$
0	1
1	0

(a)



(b)



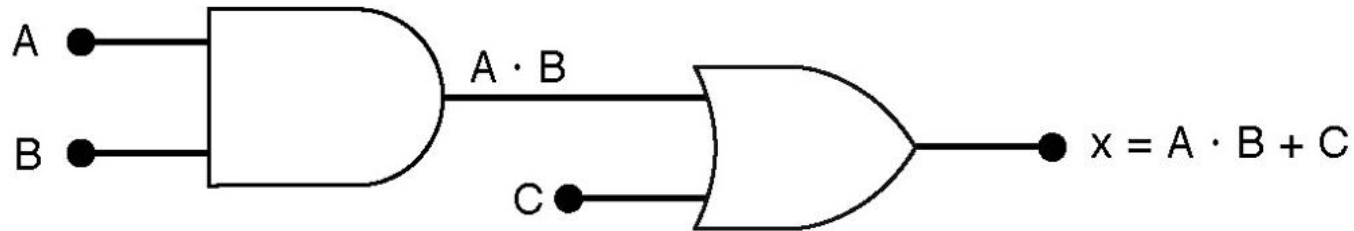
(c)

Describing Logic Circuits Algebraically

- The three basic Boolean operations (OR, AND, NOT) can describe any logic circuit.

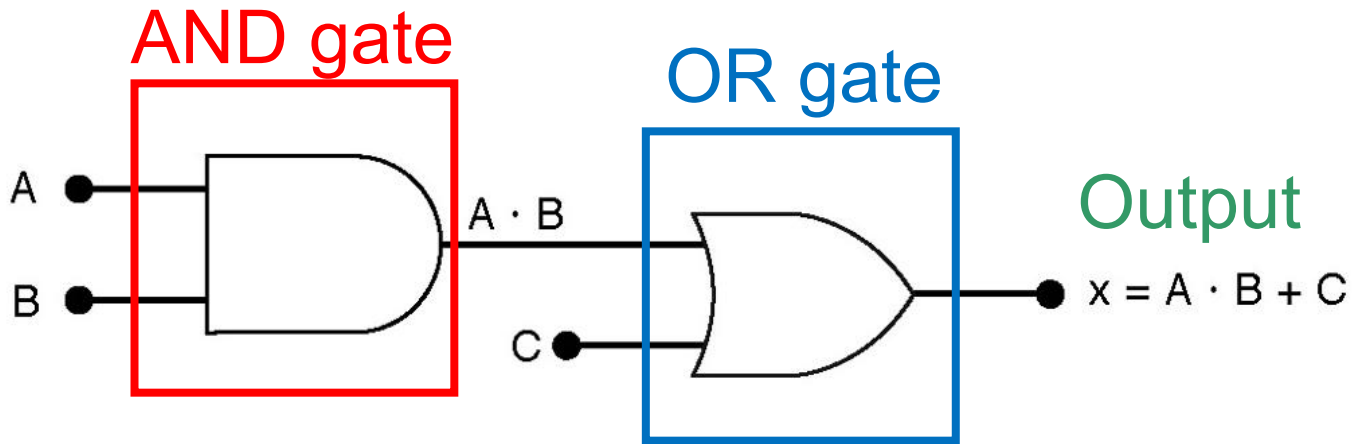
Describing Logic Circuits Algebraically

Example 1: Boolean expression for a logic circuit



Describing Logic Circuits Algebraically

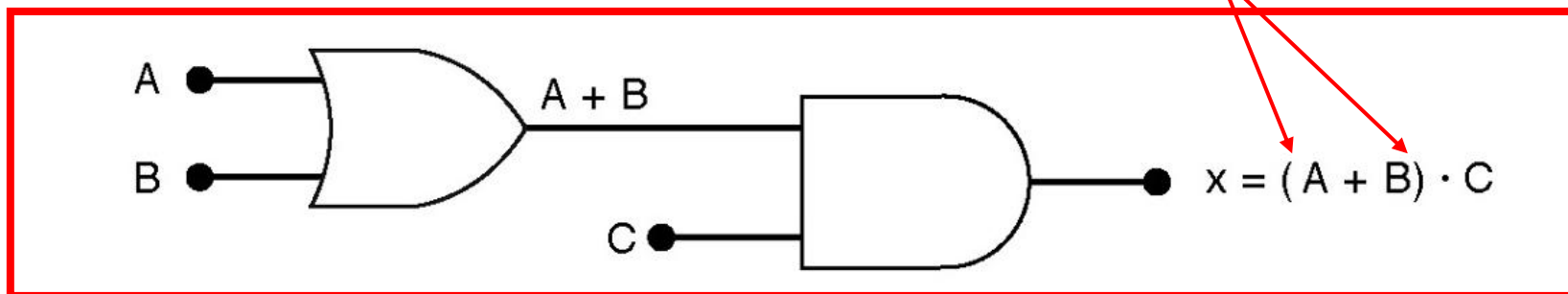
Example 1: Boolean expressions for a logic circuit:



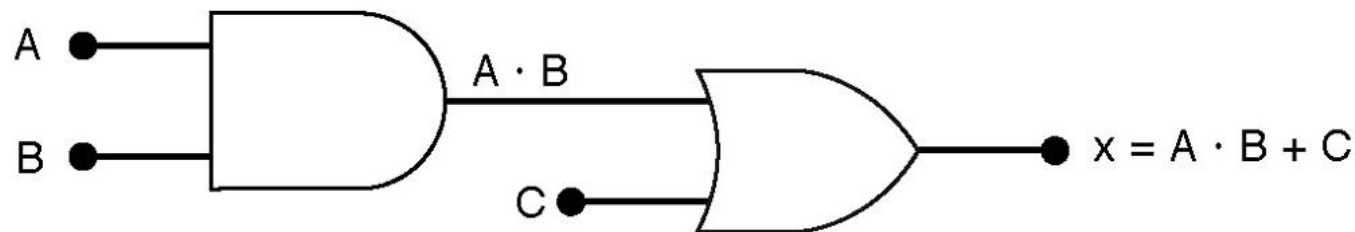
Describing Logic Circuits Algebraically

Example 2: Boolean expressions for logic circuits:

Parentheses or brackets ()

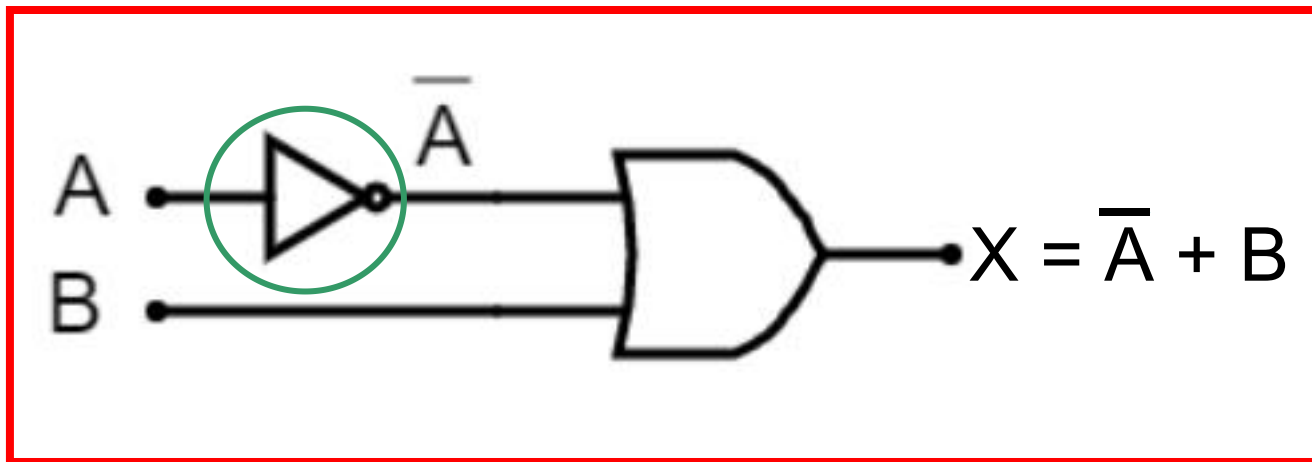


Example 1:



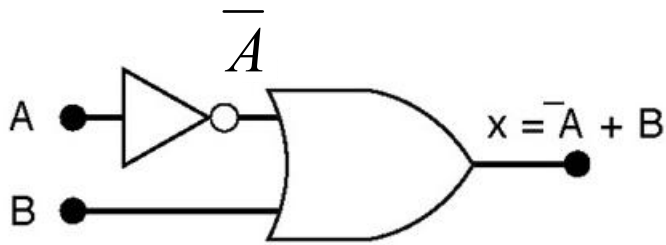
Describing Logic Circuits Algebraically

- The output of an inverter is equivalent to the input with a bar over it.
- Input A through an inverter is \bar{A}
- Example using inverters.

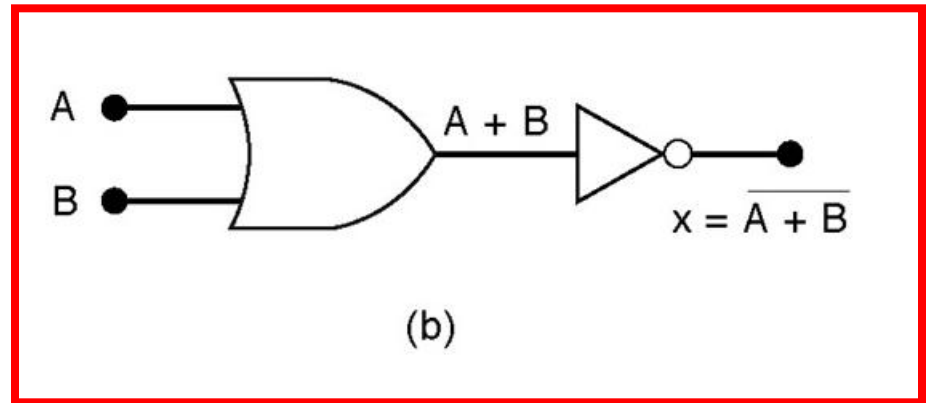


Describing Logic Circuits Algebraically

- A second example



(a)

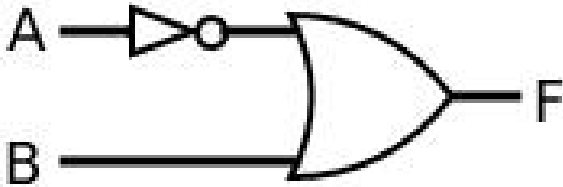


(b)

Evaluating Logic Circuit Outputs

Example 1: Complete the truth table for the given circuit.

Logic circuit



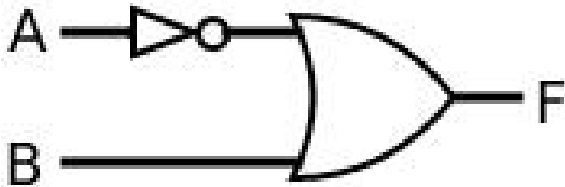
Truth table

A	B	F
0	0	
0	1	
1	0	
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Evaluating Logic Circuit Outputs

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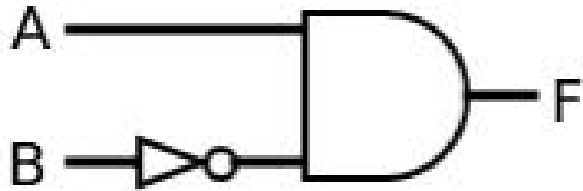
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Evaluating Logic Circuit Outputs

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Logic circuit



Truth table

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0	1	0
1	0	1
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Evaluating Logic Circuit Outputs

Rules for evaluating a Boolean expression:

1. Perform all inversions of single terms.
2. Perform all operations within **parenthesis**.
3. Perform AND operation before an OR operation unless parenthesis indicate otherwise.
4. If an expression has a bar over it, perform the operations inside the expression and then invert the result.

Evaluating Logic Circuit Outputs

Exercise 2:

- Evaluate the given Boolean expression by substituting values and performing the indicated operations.

$$A = 0, B = 1, C = 1, \text{ and } D = 1$$

$$X = \overline{A}BC \overline{(A + D)}$$

Evaluating Logic Circuit Outputs

- Evaluate Boolean expressions by substituting values and performing the indicated operations:

$$A = 0, B = 1, C = 1, \text{ and } D = 1$$

$$x = \overline{A}BC \overline{(A + D)}$$

Solution:

$$\text{Rule 1} \longrightarrow x = \overline{0} \cdot 1 \cdot 1 \cdot \overline{(0 + 1)}$$

$$\text{Rule 2} \longrightarrow = 1 \cdot 1 \cdot 1 \cdot \overline{(0 + 1)}$$

$$\text{Rule 1} \longrightarrow = 1 \cdot 1 \cdot 1 \cdot (\overline{1})$$

$$\text{Rule 3} \longrightarrow = 1 \cdot 1 \cdot 1 \cdot 0$$

$$x = 0$$

Evaluating Logic Circuit Outputs

Exercise 2:

- Evaluate the given Boolean expression by substituting values and performing the indicated operations.

$$A = 1, B = 0, C = 0 \text{ and } D = 0$$

$$X = \overline{A}BC \overline{(A + D)}$$

You have 2 minutes to determine the answer!

Evaluating Logic Circuit Outputs

Exercise 2:

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$$x = \overline{A}BC \overline{(A + D)}$$

$$= \overline{1}.0.0.\overline{(1+0)}$$

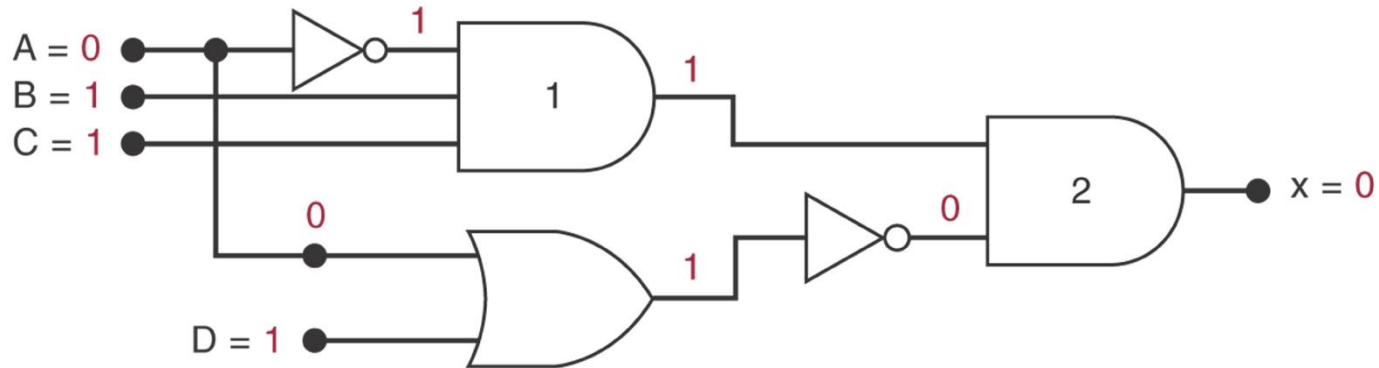
$$= 0.0.0.\overline{(1)}$$

$$= 0.0.0.0$$

$$= 0$$

Evaluating Logic Circuit Outputs

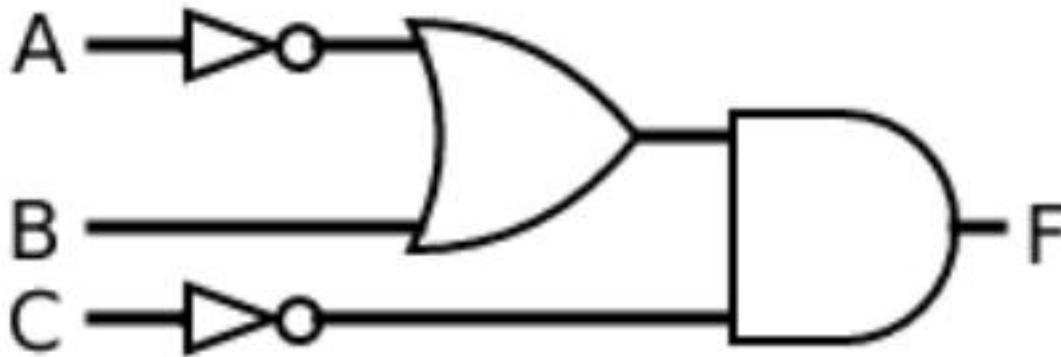
- Output logic levels can be determined directly from a circuit diagram.
- The output of each gate is noted until a final output is found.



Evaluating Logic Circuit Outputs

Exercise 3:

Evaluate the output F for the given logic circuit when $A = 0$; $B = 1$; and $C = 1$.

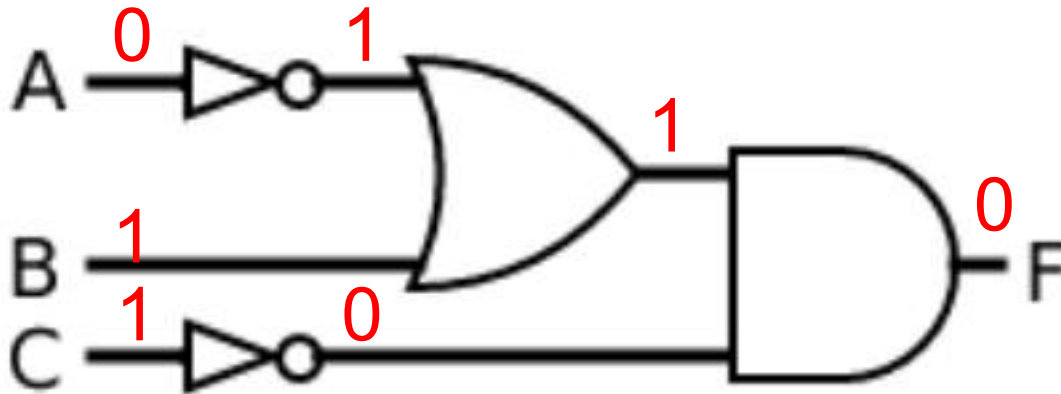


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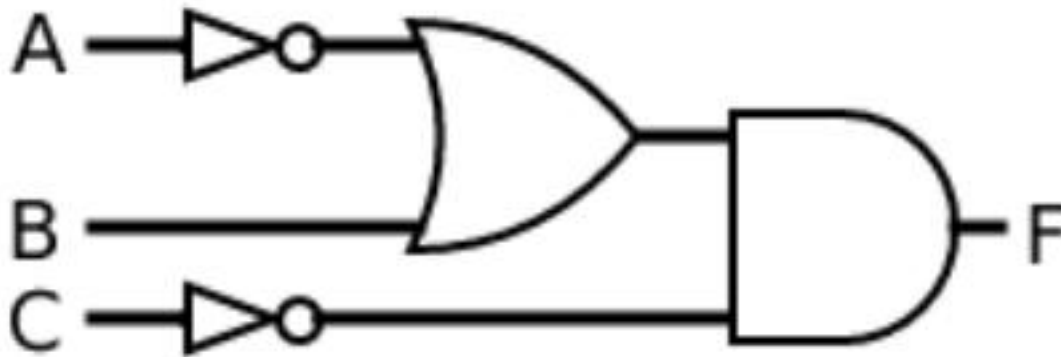


Evaluating Logic Circuit Outputs

Exercise 4 (live):

Evaluate the output F for the given logic circuit when

$A = 1; B = 0; C = 0$



You have 2 minutes to determine the answer!

Evaluating Logic Circuit Outputs

Exercise 4 (live):

Evaluate the output F for the given logic circuit when

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