Logical Gates

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September 26, 2023

Outline

Acknowledgement

The content of most slides come from the authors of the textbook:

Null, Linda, & Lobur, Julia (2018). The essentials of computer organization and architecture (5th ed.). Jones & Bartlett Learning.

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Lesson Objectives

Students are expected to be able to

1. Apply Boolean algebra and functions.
2. *Understand the relationship between Boolean logic and digital computer circuits.*
3. Learn how to design simple logic circuits.
4. Understand how digital circuits work together to form complex computer systems.

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Boolean Function to Logical Gates

Boolean functions are implemented in digital computer circuits called gates.

A gate is an electronic device that produces a result based on two or more input values.

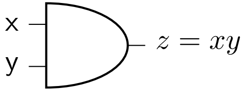
In reality, gates consist of one or more transistors, but digital designers think of them as a single unit.

Integrated circuits contain collections of gates suited to a particular purpose.

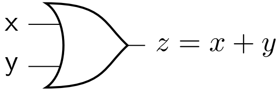
Simplest Gates: AND, OR, NOT

The three simplest gates are the AND, OR, and NOT gates.

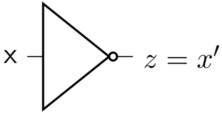
They correspond directly to their respective Boolean operations, as you can see by their truth tables.



(a) AND Gate



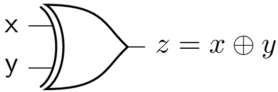
(b) OR Gate



(c) NOT Gate

XOR Gate

Another very useful gate is the exclusive OR (XOR) gate.



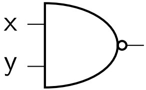
(a) XOR Gate

$x \oplus y = x'y + xy'$

x	y	$x \oplus y$
0	0	0
0	1	1
1	0	1
1	1	0

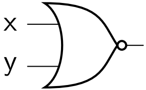
NAND and NOR Gates

NAND and NOR are two very important gates.



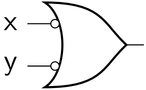
$z = (xy)'$

(a) NAND Gate



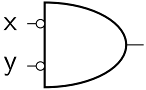
$z = (x + y)'$

(b) NOR Gate



$z = x' + y' = (xy)'$

(c) NAND Gate, alternative form



$z = x'y' = (x + y)'$

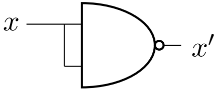
(d) NOR Gate, alternative form

Universal Gates

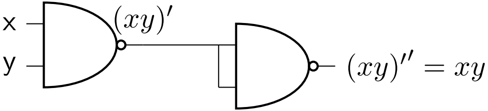
NAND and NOR are known as universal gates

- They are inexpensive to manufacture, and
- any Boolean function can be constructed using only NAND or only NOR gates.

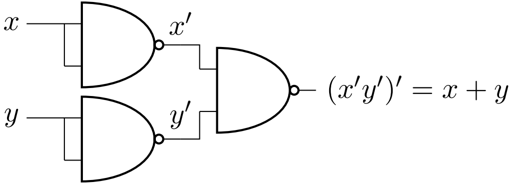
Using NAND Gates



(a) Realizing NOT gate using NAND gate

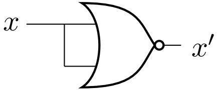


(b) Realizing AND gate using NAND gates

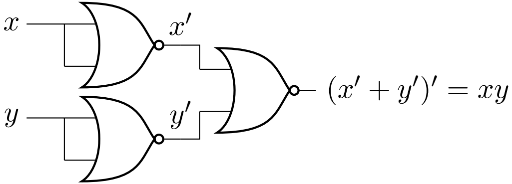


(c) Realizing OR gate using NAND gates

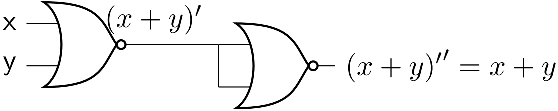
Using NOR Gates



(a) Realizing NOT gate using NOR gate



(b) Realizing AND gate using NOR gates



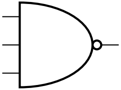
(c) Realizing OR gate using NOR gates

Multiple Input and Output Gates

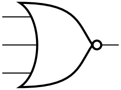
Gates can have multiple inputs and more than one output.

A second output can be provided for the complement of the operation.

We'll see more of this later.



(a) 3-input NAND gate



(b) 3-input NOR gate

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Summary and Q&A

You are expected to be able to

1. *using logical gates to represent boolean functions*;

Any questions on:

- AND, OR, and NOT gates
- XOR gates
- NAND and NOR gates
- Building NOT, AND, OR gates using either NAND or NOR gates