Overview of Digital Components

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Outline

1. Lesson Objectives
2. Overview of Digital Components
3. Problem-Solving
4. Summary and Q&A

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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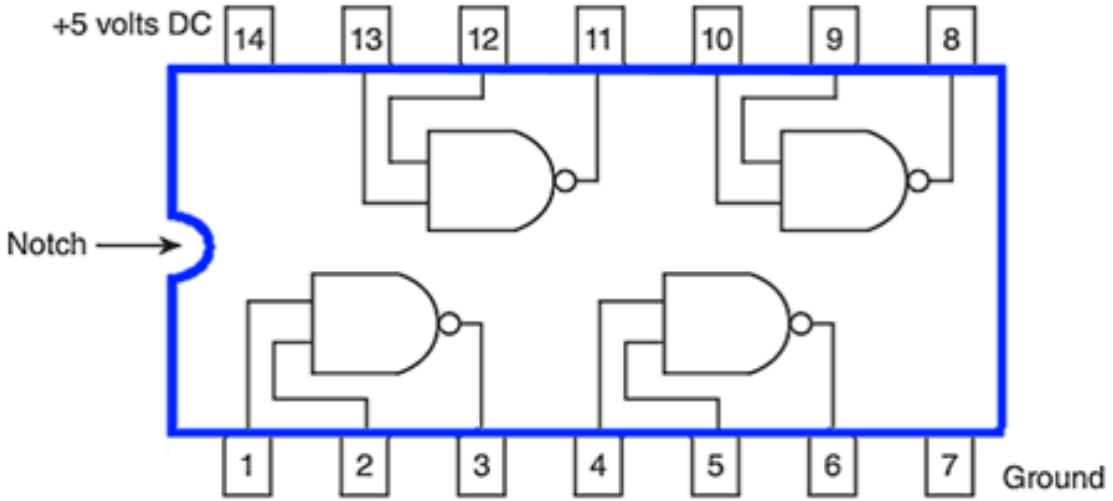
Implementing Boolean Functions

Digital circuits, i.e., combinations of gates implement Boolean functions.

- Example: Let's implement $F(x, y, z) = x + y'z$:
- Use Logisim Evolution
  - Free to download at https://github.com/logisim-evolution/logisim-evolution/tags
- In order to create simpler circuits we simply Boolean expressions.

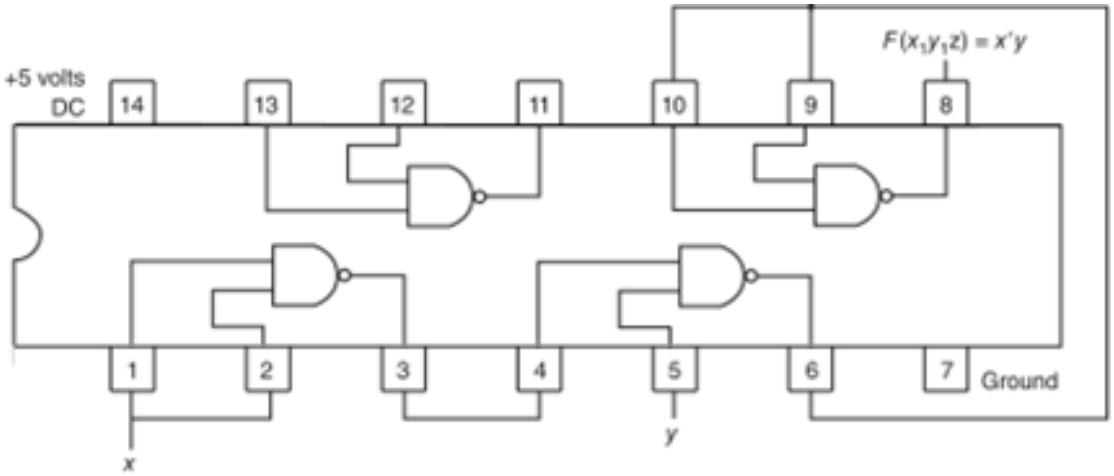
Integrated Circuit Packages

- Standard digital components are combined into single integrated circuit (IC) packages, i.e., a such package (or an IC chip) can contain Implementations of multiple boolean functions.
- Example: https://www.ti.com/lit/ds/symlink/sn74ahc00.pdf?HQS=dis-mous-null-mousermode-dsf-pf-null-wwe&ts=1696500927964



Equivalent Implementations

- A boolean function has equivalent forms.
- We can implement a Boolean function using different combinations of logic gates
- Example: Boolean function $F(x, y) = x'y$
  - Using a Not gate and an AND gate
  - Using NAND gates only
- Given a Boolean function, we can wire (one or more) of the pre-packaged circuits to implement it



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Problem-Solving via Digital Circuits

We use Boolean logic to solve practical problems.

- Expressed in terms of Boolean logic practical problems can be expressed by truth tables.
- Truth tables can be readily rendered into Boolean logic circuits.

Problem-Solving via Digital Circuits: Example

Suppose we want to determine whether it is the best time to plant a garden. We can solve the problem via a logic circuit. How do we design such a digital circuit?

- Let's consider three factors (inputs):
  1. time, where 0 represents day and 1 represents evening;
  2. moon phase, where 0 represents not full and 1 represents full; and
  3. temperature, where 0 represents $45\,\mathrm{deg}$ F and below, and 1 represents over $45\,\mathrm{deg}$ F.
- We know that the best time to plant a garden is during the evening with a full moon.

Example: Truth Table

Suppose we want to determine whether it is the best time to plant a garden. We can solve the problem via a logic circuit.

- How do we design such a digital circuit?
- We begin with the truth table

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Suppose we want to determine whether it is the best time to plant a garden. We can solve the problem via a logic circuit.

- How do we design such a digital circuit?
- We begin with the truth table

Time (x)	Moon (y)	Temperature (z)	Plant?
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

Example: Circuits

From the truth table, we derive the circuit:

$$F(x, y, z) = xyz' + xyz$$

Can we simplify it?

Example: Circuits

From the truth table, we derive the circuit:

$$F(x, y, z) = xyz' + xyz$$

Can we simplify it?

$$F(x, y, z) = xyz' + xyz = xy(z' + z) = xy1 = xy$$

What's the circuit?

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Summary and Q&A

You are expected to be able to

1. *Understand the relationship between Boolean logic and digital computer circuits.*
2. *Learn how to design simple logic circuits.*;

Any questions on:

- Concept of logic circuits
- Problem-solving using logic circuits