King Mongkut's Institute of Technology Ladkrabang
Computer Engineering International Program
01276112 Digital System Fundamentals

Lab 1 – Digital Circuit Simulation

Learning Outcomes

1. Use digital circuit simulation software.
2. Simulate logic gates.
3. Simulate adder circuits.

1. Introduction

Logisim is a simple and easy-to-use tool for designing and simulating digital circuits. It's great for learning and experimenting because it lets you build circuits by dragging and dropping components like gates, flip-flops, and multiplexers. You can see how your circuit works in real-time, which makes it easier to understand concepts and fix mistakes. Logisim also lets you create larger, more complex designs by combining smaller circuits, so it's perfect for exploring everything from basic logic to advanced digital systems. It's a popular choice for students and teachers who want a hands-on way to learn digital electronics.

Logisim was originally developed by Dr. Carl Burch as a tool for educational purposes, and it quickly gained popularity for its simplicity and effectiveness in teaching digital logic and circuit design. However, the original development of Logisim by Dr. Burch was discontinued around 2014. Since then, the project has been maintained and extended by the open-source community.

The most prominent continuation of Logisim is **Logisim-evolution**, an actively maintained open-source fork available on GitHub. Logisim-evolution builds upon the original software, introducing new features, bug fixes, and support for modern platforms. It includes enhancements such as better component libraries, improved simulation features, and the ability to export circuits for use in hardware designs. This fork keeps Logisim relevant and useful for both educators and students in the ever-evolving field of digital electronics.

2. Process

Basically, there are two steps to simulate the digital circuits using Logisim as shown in Fig 2.1. First, draw the circuit using components from the explorer pane. Then test manually or automatically by using the test script.

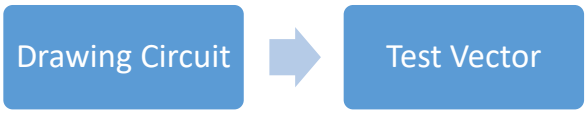

Fig 2.1 The process to basically simulate the digital circuits.

2.1 Drawing Circuit

The main parts of Logisim user interface are composed of the toolbar, the explorer pane, the attribute table and the canvas as shown in Fig 2.2. The canvas is the area to draw the digital circuits by placing components such as digital gates from the explorer pane. Each component from the explorer pane can be configured such as its label or direction in the attribute table. The toolbar provides useful buttons, for example, change values, edit selection, add wires, input port and out port buttons.

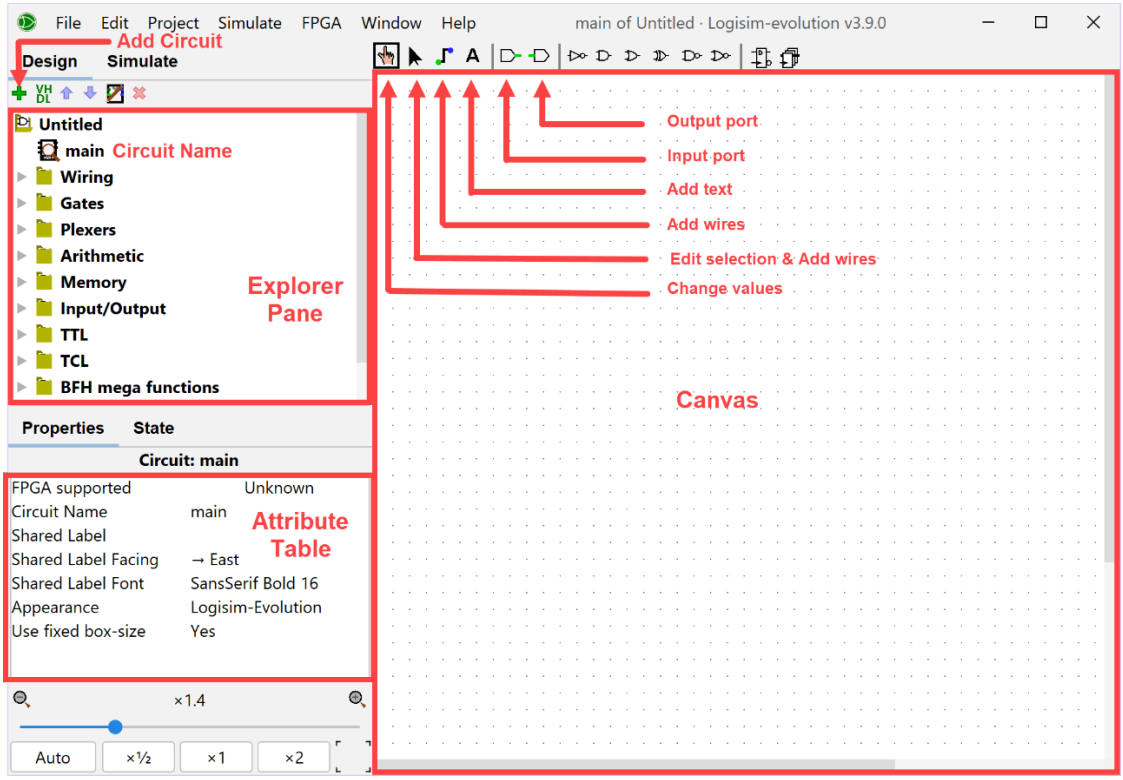

Fig 2.2 Logisim user interface.

2.2 Test Vector

After drawing the circuit, it can be tested manually by using the change values button on the toolbar to change the value of the input ports and observe the output change. However, the test can be achieved automatically by using the test script also known as the test vector.

The test vector is a text file composed of signal names, their input and output values. The signal names must match the labels used in the drawing circuit on the Logisim canvas with case sensitive. Usually, all input scenarios and their output values are provided within the file. The test vector for half adder can be shown in Fig 2.3. Notice that the space separating the signal names and values called the white space that can be a space, multiple space, a tap, or multiple tab. The sharp sign (#) indicates the comment line and the blank line is ignored.

```
# Test Vector for Half Adder

A B  Cout Sum

0 0   0    0
0 1   0    1
1 0   0    1
1 1   1    0
```

Fig 2.3 The test vector for half adder.

3. Experiment

Half Adder

1. Watch half adder (HA) simulation tutorial:

https://youtu.be/4fPLXSl96OQ

2. Use Logisim to simulate HA. First, draw the HA as shown in Fig 3.1 and then use the test vector as shown in Fig 3.2 to test the circuit.

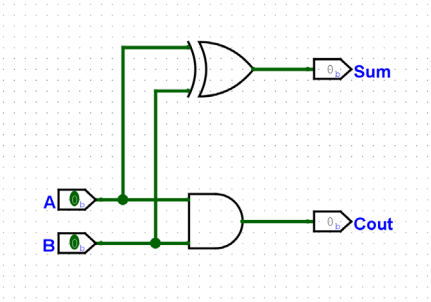

Fig 3.1 Logic diagram for half adder.

```
# Test Vector for Half Adder

A B  Cout Sum

0 0   0    0
0 1   0    1
1 0   0    1
1 1   1    0
```

Fig 3.2 Test vector for half adder.

Full Adder

3. Watch full adder (FA) simulation tutorial:

https://youtu.be/2brqEKUt2sE

4. Use Logisim to simulate FA. First, drawing the FA as shown in Fig 3.3 and then use the test vector as shown in Fig 3.4 to test the circuit.

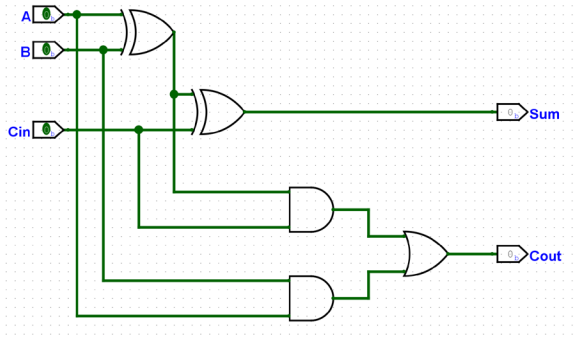

Fig 3.3 Logic diagram for full adder.

```
# Test Vector

Cin A B  Cout Sum

 0  0 0   0    0
 0  0 1   0    1
 0  1 0   0    1
 0  1 1   1    0
 1  0 0   0    1
 1  0 1   1    0
 1  1 0   1    0
 1  1 1   1    1
```

Fig 3.4 Test vector for full adder.

Two-bit Adder

5. Watch two-bit adder simulation tutorial:

https://youtu.be/2brqEKUt2sE

6. Use Logisim to simulate two-bit adder. First, draw the circuit by using FA subcircuits from **Experiment 4** as shown in Fig 3.5 and then use the test vector as shown in Fig 3.6 to test the circuit.

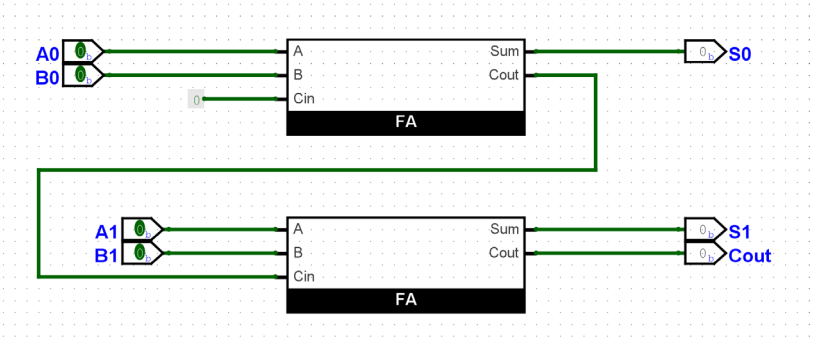

Fig 3.5 Two-bit adder.

```
# Test vector for two-bit adder

A1 A0 B1 B0  Cout S1 S0

0  0  0  0    0   0  0
0  0  0  1    0   0  1
0  0  1  0    0   1  0
0  0  1  1    0   1  1
0  1  0  0    0   0  1
0  1  0  1    0   1  0
0  1  1  0    0   1  1
0  1  1  1    1   0  0
1  0  0  0    0   1  0
1  0  0  1    0   1  1
1  0  1  0    1   0  0
1  0  1  1    1   0  1
1  1  0  0    0   1  1
1  1  0  1    1   0  0
1  1  1  0    1   0  1
1  1  1  1    1   1  0
```

Fig 3.6 Test vector for two-bit adder.

Lab 1 Submission

Date _____ **Group No.** _____

1. Student ID _____ Name _____

2. Student ID _____ Name _____

3. Student ID _____ Name _____

Checkpoints

Experiment 2 _____ (0 pts)

Experiment 4 _____ (10 pts)

Experiment 6 _____ (10 pts)