

LAB #07 Introduction to Logisim

Logisim Environment Layout

Logisim is an educational and user-friendly tool. It mainly consists of an interactive graphical schematic editor and logic simulator. Logisim has a layout like most available software tools as shown in Fig 1.

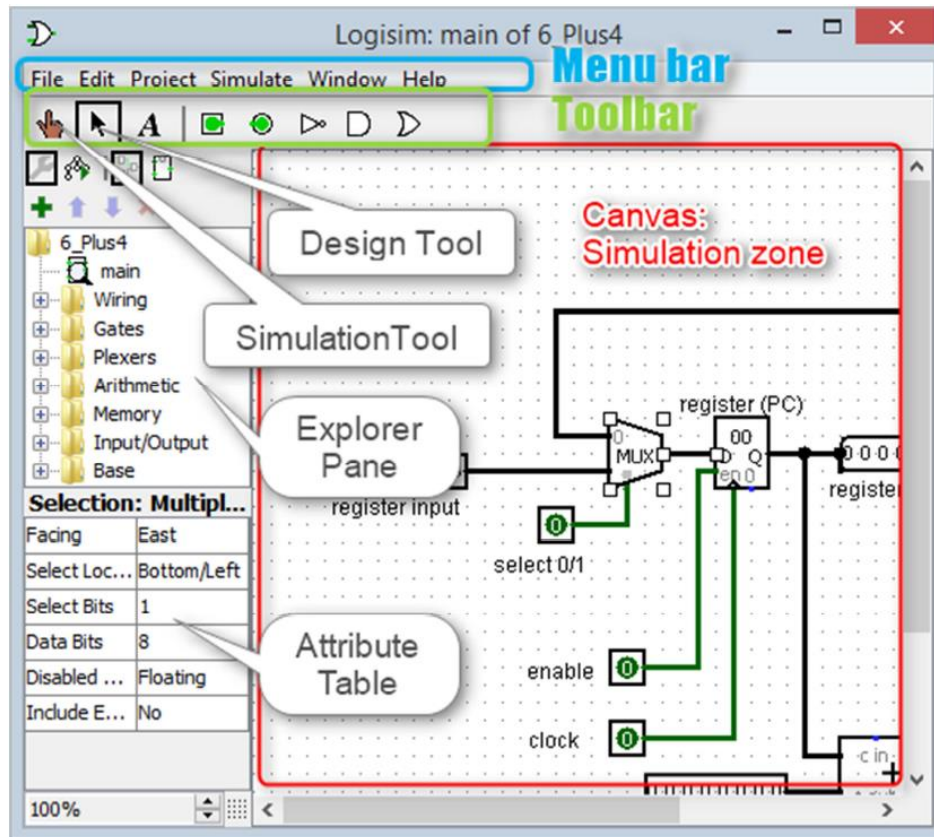


Fig. 1 Logisim Main Window Layout

The main window consists of the following items:

Toolbar: contains short cuts to several commonly used items

- **The simulation tool:** shaped like a hand, is used in simulation mode to alter input pins.
- **The design tool:** used while designing the circuit.
- **The input pin:** green circle surrounded by a square box, is used to send a signal through a wire. When placing the input on the canvas it initializes the input to logic 1 or 0. The number of bits can be increased in the Attribute Table.
- **The output pin:** green circle surrounded by a circular shape, is used to observe the output from a gate or a block. The output pin toggles in real time as long as the simulation is enabled from the menu bar: [Simulate > Simulation Enabled](#)

Explorer Pane: This pane contains the list of wiring, gates, multiplexers and other components that are available for digital design in Logisim.

Attribute Table: Gives detailed attributes of digital design components (e.g., AND, OR, XOR gates). The attribute table allows you to alter the number of inputs/outputs that a digital component may have.

Canvas: The canvas is the area for you to create your digital circuits. In this area you may simulate your circuits while designing in real time.

Circuit Design

Logisim operates in two modes: **Design** and **Simulate**. Logisim is first operated in edit mode while designing a logic circuit, then in simulate mode to see how the circuit would work.

Edit Mode

- To use the edit mode, select the Design tool (Figure 1).
- Select then a component in the library on the left. To add it in your design, simply drag and drop the desired component in the canvas:
 1. To insert a logic gate, expand the folder Gates and click on the desired logic gate. Once the gate is selected, the mouse will turn into the shape of the selected gate. Place the gate in the canvas or circuit area on the right.
 2. Each selected component has modifiable attributes in the attribute area. For example, for an AND gate, the number of input signals, the number of bits per input or output and the size of the component can all be modified.
 3. It is also possible to copy and paste of one or more components in the canvas. In this case, the components retain all the attributes previously defined.
- To connect the gates, select the arrow icon on top. Then drag from the output of one gate to the input of another gate. You can connect to any of the small blue dots on the gate symbol.
- To create an input to the circuit, select the “Add Pin” icon with an outline of a square.
- Similarly, add an output to the circuit by using the “Add Pin” icon with an outline of a circle.
- To assign a name to the input/output pin, click on the pin while the arrow icon is selected.
- You may then add the label for the pins.
- While components are added to the circuit, notice how the color of the wire changes (Figure 2).

Wire Color	Meaning
dark green	logical `0'
light green	logical `1'
blue	unknown value
gray	unconnected wire
black	wire has more than one bit (bus)
red	conflicting values, error
orange	incompatible bus width

Fig. 2 Logisim Wire Color Conventions

Full Adder Design

In Logisim, a digital circuit may be designed using either one of two approaches:

- Drawing schematic: the user has to do the design by choosing the necessary components as per his design, based on the digital schematic.
- Analyzing the circuit, by providing the truth tables with necessary inputs and outputs and let Logisim do the design.

Schematic Design:

1. Set up the truth table for a simple Full Adder. Let A, B, and Ci be the inputs, S and Co the outputs.

A	B	Ci	S	Co
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Fig. 3 Input/output table of Full Adder

2. Derive the logic equations for S and Cout:

$$S = A \oplus B \oplus C_i, C_0 = (A \wedge B) + (C_i \wedge (A \oplus B))$$

3. Finally, design the circuit based on the above equations (Figure 4)

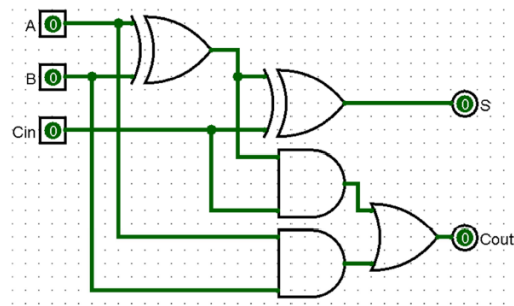


Fig. 4 Full Adder Circuit Design

Circuit Analysis:

From the Menu Bar select "Window" then "Combinational Analysis". You may also go to Project then, select "Analyze Circuit".

1. Create three inputs named Cin, A, and B.
2. Create two outputs named Cout and S.
3. Complete the truth table for a full adder.
4. Look at the "Expression" and "Minimized" tabs.
5. Press the "Build Circuit" button and enter FA0 as the name of the new circuit.

Once your design is complete, you may proceed by testing its functionality:

1. Use the Simulation Tool in the Toolbar.
2. Click on an input to see its state toggle between the values 0 and 1
3. While doing so, check the outputs that they correspond exactly to your design.

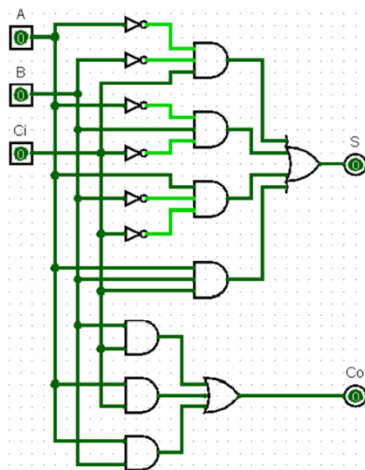


Fig. 5 Full Adder Circuit Design using Analysis

Hierarchical Design

A complex circuit is usually broken down into smaller sub-circuits. These sub-circuits are designed independently, tested, arranged into libraries, and then used to build the big circuit.

Circuit Appearance

Later, you may use your circuit as a sub-circuit in another design. For that purpose, you may want to alter the locations of the inputs and outputs or the appearance of the whole circuit as a module. To do so, while your design is on the editor, click the Appearance Tool under the toolbar (Figure 6). This will show your circuit as a block with the inputs and outputs; once you click any of the input/output pins, on the bottom right corner your circuit will appear showing the location of the pin you selected.

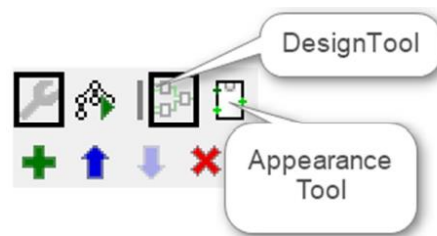


Fig. 6 Design and Appearance Tools

You may then modify the following properties of your circuit appearance: pin locations, general appearance, and color.

Using Sub-Circuits

One of the good features of Logisim is that you can use a circuit you have already built as a building block in another, more complex circuit.

You can create a new sub-circuit with ([Project > Add Circuit](#))

1. Save all your sub-circuits in one folder where you will make your own library.
2. On the menu bar select load [Project > Load Library > Logisim-Library](#) then select your folder and the module you would like to add.
3. Your circuit will appear as a new element in the explorer pane. Select your module then drag and drop.
4. You may then add pins for input and output, or connect your module to your circuit using wires.

Within the newly created full adder FA0 circuit designed above (Figures 4 or 5), change the orientation of the Ci input so that it is facing south. Change the orientation of the Co output so that it is facing north (Figure 10.5). Your circuit is ready to be used as a module or sub-circuit in a more complex digital system design.

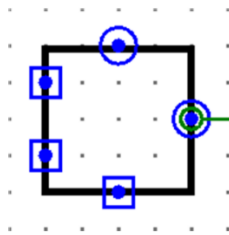


Fig. 7 Full Adder Block

Splitters and Tunnels

These are components mainly used to simplify wiring. Splitters are used to group or separate bits in a bus, and tunnels are used to avoid lengthy connections between components in the design.

Splitters

Wire splitters split a multi-bit wire into smaller wires (e.g., an 8-bit wire into 2 x 4-bit wires). They can also combine multiple wires into a single wire with a wider bit width.

- To use a splitter from the menu select ([Wiring > Splitter](#))
- Set the fan out and the bit width in properties.
 1. "Fan Out" controls how many teeth the wire splitter has.
 2. "Bit Width In" controls the actual size of the data the splitter is splitting.
- If you have more data bits than outputs, some of the fan outs would carry more than one data bit.

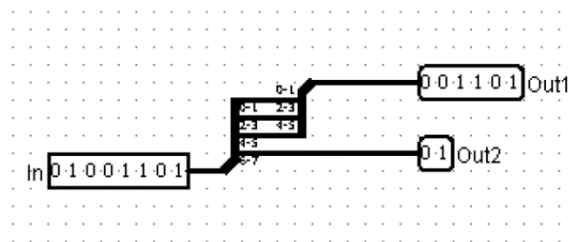


Fig. 8 Splitter

Tunnels

Tunnels are you to transmit signals without using wires.

- From the menu, select ([Wiring > Tunnel](#))
- Tunnels are mainly used to avoid excessive wiring, but can be used to connect control and clock signals.



Fig. 9 Tunnels

Detailed information can be found at the website: <http://www.cburch.com/logisim/index.html>.

Or, in the "Logisim tutorial.pdf" file (This file is pdf version of the website).

Task to do

1. Follow the steps (0 to 4) in “Logisim tutorial.pdf”, page 2 – 8.
2. Build a Full Adder in Figure 4 (in this document) and test it.

NOTE: You don't need to submit anything. Just get familiar with Logisim.