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B38DB Digital Design & Programming

Lab 4 –Adders and Subtractors

Part 1: Introduction

In Lab 4, we are going to look at how to design, implement and test adder and subtractor circuits. Moreover, you are also going to learn how to create blocks of circuits which can be used when multiple instances of a circuit are needed. Adders in digital logic circuits are used extensively for the addition of numbers. They are also found as a part of ALUs and other processors for calculating addresses and related activities. Adders are classified into two types, Half Adder and Full Adder.

Part 2: Design and Implementation of a Half Adder

For the first task, you are required to design a Half Adder circuit block. To create a new circuit block, do the following steps.

Step 1: In the menu bar, click on Project -> Add Circuit

Step 2: In the window that appears, name the circuit “Half Adder”

Step 3: Double click on the “Half Adder” circuit block in the object browser. Ensure that it is the current circuit being edited. You will know this by the appearance of the magnifying glass on the circuit.

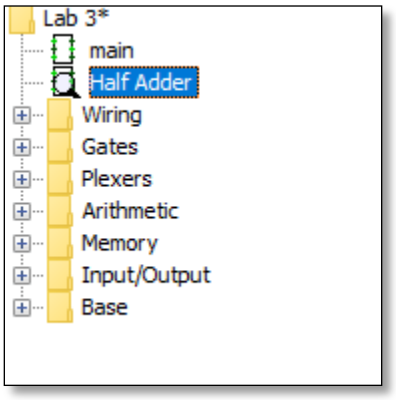


Figure 1: Object browser showcasing the half adder circuit being edited

Now you can proceed to design the half adder circuitry within the “Half Adder”. Make sure the inputs are **A**, **B** and outputs **S** (sum), **C** (carry out)**.** Use the various logic gates available to you and knowledge from previous labs for this design. Attach the screenshot of the design and fill the truth table found in Table 1.

Screenshot of half adder design:

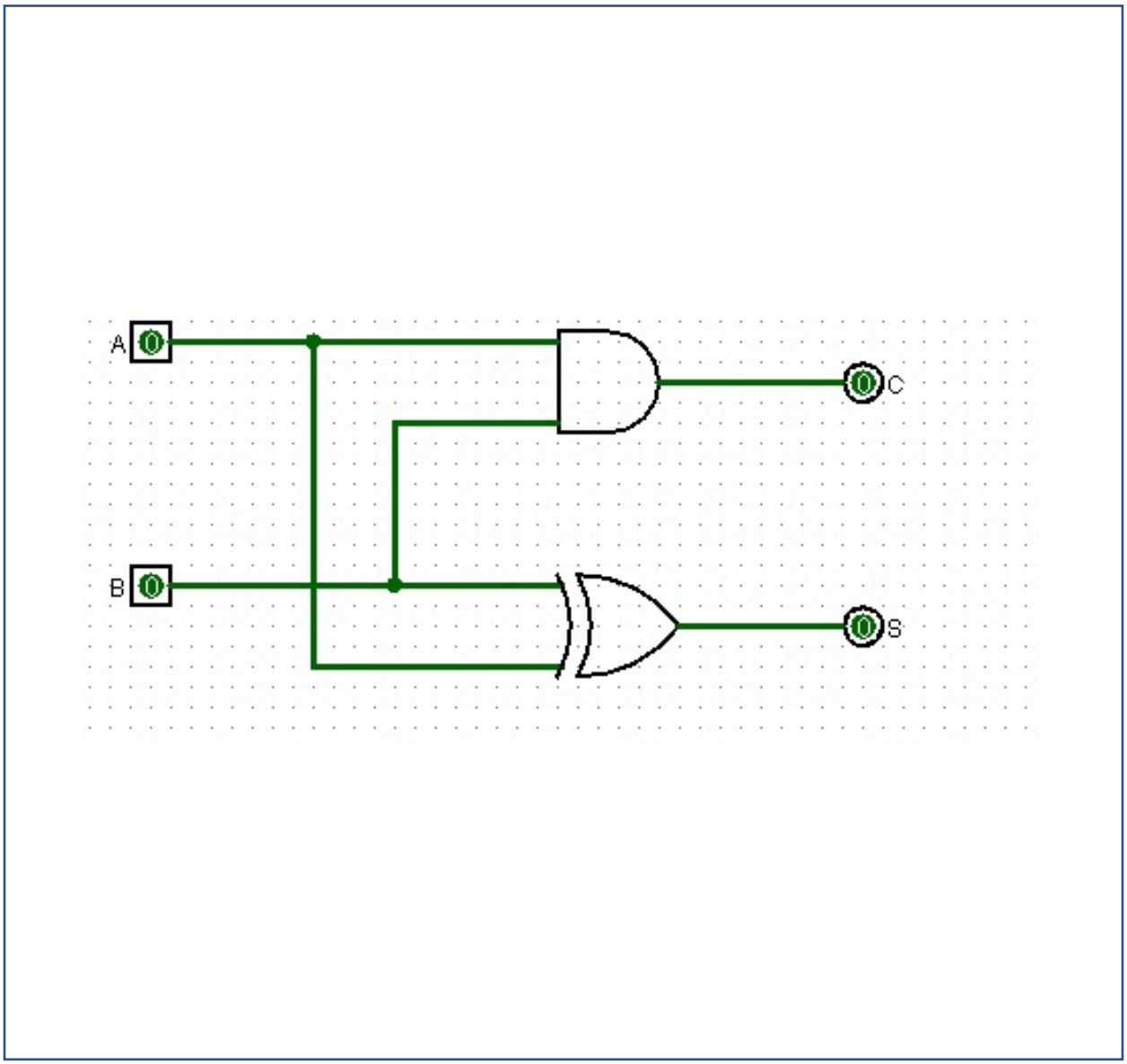


Table 1: Truth table for half adder

Inputs		Outputs	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Part 3: Design and Implementation of a Full Adder

For the second task, you are required to design a Full Adder circuit block, following similar steps as you have done in Part 2. Your object browser should look like this before you start designing the Full Adder circuitry.

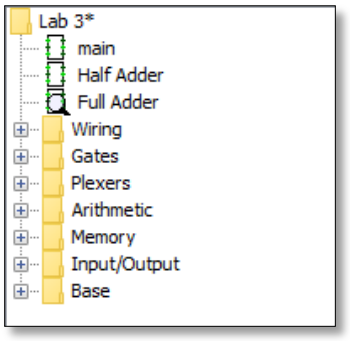


Figure 2: Object browser showcasing the full adder circuit being edited

Now you can proceed to design the full adder circuitry within the "Full Adder". Make sure the inputs are **A**, **B**, **Cin** (carry in) and outputs **S** (sum), **Cout** (carry out) Use the various logic gates available to you and knowledge from previous labs for this design. Attach the screenshot of the design and fill the truth table found in Table 2.

Screenshot of full adder design:

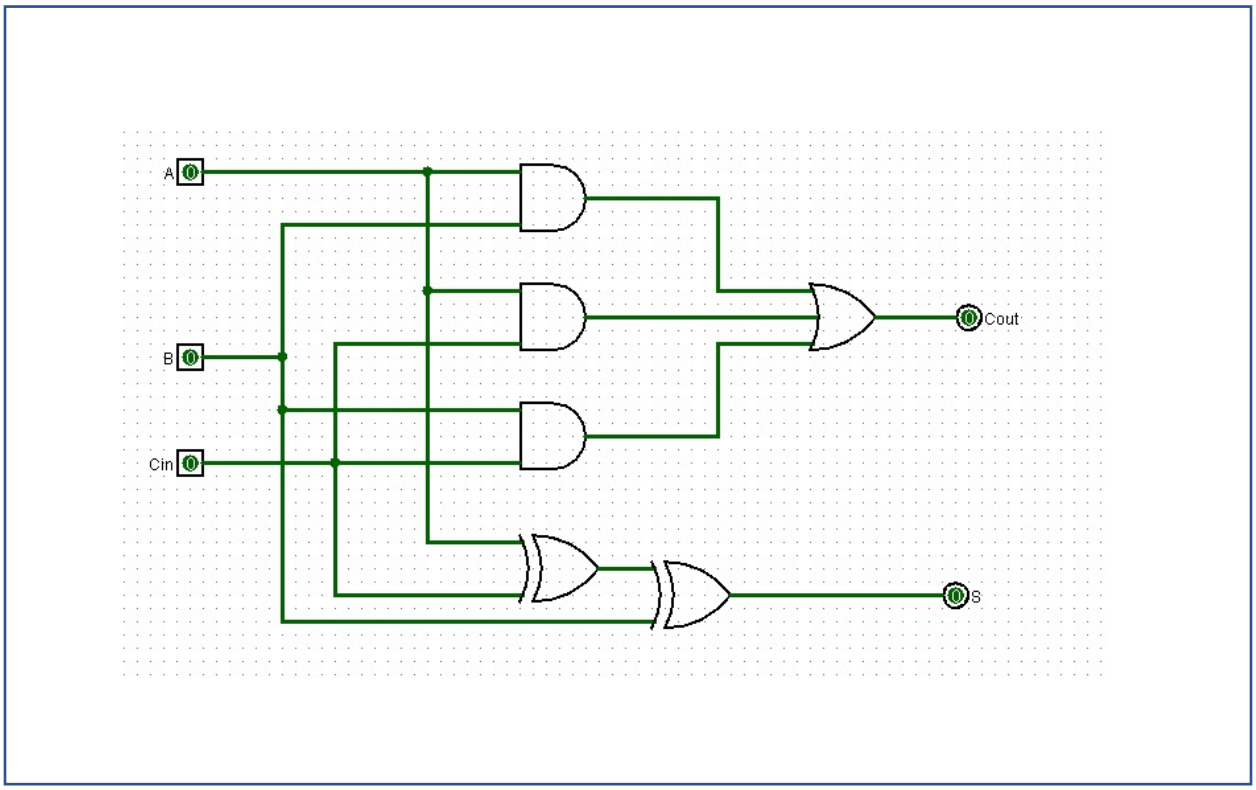


Table 2: Truth table for full adder

Inputs			Outputs	
A	**B**	**Cin**	**S**	**Cout**
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

Part 4: Design and Implementation of a 4-bit Adder using one Half Adder block and three Full Adder blocks

In this part, you are required to use the circuit blocks you have created in Part 2 and Part 3 to create a 4-bit adder. First, go back to the main circuit and ensure your object browser looks like the one shown in Figure 3.

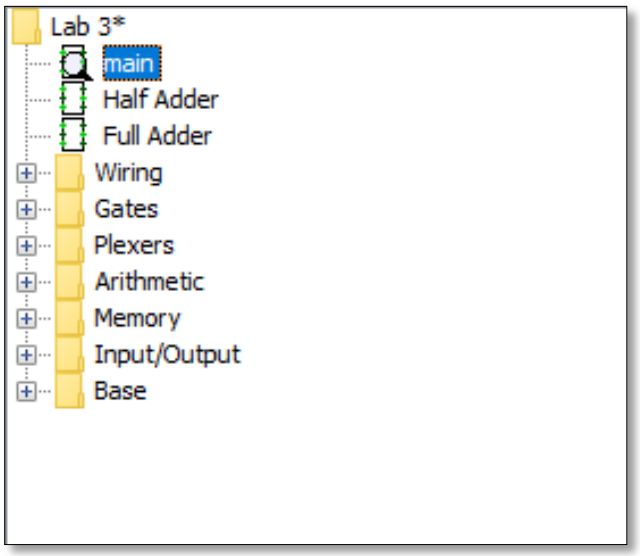


Figure 3: Object browser showcasing the main circuit being edited

Now, you can drag the circuit blocks you have created into the main circuit's workspace. An example is shown in Figure 4. Ensure to label them using the property window to differentiate between the blocks more easily.

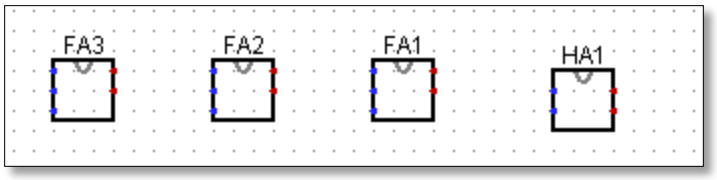


Figure 4: Half adder and Full adder blocks dragged into the main circuit workspace

The inputs to each block are colored in **blue** and outputs from each block are colored **red**. The order of inputs and outputs follow the same pattern as you have designed them in Parts 2 and 3. You are now required to create two 4-bit inputs and one 5-bit output.

- To do this, you can create 1-bit versions and edit the property 'data bits' to 4 and 5, respectively.
- To feed the inputs individually into the adders as required and then finally combine them into one output requires a component from Logisim called the 'splitter'. This can be found in the "wiring" section of the object browser.
- Create two splitters and edit their properties to have a 'Fan Out' of 4 and "Bit Width In" of 4.
- Create one more splitter but this time with a 'Fan Out' of 5 and "Bit Width" of 5. This is for the output.
- Connect the inputs and the output their respective splitters. An example of how it should look is shown in Figure 5.

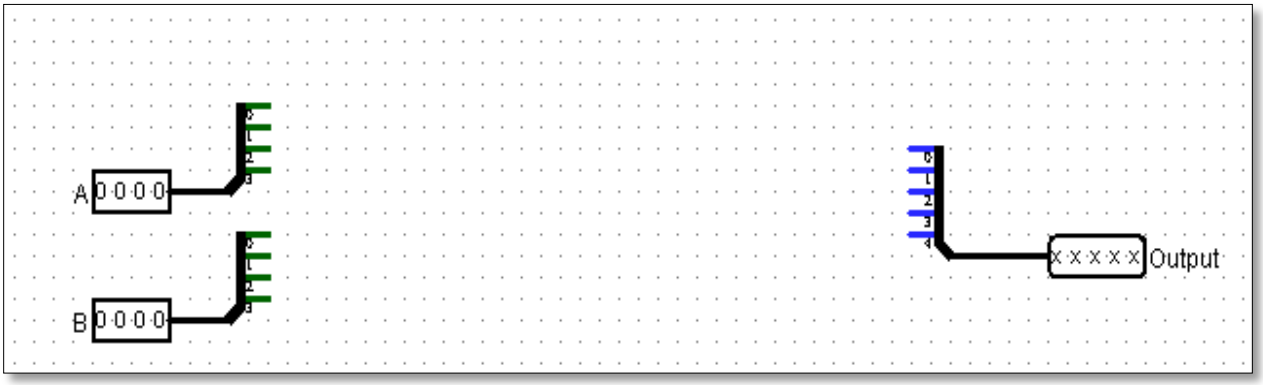
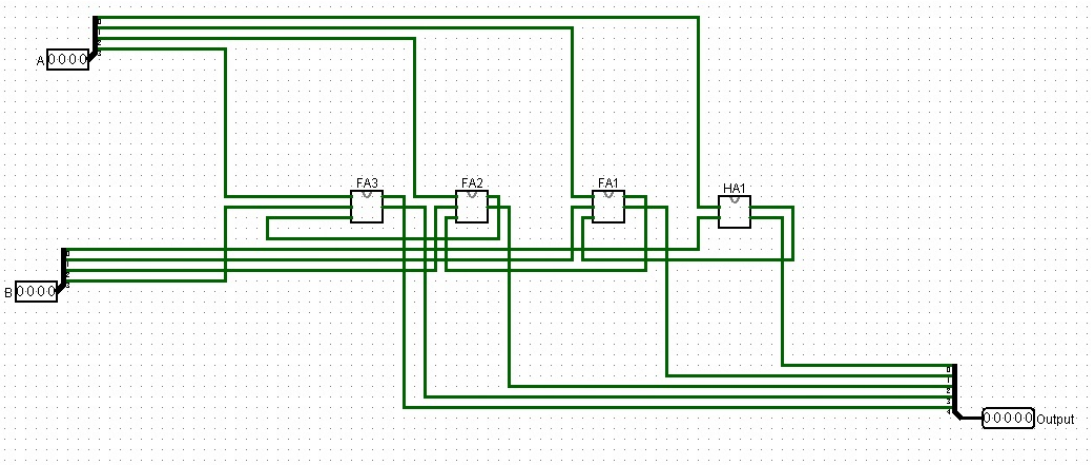


Figure 5: 4-bit inputs and 4-bit output

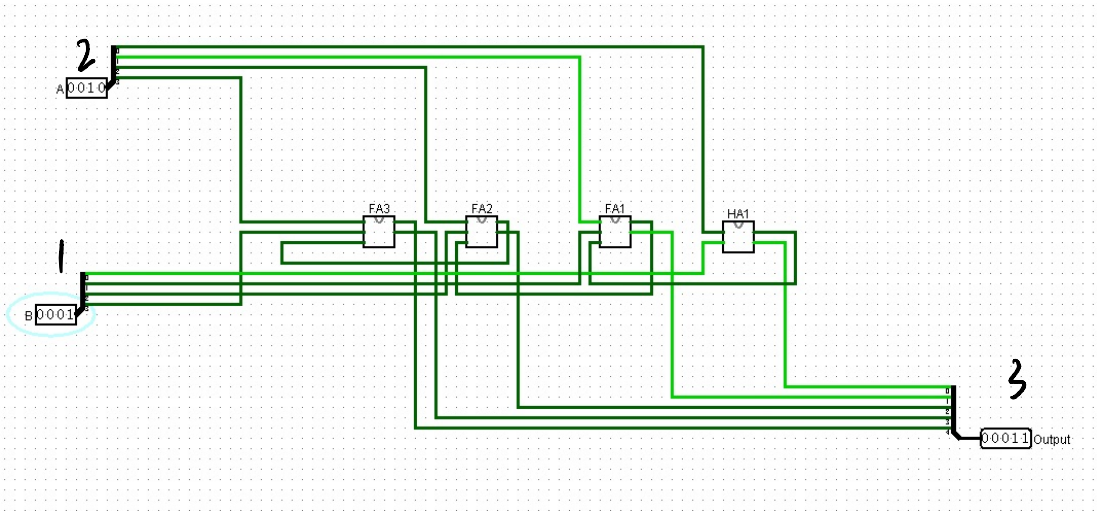
Now you can begin connecting the inputs and outputs to the required terminals as to implement the 4-bit adder. Attach the screenshot of your final 4-bit Adder design and examples of various input combinations in the space provided.

Screenshot of 4-bit adder design:



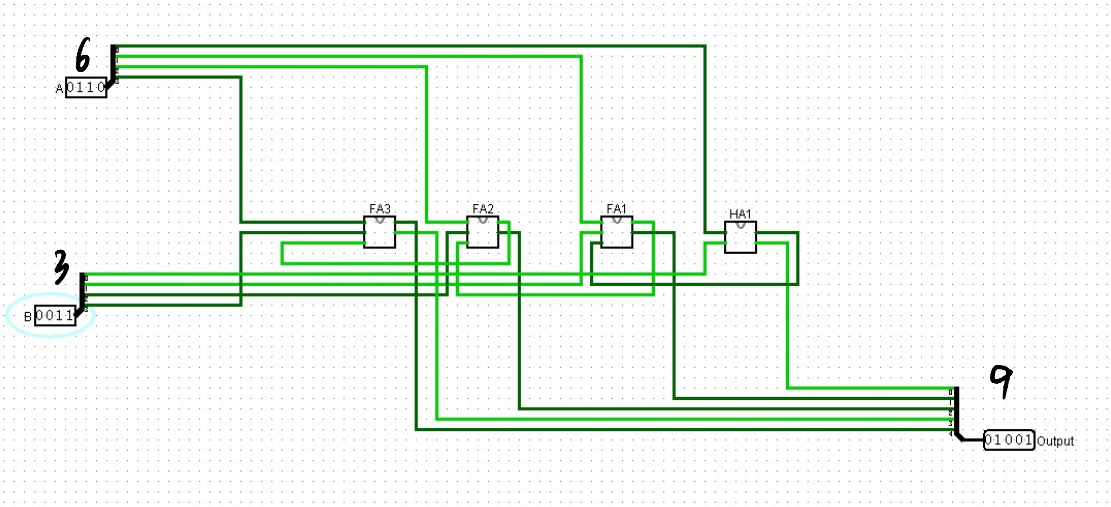
Screenshot of 4-bit adder with input: XXXX: 0010_2 0001_2

$(2_{10} + 1_{10} = 3_{10})$



Screenshot of 4-bit adder with input: XXXX: $0110_2 \quad 0011_2$

$(6_{10} + 3_{10} = 9_{10})$



Part 5: Conclusion

In this lab, you have learnt how a half adder, full adder, half subtractor and full subtractor functions. You have also learnt how to design and implement them. Moreover, you have learnt how to create sub circuit blocks which can be combined to create more complex circuits. You have used this technique to design and implement a 4 bit adder.