

EXPERIMENT # 10: Implementing Binary Adders**Name:** _____ **Date:** _____**Equipment/Parts Needed:**

PC (Altera Quartus II V9.1 installed)
DE-2 board

Objective:

- Design a half adder by extracting the Boolean equation from a truth table.
- Design a full adder by extracting the Boolean equation from a truth table.
- Construct the half adder and full adder circuits from a Boolean equation.
- Design and test a 3-bit adder circuit with using the Quartus II development software with the DE-2 board.

Discussion:

The fundamental building block of addition is the half adder, whose truth table is shown in the Table 10-1. By observation, you may recognize that the Carry output is the AND gate with respect to inputs A and B. The Sum output is the exclusive OR gate with respect to inputs A and B.

A ₀	B ₀	Carry	Sum
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

Table 10-1 Half adder truth table

The full adder is a circuit with the three inputs, A, B, C_{IN}, and two outputs, Sum and Carry. The truth table for the full adder is shown in the Table 10-2.

A ₁	B ₁	C _{IN}	Carry	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

Table 10-2 Full adder truth table

Part 1: Half adder circuit

1. Open the Quartus II software. Select **File – New Project Wizard**. Enter the appropriate drive letter for the designated storage area on the computer you are using followed by the working directory C:\altera\91sp2\quartus\kwon\Lab10. You need to go through the step from 1 through 8 in the Part 1 of **Lab6** manual. Don't forget to create the folder **Lab10** under the subfolder of your last name. Assign the project name **Lab10_1**, assign **Cyclone II** for the device family, and select the **EP2C35F672C6** chip in the Family & device settings [page of 3 of 5].

2. Create the Boolean equation from the truth table that represents the Carry output with respect to inputs A_0 and B_0 .

Carry = _____

3. Write the Boolean equation from the truth table that represents the Sum output with respect to inputs A_0 and B_0 .

Sum = _____

4. Open a new Block diagram/Schematic file (**File > New**) and construct the circuits of a half adder based on your equations. Each symbol should be available in the Project Library in the Symbol diagonal box.

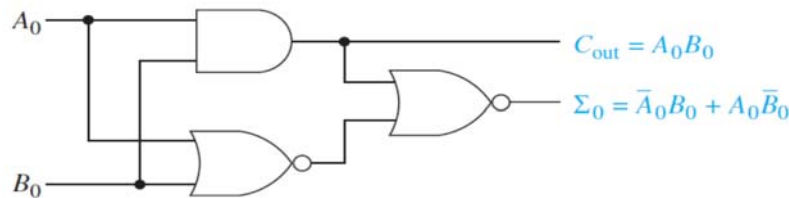


Figure 10-1 Half adder circuit

5. Before compiling this *bdf* file, we need to name this *bdf* file and save it as part of our project under your subfolder. Choose **File > Save As** and enter **File name** as **lab10_1**. Place a *check mark* in the space labeled **Add file to current project** and press **Save**.
6. Compile the project by selecting **Processing > Start Compilation**, or press Ctrl-L, or use the Compilation button in the toolbar. The compilation takes several seconds. When it is complete it should give a message that indicates, "Full compilation was successful". Press **OK**. If unsuccessful, correct all errors and try to re-compile.
7. You need to create a **Vector Waveform File (vwf)** to simulate a design(*bdf*) file. Add all inputs and output, specify an end time of 1 μ s and a grid size of 100ns for our waveform display, and then save it as **lab10_1.vwf**.
8. Select **Processing – Start Simulation**, or press Ctrl-I, or use the Simulation button in the toolbar. After a few moments a message stating "Simulation was successful" should appear. Click **OK**.

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- The Simulation Waveforms appear in the Simulation Report. You may have to expand the size of the Simulation Waveforms to suit your need and choose **View > Fit in Window** to see the entire waveform.

Part 2: Full adder circuit

- Create the Boolean equation from the truth table that represents the Carry output with respect to inputs A_1 and B_1 .

Carry = _____

- Write the Boolean equation from the truth table that represents the Sum output with respect to inputs A_1 and B_1 .

Sum = _____

- Create the project **Lab10_2**, assign **Cyclone II** for the device family, and select the **EP2C35F672C6** chip in the Family & device settings [page of 3 of 5]. Do not select a different project directory, click NO.
- Open a new Block diagram/Schematic file (**File > New**) and construct the circuits of a full adder based on your equations.

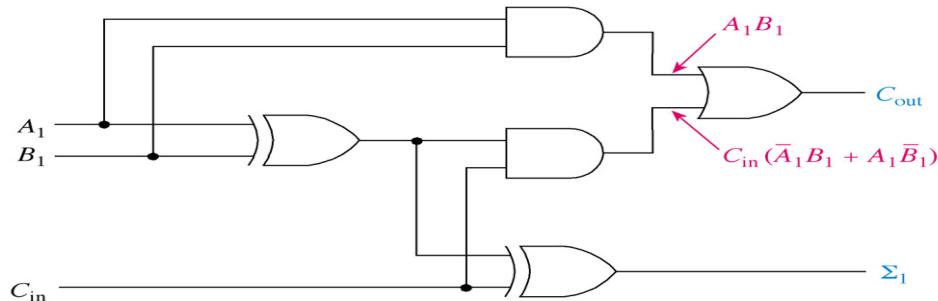


Figure 10-2 Full adder circuit

- Before compiling this *bdf* file, we need to name this *bdf* file and save it as part of our project under your subfolder. Choose **File > Save As** and enter **File name** as **lab10_2**. Place a *check mark* in the space labeled **Add file to current project** and press **Save**.
- Compile the project by selecting **Processing > Start Compilation**, or press Ctrl-L, or use the Compilation button in the toolbar. The compilation takes several seconds. When it is complete it should give a message that indicates, "Full compilation was successful". Press **OK**. If unsuccessful, correct all errors and try to re-compile.
- Create a **Vector Waveform File (vwf)** to simulate a design (*bdf*) file. Add all inputs and output, specify an end time of 1 μ s and a grid size of 100ns for our waveform display, and then save it as *lab10_2.vwf*.
- Select **Processing – Start Simulation**, or press Ctrl-I, or use the Simulation button in the toolbar. After a few moments a message stating "Simulation was successful" should appear. Click **OK**.

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9. The Simulation Waveforms appear in the Simulation Report. You may have to expand the size of the Simulation Waveforms to suit your need and choose **View > Fit in Window** to see the entire waveform.

Part 3: 3-bit Full adder circuit

1. Fill in the truth table with the expected outputs of a 3-bit Adder circuit.

A2	A1	A0	B2	B1	B0	Cout	Sum2	Sum1	Sum0
0	0	0	0	0	0				
0	0	1	0	0	1				
0	1	0	0	1	0				
0	1	1	0	1	1				
1	0	0	1	0	0				
1	0	1	1	0	1				
1	1	0	1	1	0				
1	1	1	1	1	1				
0	0	0	1	1	1				
0	0	1	1	1	0				
0	1	0	1	0	1				
0	1	1	1	0	0				
1	0	0	0	1	1				
1	0	1	0	1	0				
1	1	0	0	0	1				
1	1	1	0	0	0				

Table 10-3 3-bit Full adder truth table

2. Start the Quartus II software. Select **File – New Project Wizard**. And create a new project name under the directory C:\altera\91sp2\quartus\your last name\Lab10. Assign the project name **Lab10_3**, assign **Cyclone II** for the device family, and select the **EP2C35F672C6** chip in the Family & device settings.
3. Open a New Block Diagram/Schematic file and draw the circuit for 3-bit binary adders shown in Figure 10-3. And compile the circuit and correct all errors if you have any.
4. Open a new Vector Waveform file and create waveforms all inputs (A0 through B2). And simulate the waveforms and analyze the output waveforms with respect to the inputs, and then compare the outputs with your Truth table.
5. To program files and test it on DE-2 board, choose **Assignment > Pins** and then assign the pin numbers as shown in the tables below.

SWITCH INPUTS

Name	Pin Num.	Switches
A2	PIN_V2	SW[17]
A1	PIN_V1	SW[16]
A0	PIN_U4	SW[15]
B2	PIN_P25	SW[2]
B1	PIN_N26	SW[1]
B0	PIN_N25	SW[0]

LED OUTPUTS

Name	Pin Num.	LED
Cout	PIN_AE23	LEDR[0]
Sum2	PIN_W19	LEDG[2]
Sum1	PIN_AF22	LEDG[1]
Sum0	PIN_AE22	LEDG[0]

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6. Save and compile the design again before programming. Then connect DE-2 board to computer. (If you're not sure, refer to the Part 2 of Lab 7 manual.)
7. Now program the design and exercise the toggle switches and verify the proper LED is illuminated by comparing with the truth table in Table 10-3 where you filled with above. You need to show and explain it to your Instructor. (Remember that Input switches in the ON position mean a HIGH(1). Also remember that the DE-2 board has active-HIGH LEDs.)

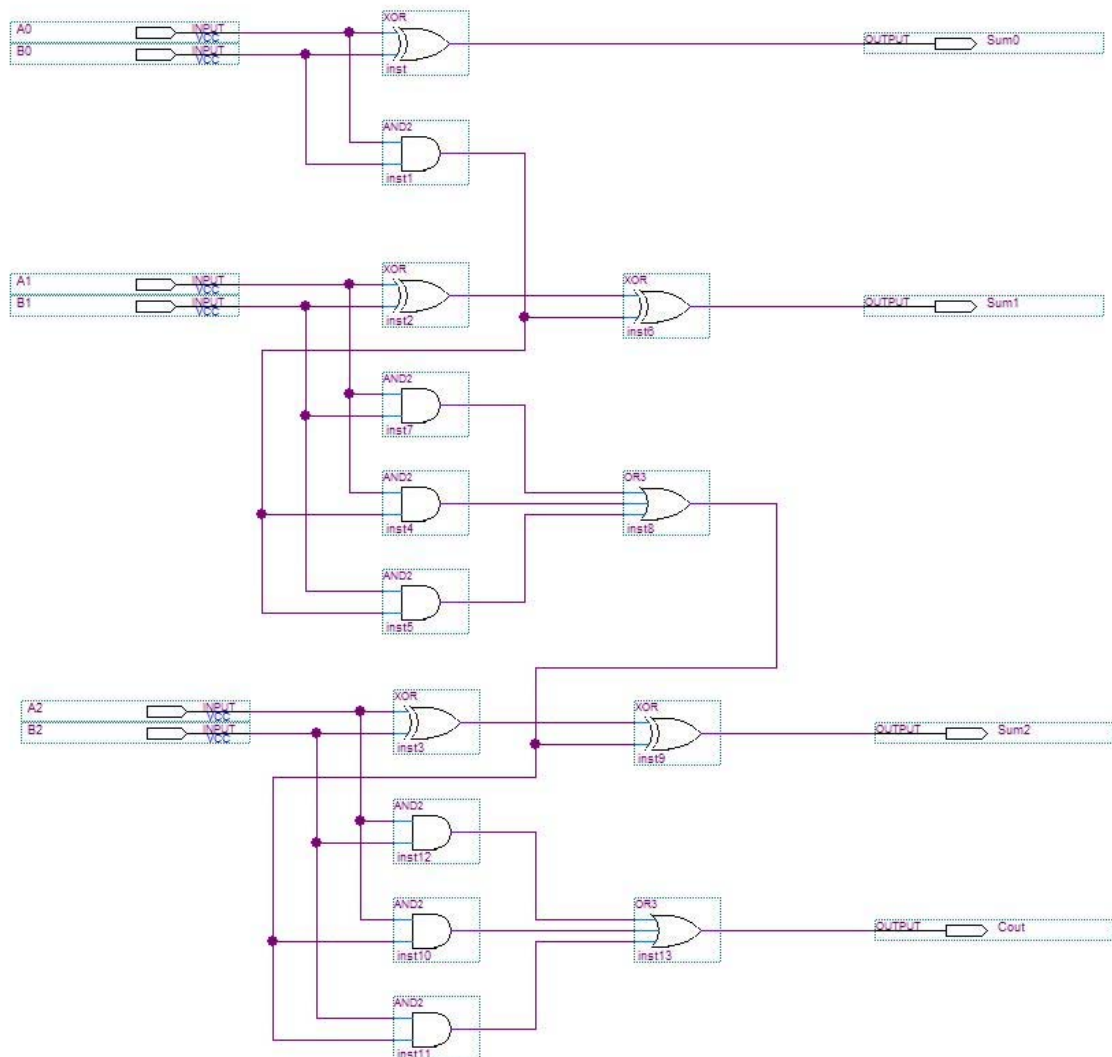


Figure 10-3 3-bit Binary Adder Circuit

Instructor's Signature: _____,

Date: _____

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Questions/Report:

- 1. Include the schematics, vector waveforms, truth tables, and pin outs in the lab report.**
- 2. What is the range of values for an 8-bit unsigned binary number?**