

Lab 2
(Full Score: 60 points)

(Due by 2/11/Friday in class/at at Moodle)

Your name:	Score:
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Design and Implementation of a 4-bit Adder with Overflow Detection

Goal

The goal of this lab is to learn how to design and implement of an adder that can be used as a central component in ALU, a key module in the CPU module.

Objectives

- To practice the techniques for combinational circuit design.
- To design a 4-bit ripple-carry adder using 1-bit Full-Adders.
- To use the Quartus II CAD design software to design and simulate a 4-bit adder and test it on DE 2 Board.

Requirements

1. You are to design a 4-bit ripple-carry adder with overflow detection that can perform addition of two 4-bit two's complement numbers. Note that the operands are already represented in 2's complement.
2. Your design must be based on a 1-bit full-adder module. You should first design and simulate a 1-bit full-adder circuit in Quartus II. You are required to use the all NANDs 1-bit Full-Adder circuit presented in the text. You will design and simulate this circuit *fully* to make sure that it functions correctly before you use it to design the 4-bit adder.
3. Once you have the 1-bit adder correctly designed in Quartus II, make a sub-circuit module and create a symbol for it, name it "*Your_initias_Lab01_FA*" (e.g., "BYI_Lab01_FA" for my design). Then, you will use this FA module as a basic building block for the 4-bit ripple carry adder.
 - a. It will save you tons of energy and huge amount of time if you make sure that your FA works perfectly. In that way, if the 4-bit adder has problems it should be caused only by the connections among the FAs, not inside the FA module.

4. You need to design and implement an overflow detector applied to the adder to detect any operational overflows. Overflow detecting is an important part of an ALU module. Review the concept and method of overflow detection in Chapter 3 of the text.
5. In Quartus II, go through the following steps for the design of the 1-bit full adder and the 4-bit ripple-carry adder with overflow detection.
 - (1) Schematic design entry
 - (2) Compilation
 - (3) Prepare a wave form file for the simulation of your design. You should may use the following table to design the input wave forms—try to use as many as input combinations, when I test your circuit you don't have to change the inputs.

2's C	Dec		2's C	Dec
0111	7		1111	-1
0110	6		1110	-2
0101	5		1101	-3
0100	4		1100	-4
0011	3		1011	-5
0010	2		1010	-6
0001	1		1001	-7
0000	0		1000	-8

- (4) After having thoroughly tested your circuits and simulated with many inputs in Quartus II, compressed your Quartus II project folder and submit it at Moodle.
 - (5) Come to the lab by the deadline, ask the instructor to test your project on DE2 Board.
6. When you perform the pin assignment to the DE2 board, use the 8 out of the 18 switches on the DE2 board for input from the two 4-bit operands and use the 5 green LEDs on the DE2 board for the 4-bit output display and 1 bit overflow indicator.
 - a. Be very careful in selecting these pins. Check DE2 Pin Assignments at http://cs.salemstate.edu/~b_yi/2011Spring/CSC295/resources/index.html on Pin names.

Submission

1. Submit your Quartus II project (in a compressed file) to Moodle before the deadline. Both the instructor and you will test your project on Quartus II and DE2 Borad on the scheduled lab day/hours (which will be announced in class).
2. A *printout/paper* with **your name, lab title**, and **a list of PIN assignments for the Inputs and Outputs** for the project you have used—so I will be able to test your project on DE 2 Board!

Group or Individual Work?

- If you have completed this project **individually**, you will get **15%** bonus points.
- If you work in **group**, each member will receive the same grade.
 - **The number of the group members is 2.**
 - Both members must show up during testing in the lab and each should be prepared to answer questions related to the project. **If a member did not show the knowledge that is required for the design of the submitted project, the instructor may deduct his/her grade!!**

Bonus Work:

- **(5 points)** This 4-bit adder will be able to detect Negative, Zero, Carry/Borrow statuses in addition to the required Overflow.
- **(15 points)** Your designed circuit can work as a 4-bit Adder/Subtractor defined in the textbook in Table 3.8 (with 4 different functions of additions and subtractions).