Name: _____ ID# _____

Date Submitted: _____ Lab Section # _____

CSE 2441 – Introduction to Digital Logic Fall Semester 2014

Lab Number 3 – Two's-Complement Adders and Subtractors

To be performed September 11-12, 18-19, 2014

Note: You have two weeks to complete this lab.

CSE 2441 LABORATORY SESSION 3 FALL 2014

TWO'S-COMPLEMENT ADDERS AND SUBTRACTORS

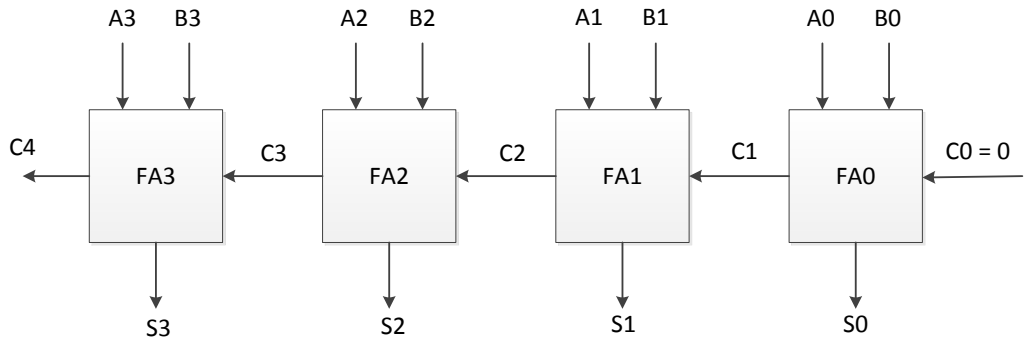
(100 POINTS)

PURPOSE/OUTCOMES

To introduce you to circuits for adding and subtracting numbers in a two's complement number system. After completing this lab, you will have demonstrated an ability to design four-bit adders and subtractors, to capture and verify your designs using Quartus II, construct your designs on a solderless breadboard, and test your implementations using an IDL-800. Record your prelab and in-lab work in your laboratory notebook. Have your lab instructor check your results after each part.

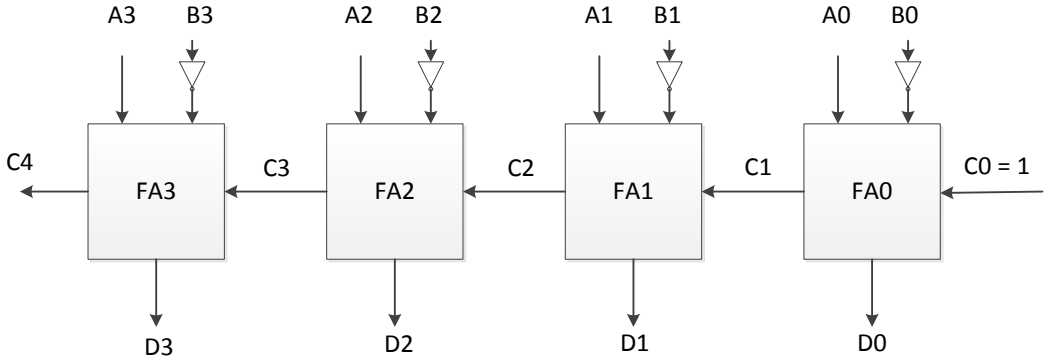
BACKGROUND

In lab 2, you designed a four-bit ripple-carry adder using four full-adders as components as shown below. This circuit will form the basis of the adder/subtractor that you will design, construct and test in this lab.



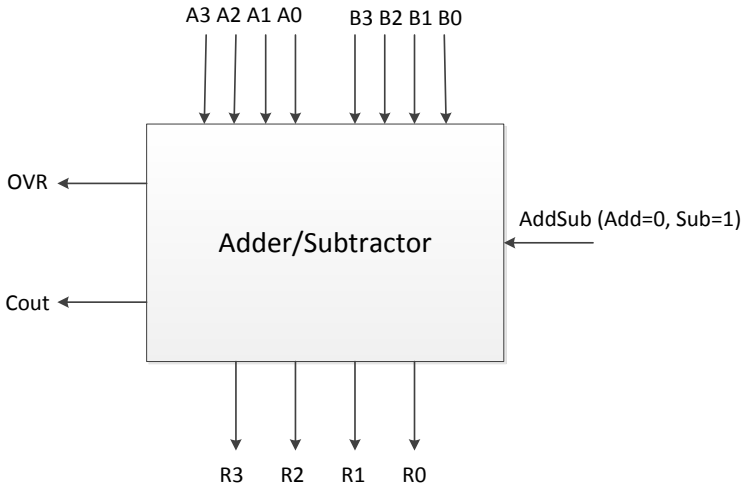
Note that FA0 could be replaced by a HA since C0 = 0. However, a FA is preferred since it allows a ripple-carry adder to also be used for subtraction as illustrated below.

Recall that if *A* and *B* are binary numbers then $A - B = A + (-B) = A + [B]_2 = A + [B]_1 + 1$ where $[B]_2$ is the *2's* complement of *B and* $[B]_1$ is the 1's complement. Example, if *A = 0101* and *B = 0010*, then $A - B = 0101 + (-0010) = 0101 + [0010]_2 = 0101 + [0010]_1 + 1 = 0101 + 1101 + 1 = \cancel{1}0011$. The following modified four-bit ripple-carry adder will perfom all of this in hardware.



PRE-LAB WORK (20 points) – Must be completed prior to your lab session.

1. Design an implementation of a four-bit, two's-complement adder/subtractor according with the block diagram below. Your design should incorporate the ripple-carry adder that you designed in lab 2.
2. Use Quartus II to capture and verify your design.
3. Create a symbol file for your design for use in a later lab assignment.



IN-LAB WORK (80 points) – Have your lab instructor check your results after each part.

1. Construct your ripple-carry adder implementation. Use the following IDL-800 LED and switch assignments.

   A3: SW7, *A2:* SW6, *A1*: SW5, *A0*: SW4
   B3: SW3, *B2*: SW2, *B1*: SW1, *B0*: SW0
   R3: LED3, *R2*: LED2, *R1*: LED1, *R0*: LED0
   C4: LED4
   C0: PSA

2. Test your ripple-carry adder for the values of *A* and *B* in the following table.

A	***B***	***S = A + B***
0101	0001	
0111	0001	
0111	1111	
1001	1110	

3. Construct your adder/subtractor and test it for the values of A and B in the following table.

A	***B***	***R = A + B***	***Cout(C4)***	***R = A - B***	***Cout(C4)***
0101	0001				
0111	0001				
0111	1111				
1001	1110				
1010	1110				
1101	1100				

Use the same IDL-800 assignments as in part 1.