

Ryerson University
Department of Electrical and Computer Engineering
COE/BME 328 – Digital Systems

Lab 3 - Adder and Subtractor Unit**15 Marks (2 weeks)****Due Date: Week 7****1 Objectives**

- To design and build a 4-bit Adder/Subtractor unit (ASU) using an Altera CPLD chip.
- To design the Adder/Subtractor unit that multiplexes add and subtract operations with a common Cin input.
- To implement the 4-bit ASU using VHDL coding.
- To design a Combinational Circuit that takes the decoded output of ASU as input. This Combinational Circuit will have the design logic to output individual digits of the Student Identification number of the student performing laboratory work.

Pre-Lab Preparation**2**

1. Modify the VHDL code from Figure 5.28 (see course text) to implement the ASU represented in Figure 5.13 (see course textbook). Create a file *ASU.vhd* to accomplish this task.
Note: change `ieee.std_logic_signed.all` to `ieee.std_logic_unsigned.all`.
2. Copy the code that implements a 4 bit-to-7-segment converter from Figure 6.47 (course textbook) into a file *sseg.vhd*.
3. Modify the code in file *sseg.vhd* to represent the sequence **0-F** on a seven segment display. It must also be able to show the sign (-) in case of negative numbers.
4. Minimize the logic expressions for your customized L3, L2, L1 and L0 -signals. These minimized logic expressions are to be implemented as outputs of the combinational circuit C in Figure 2 (shown below).
5. Create a new VHDL file *C.vhd* to implement the minimized logic expressions for the L3, L2, L1 and L0 signals that correspond to a 4-bit representation of your student identification number. The minimized logic expressions for these signals can be generated using K-Maps and converting each of the resulting expressions to VHDL code.
6. Using the Functional Simulator (waveforms), verify the circuit described by the VHDL file obtained in step 3. By setting values for X3, X2, X1, X0, Y3, Y2, Y1, Y0 and Cin, observe the following signals: S3, S2, S1, S0 and Cout. This ensures that two displays will show the **signed sum**.

3 Laboratory Work

The procedure is divided into two parts:

Part A.

1. This part must be completed during the week 1 of this lab experiment.
2. Compile your modified 4-bit Adder/Subtractor unit (ASU) file *ASU.vhd* and create a symbol file *ASU.bsf*
3. Compile your seven segment code *sseg.vhd* as a separate project and create a symbol file *sseg.bsf*
4. Start a new Project **CombinedASU1** and create a block schematic file *CombineASU1.bdf*.
5. Import the symbols **ASU** and **sseg** into the block schematic file *CombinedASU1.bdf*.
6. Complete the wiring and pin assignments by following the connections described in the Figure 1 (Typical Schematic generated using Quartus II depicted in).

S (ASU Output)				STUDENT_ID (C Output)			
S ₃	S ₂	S ₁	S ₀	L ₃	L ₂	L ₁	L ₀
0	0	0	0	0	0	0	1
0	0	0	1	0	1	0	1
0	0	1	0	0	0	0	0
0	0	1	1	0	0	0	1
0	1	0	0	0	0	0	0
0	1	0	1	0	0	0	1
0	1	1	0	0	0	0	1
0	1	1	1	1	0	0	0
1	0	0	0	0	1	0	1
1	0	0	1	0	0	2	0
X	X	X	X	1	1	1	0
X	X	X	X	1	1	1	0
X	X	X	X	1	1	1	0
X	X	X	X	1	1	1	0

Fill your Student ID in Binary form

Don't Cares

Table 1. . 4-bit Student ID generated by combinatorial logic

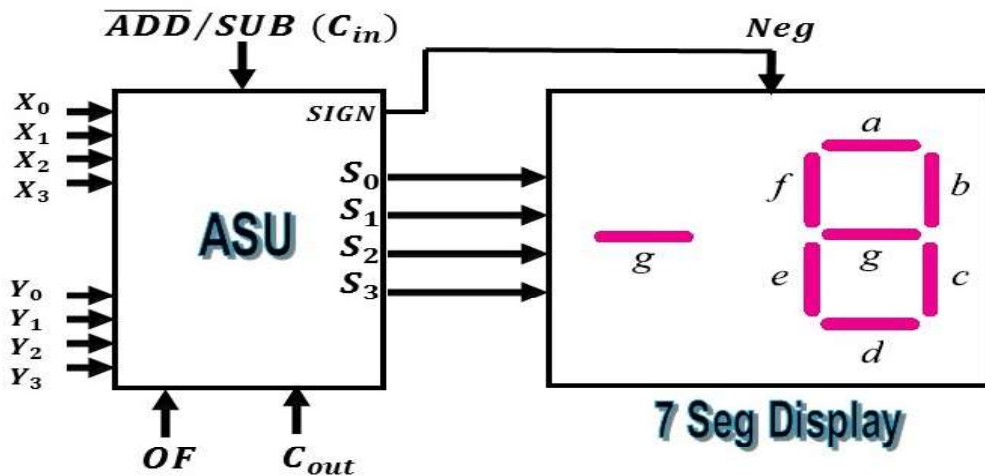


Figure 1. Block Diagram for PART A implementation

Part B.

1. This part must be completed during the week 2 of this lab experiment.
2. Consider the 9 digits of the student identifier $D = \{d_1, d_2, d_3, d_4, d_5, d_6, d_7, d_8, d_9\}$ in its general representation. Write a table that represents each digit of your student ID in four bits. For example, if a student's ID is: **111726015**, it will likely follow a 4-bit sequence **{0001, 0001, 0001, 0111,, 0101}** as depicted in Table 1.
3. Compile your customized Combinatorial Unit *C.vhd* and create a symbol file *c.bsf*
4. Start a new Project **CombinedASU2** and create a block schematic file *CombineASU2.bdf*.

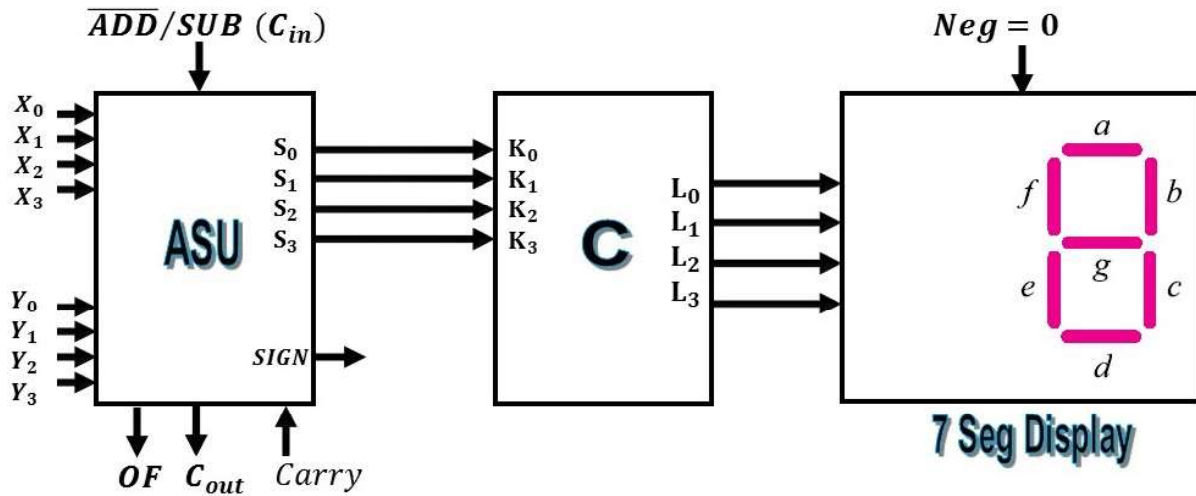


Figure 2. Block Diagram for PART B implementation

5. Import the symbols **ASU**, **combinatorial** and **sseg** (refer Part A) into the block schematic file *CombinedASU2.bdf*.
6. Complete the wiring and pin assignments by following the connections described in the Figure 2 (Typical Schematic generated using Quartus II depicted in).

■ Appendix A

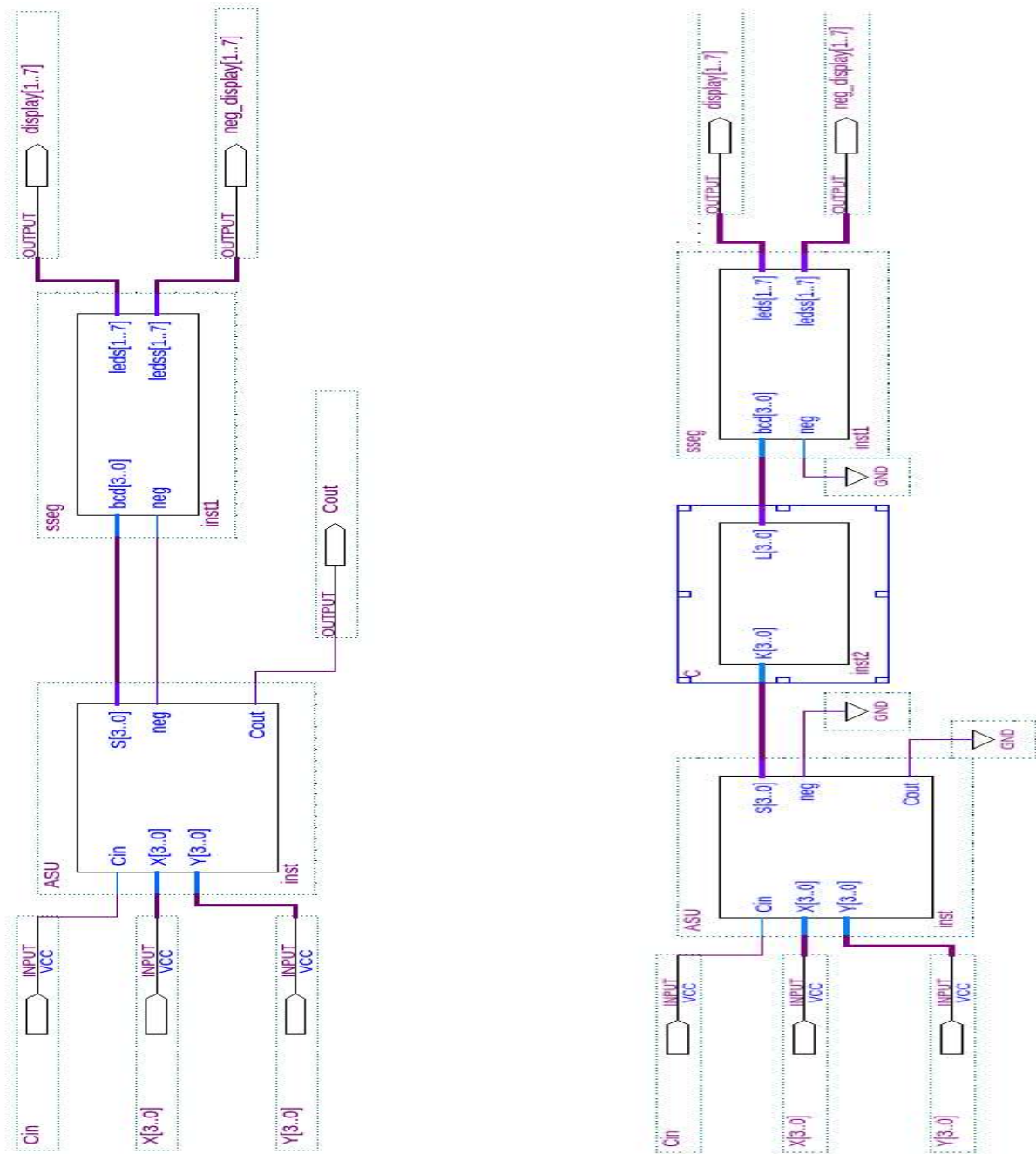


Figure 3. Typical Block schematic for PART A & B implementation using Quartus II