

# Lab 4 - Combinational Logic Circuits (IV)

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CDA 3201L-003

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## Purpose and Objectives

This lab we set out to implement four functions that work with 4-bit, two's complement inputs ( $A+1$ ,  $A+B$ ,  $A-B$ , and  $A-1$ ). Since subtraction can be accomplished by negating one of the inputs we will only need a single 4-bit adder.

## Component List

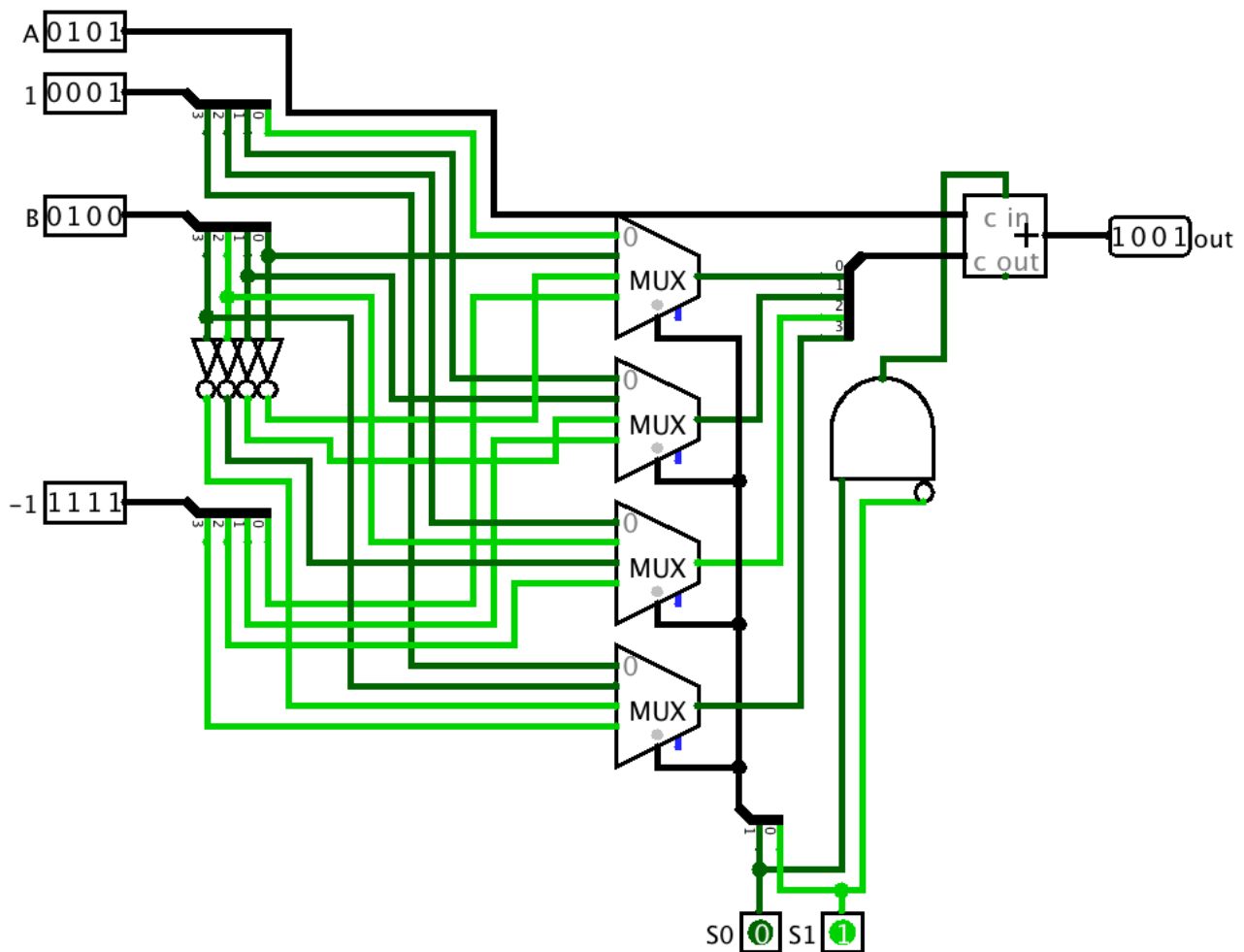
- Breadboard
- Wiring
- 5v power supply
- 1 x 4 bit adder (74LS83)
- 2 x Dual 4 to 1 Selector/Multiplexer (74LS153)
- 1 x Hex Inverter (74LS04)
- 1 x Quad 2-input AND Gate (74LS08)
- 4 x LED
- 4 x Resistor (470 Ohms 5%)

## Design

Since our design was constrained to a single 4-bit adder we wired the A input into the adder as it is required for all four functions. We then used multiplexers to select from four different inputs. For subtraction we negated all the bits of B and set the carry for the adder. This was the design we came up with in logisim:

## 2's Complement Functions

$A+1$ ,  $A+B$ ,  $A-B$ ,  $A-1$



We implemented this in hardware.

## Test Vectors and Verification

We decided to test our design against various inputs that we thought would cover a majority of the circuit. This is the truth table we tested from:

s0	s1	A	B	F
0	0	-8	X	-7
0	0	0	X	1
0	0	6	X	7
0	1	0	-8	-8
0	1	7	-8	-1

s0	s1	A	B	F
0	1	-8	0	-8
0	1	0	0	0
0	1	7	0	7
0	1	-8	7	-1
0	1	0	7	7
1	0	-8	-8	0
1	0	-8	0	-8
1	0	0	0	0
1	0	7	0	7
1	0	0	7	-7
1	1	-7	X	-8
1	1	0	X	-1
1	1	7	X	6

## Discussion and Conclusion

In this lab we demonstrated the limits of 4-bit, signed integers through the implementation of a 4 bit adder. Because the left most bit is the sign bit, this means the max value that can be represented is 7 while the minimum value that can be represented is -8 because of two's complement. This helped us exercise and understand the fundamentals of adding and subtracting in circuits and how overflow creates mathematical errors in computing and when to look out for them.

## Questions and Answers

Is the output valid for the following input combinations:

- S0 = 0, S1 = 0, A = 7, B = 3? **Invalid**
- S0 = 0, S1 = 1, A = 7, B = -3? **Valid**
- S0 = 1, S1 = 0, A = -4, B = -5? **Valid**

What is the range of inputs (for both A and B) that will produce the valid output for each of the functions?



$$A+1 : -9 < A < 7$$

$$A+B : -9 < A < 8$$

$$-9 < B < 8$$

$$\text{where } -9 < A+B < 8$$

$$A-B : -9 < A < 8$$

$$-9 < B < 8$$

$$\text{where } -9 < A+B < 8$$

$$A-1 : -8 < A < 8$$