

## Binary Arithmetic

### 3.1 Introduction

In this experiment, you will implement logic circuits for arithmetic operations on signed and unsigned binary numbers.

### 3.2 Preliminary

- Recall signed and unsigned addition for binary numbers in 2s complement notation.
- Recall signed and unsigned subtraction for binary numbers in 2s complement notation.
- Recall what carry, borrow and overflow mean, when they occur and how are they interpreted.
- Study the function table and pin descriptions of 74xx83, 4-Bit Binary Full Adder.

### 3.3 Equipments and Integrated Circuits (ICs)

Following equipment and ICs are going to be used in the experiment.

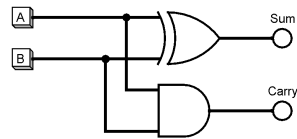
- C.A.D.E.T. (Complete Analogue Digital Electronic Trainer)
- 74000 series ICs
  - 74xx08 - Quadruple 2-input Positive AND Gates
  - 74xx32 - Quadruple 2-input Positive OR Gates
  - 74xx83 - 4-bit Binary Full Adder
  - 74xx86 - Quadruple 2-input Positive Exclusive Or (XOR) Gates

Fundamental information (function tables and pin configurations) of the ICs listed above are given in the Appendix. You should also examine the data-sheets in order to acquire further information about these ICs.

### 3.4 Experiment

#### 3.4.1 Experiment - Part 1

A half adder circuit is given below. Implement and test the circuit to draw the truth table of the half adder. Use switches for inputs and LEDs for outputs.



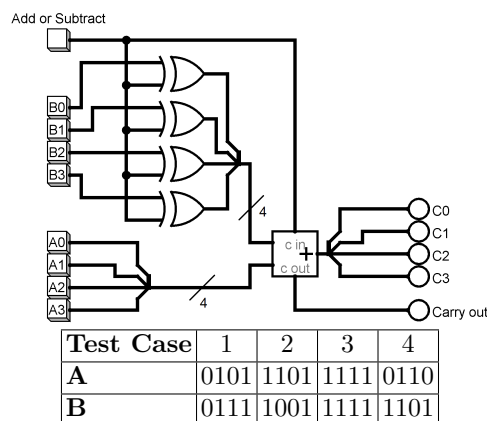
**Attention:** After you have completed this part, do not disassemble the circuit since you will reuse it in the next part.

### 3.4.2 Experiment - Part 2

Attach one more input (for  $C_{in}$ ) and additional gates to your circuit in Part 1 to obtain a full adder. Test the circuit and draw the truth table.

### 3.4.3 Experiment - Part 3

Using a 4-bit full adder (74xx83) implement the circuit below. You can observe your calculation results on LED logic indicators (for binary form) and seven segments displays (for decimal form).



For each test cases above, carry out the following tests.

- Calculate the result of  $A + B$ . Interpret inputs as **unsigned**. Draw a table with the following columns and add your results.  

A	B	Carry	Result in Binary	Result in Decimal
---	---	-------	------------------	-------------------
- Calculate the result of  $A + B$ . Interpret inputs as **signed**. Draw a table with the following columns and add your results.  

A	B	Overflow	Result sign	Result in Binary	Result in Decimal
---	---	----------	-------------	------------------	-------------------
- Calculate the result of  $A - B$ . Interpret inputs as **unsigned**. Draw a table with the following columns and add your results.  

A	B	Borrow	Result in Binary	Result in Decimal
---	---	--------	------------------	-------------------
- Calculate the result of  $A - B$ . Interpret inputs as **signed**. Draw a table with the following columns and add your results.  

A	B	Overflow	Result sign	Result in Binary	Result in Decimal
---	---	----------	-------------	------------------	-------------------

## 3.5 Report

Prepare your report by using the guidelines and the report template which are posted on Ninova e-Learning System. Your report should also include the following materials:

- Circuits diagrams of the expressions which were implemented during this experiment.
- Your results as tables for each part of the experiment.

During the experiment, please do not forget to take notes about the critical points of the implementations in order to write a proper report for the experiment. Additionally, if there were any complications which affect your performance during the experiment, please also indicate these difficulties in your report.