

ECE 85L Digital Logic Design Laboratory
Fresno State, Lyles College of Engineering
Electrical and Computer Engineering Department
Spring 2015

Laboratory 9 – Arithmetic Circuits

1. OBJECTIVES

- Design and Construct Various Adder and Subtractor Circuits
- Perform the Arithmetic Sum of Two Binary Numbers
- Perform the Subtraction of Binary Numbers using the 2's Complement Technique

2. DISCUSSION

In this experiment, you will construct and test various Adder and Subtractor circuits. When arithmetic operations are implemented in a computer, it is more convenient to use a system referred to as the signed-complement system for representing negative numbers. Therefore, in a digital system or in a computer, a negative number is indicated by its complement. Subtraction of two binary numbers when negative numbers are in 2's complement form is simple. The procedure can be stated as follows:

1. Take the 2's complement of the subtrahend (bottom number).
2. Add it to the minuend (top number).
3. Overflow indicates that the answer is positive. Ignore the overflow.
4. No overflow indicates that the answer is negative. Take the 2's complement of the original sum to obtain the true magnitude of the answer.

3. PRELAB

1. A half adder is a circuit that has two inputs, A and B, and two outputs, sum and carry. It adds A and B according to the rules of binary addition and outputs the sum and carry. Design a half-adder circuit using one XOR gate and one AND gate. Verify your design through truth table and with Multisim.
2. Whereas the half adder added two inputs A and B, the full adder adds three inputs together, A, B, and a carry from a previous addition, and outputs a sum and carry.

Design a full adder circuit to AND, OR, and XOR gates. Verify its operation through truth table and with Multisim.

4. LAB ASSIGNMENT

4.1 4-Bit Binary Adder Design

Design, construct, and test a four-bit binary parallel adder by cascading four one-bit adders using the adder you designed in Prelab. The design will require 2 4-bit binary inputs and a carry in bit, and a 4-bit binary output with a carry out bit. Verify the design by adding several sets of binary numbers together using the toggle switches and LED indicator lights for the inputs and outputs, respectively. See Figure 4.1 as a reference for the required inputs and outputs (ignoring the Pin numbers).

4.2 7483 4-Bit Binary Adder

Test the 7483 4-Bit Binary Adder shown in Figure 3.1. The pin assignments for 2 4-bit numbers in the adder are **A1** through **A4** and **B1** through **B4**, as shown. The 4-bit sum is obtained from **S1** through **S4**. **C0** is the input carry and the **C4** the output carry.

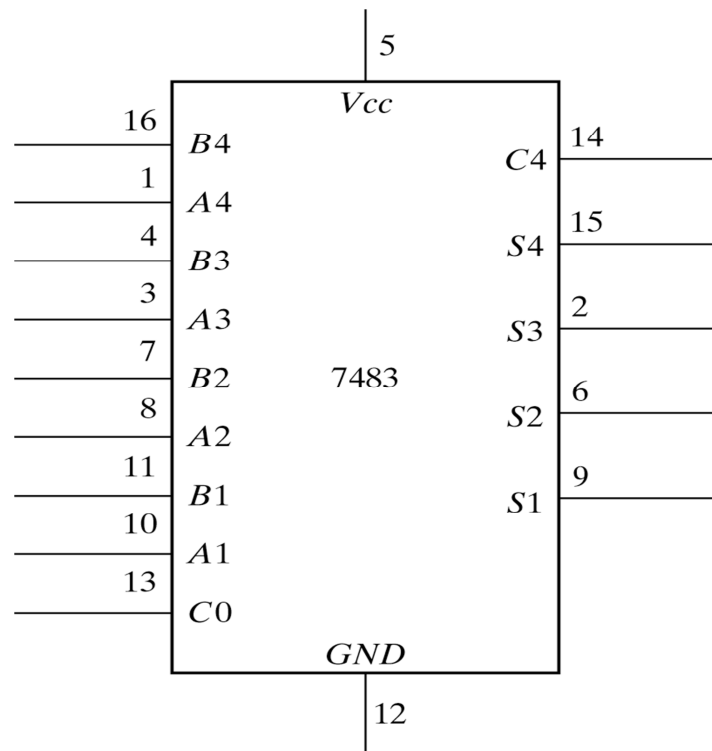


Figure 4.1: 7483 4-bit Adder

Test the 4-bit binary adder by connecting the power supply and ground terminals. Then connect the four **A** inputs to a fixed binary number, such as 1001, and the **B** inputs and the input carry to five toggle switches. The five outputs are applied to indicator LEDs. Perform the addition of a few binary numbers and check that the output sum and output carry give the proper values. Show that when the input carry is equal to 1, it adds 1 to the output sum.

4.2 4-Bit Subtractor using 2's Complement Addition

Two binary numbers can be subtracted by taking the 2's complement of the subtrahend and adding it to the minuend. The 2's complement can be obtained by taking the 1's complement and adding 1. To perform $A - B$, we complement the four bits of B , add them to the four bits of A , and add 1 through the input carry. This is done as shown in the Figure 4.2. The four XOR gates complement the bits of B when the mode select $M = 1$ and leave the bits of B unchanged when $M = 0$. Thus, when the mode select M is equal to 1, the input carry C_0 is equal to 1 and the sum output is A plus the 2's complement of B . When M is equal to 0, the input carry is equal to 0 and the sum generates $A + B$.

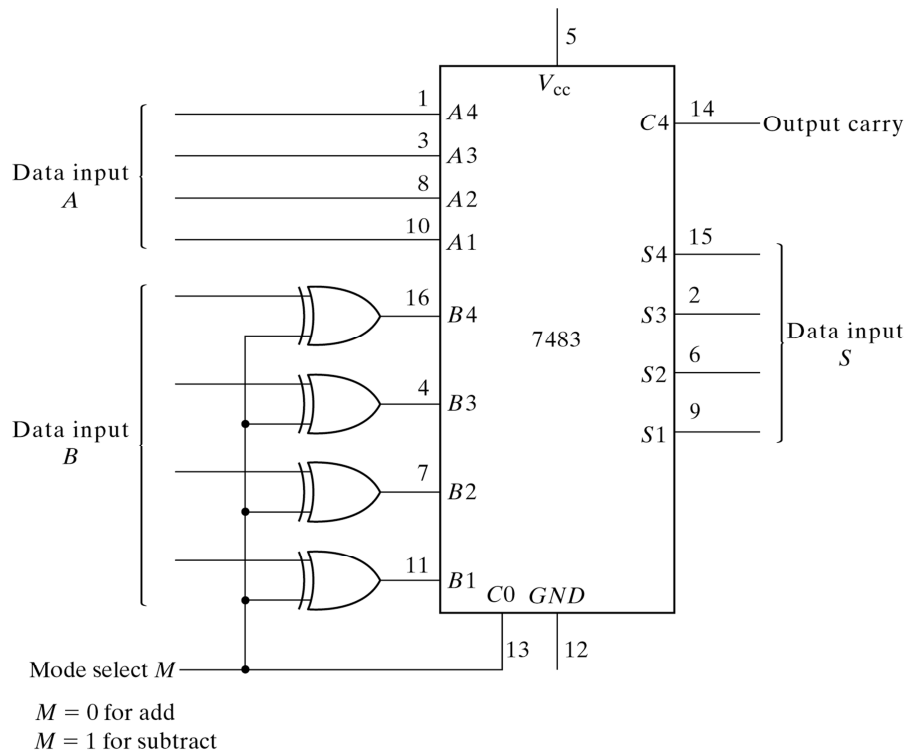


Figure 4.2: 2's Complement Subtraction using a 7483 Adder

Connect the circuit and test it for proper operation. Connect the four A inputs to a fixed binary number 1001 and the B inputs to switches. Perform the following operations and record the values of the output sum and the output carry C_4 :

$9 + 5$	$9 - 5$
$9 + 9$	$9 - 9$
$9 + 15$	$9 - 15$

Show that during addition, the output carry is equal to 1 when the sum exceeds 15. Also, show that when A is greater or equal than B, the subtraction operation gives the correct answer, $A - B$, and the output carry C_4 is equal to 1, but when A is less than B, the subtraction gives the 2's complement of $B - A$ and the output carry is equal to 0.

5. REVIEW QUESTIONS

1. Explain the difference between a half adder and full adder.
2. Explain why a full adder requires a carry input, opposed to just a carry output.
3. Explain why 2's complement addition is required opposed to 1's complement addition to implement subtraction in digital circuits.
4. Explain generally how adder circuits can also be used to implement multiplication and division.