The University of Texas at Dallas
Department of Computer Science
CS 4141: Digital Systems Lab

Experiment #3– The Digital Adder Circuit

CS 4141 Laboratory 3, PRE-LAB 3

Objective:

The objective of this lab is to become familiar with the functionality of the digital adder circuit. Previous labs dealt with logic, this lab uses logic to implement mathematics. Learn how a 74LS283 4-Bit Full Adder IC functions to understand the adder circuit.

Turn-In Checklist

Make certain that your name, your lab section, the date, and “Pre-Lab 3” is at the top of your paper.

- Problem 1. Adder IC (74LS283)
- Problem 2. Subtraction with Two’s Complement
- Problem 3. A 1-Digit Binary Coded Decimal Circuit Design

Problem 1. Adder IC (74LS283)

The circuit diagram and logic symbol are on the left and right, respectively. You can read more information about this chip in ***Adder-74283.pdf***.

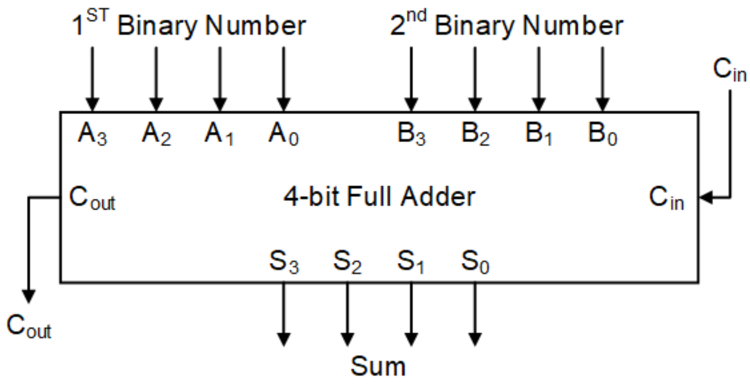

Fig. 1. Logic Symbol for a 4-bit Full Adder

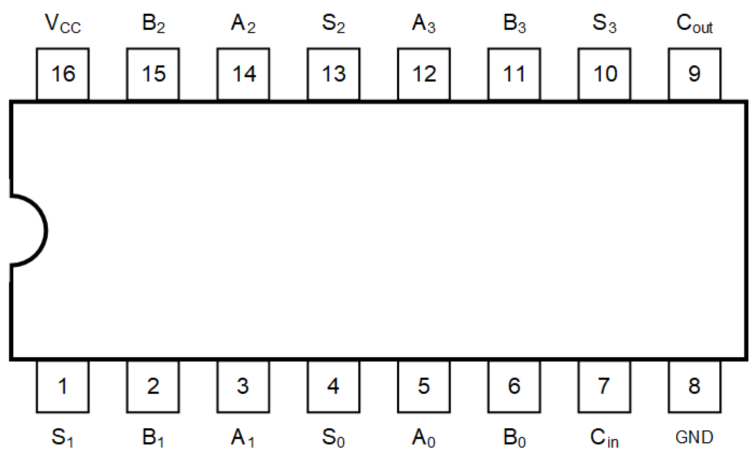

Fig 2.IC 74LS283 Pinout with matching logic labels

This adder chip is a 4-bit adder, which has 9 1-bit inputs. The first 1-bit input is the carry in, labeled C_{in}. The next set of 1-bit inputs are a sequence representing the first 4-bit binary integer, labeled A_3, A_2, A_1, and A_0.The last set of 1-bit inputs are a sequence representing the second 4-bit binary integer, labeled B_3, B_2, B_1, and B_0. The 4-bit adder also has 5 1-bit outputs. The first 1-bit output is the carry out, labeled C_{out}. A set of 4 1-bit outputs are a sequence representing the sum, S_3, S_2, S_1, and S_0.

The mathematical equation computed by the 4-bit adder is

$C_{in} + 2^0(A_0+B_0) + 2^1(A_1+B_1) + 2^2(A_2+B_2) + 2^3(A_3+B_3) = 2^0S_0 + 2^1S_1 + 2^2S_2 + 2^3S_3 + 2^4C_{out}$.

Answer the following questions:

1.1 Which pin is V_{CC}?
1.2 Which pin is GND?
1.3 For input A (same for B and output S), which is the more significant bit, A_0 or A_3?
1.4 Compute 8 + 12 using the binary adder using the binary adder logic symbol. Draw an image of the logic symbol, and label the appropriate inputs and outputs with a 1 or a 0.
1.5 Compute 5 + 6 using the binary adder IC pinout. Draw an image of the IC chip and label the appropriate pins with a 1 and 0. Include V_{CC} and GND.

Problem 2. Subtraction with Two's Complement

Question 2 in the lab requires the construction of a 2-bit adder/subtractor using the 4-bit chip.

To perform addition, compute input A+ input B as normal.

To perform subtraction, Input A will remain the same, but Input B will need to be converted to its 2's Compliment. To compute A – B, the formula is A + B' + 1, where B' means inverting each bit of input B.

Let C_{in} be the toggle between doing add and subtract; i.e. when C_{in} = 0, the circuit performs addition, and when C_{in}=1, the circuit performs subtraction.

If C_{in} = 0, then the circuit performs A + B + C_{in} = A + B + 0

If C_{in} = 1, then the circuit performs A + B' + C_{in} = A + B' + 1

The remaining problem is inverting bits of B when C_{in} = 1

Solve this problem and you will have a 2-bit adder/subtractor.

For this question, do the following:

2.1 Explain how you manipulate the bits of B to do both add and subtract
2.2 Draw the logic diagram ***(not circuit diagram)*** of the 4-bit adder/subtractor. For the Full Adder, use the logic symbol in the first page. A logical diagram should contain block notations (such as Full Adder, D Flip-Flop, Decoder, Multiplexer) and gate symbols (such as AND, OR, and NOT).

Problem 3 1-Digit BCD Full Adder

Learn about Binary Coded Decimal. Check the logic behind a 1-digit BCD full adder. Come up with a truth table and logic diagram for the BCD full adder. (Note : You have to implement the same question in the lab). A logical diagram should contain block notations (such as Full Adder, D Flip-Flop, Decoder, Multiplexer) and gate symbols (such as AND, OR, and NOT).