Lecture 13 In-Class Worksheet

1 Learning Objectives

This worksheet is based on Lumetta course notes section 2.3. After completing this lesson, you will know how to:

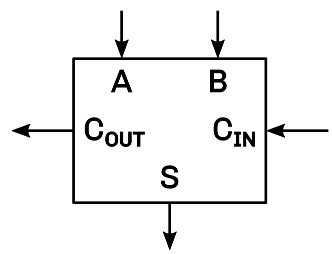
- [S13-1] Give the Boolean equations and truth table for a full adder.
- [S13-2] Construct an n-bit adder using full adders.

2 Bit Slicing

Bit slicing is a technique for building logic circuits that operate on groups of bits, such as an n-bit adder. In a bit-sliced design, each bit is processed by an identical, or nearly identical building block that passes a small amount of information (bits) to adjacent building blocks. By combining many building blocks, each operating on a single bit, we can build logic circuits that operate on arbitrarily large operands.

3 Full Adder

A *full adder* is a logic circuit that takes three inputs and produces a two-bit output that represents the sum of the three inputs. A full adder is the basic building block for a bit-sliced n-bit adder. The diagram on the right shows the block diagram of full adder. The least significant bit of the sum is denoted S in the figure, and the most significant bit, called the *carry out*, is denoted C_{OUT}. These outputs are described by the following Boolean expressions:



Full Adder Equations

$$S = A \oplus B \oplus C_{\mathsf{IN}} \tag{1}$$

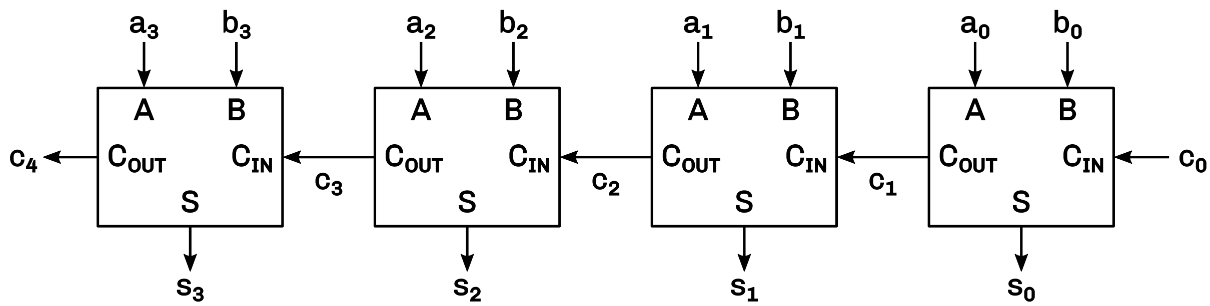
$$C_{\mathsf{OUT}} = AB + AC_{\mathsf{IN}} + BC_{\mathsf{IN}} \tag{2}$$

Q1. Give an expression for the outputs of a full adder when $B = 0$.

Q2. Give an expression for the outputs of a full adder when $B = 1$.

4 N-bit Adder

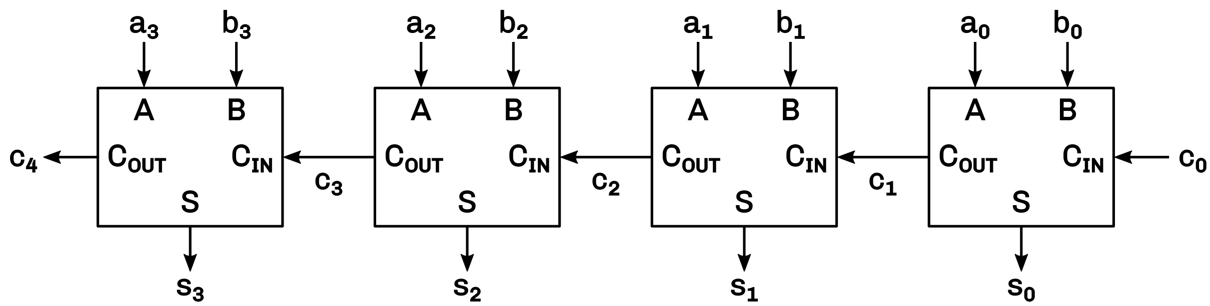
To add values greater than 1 bit, we chain several full adders, using one of the three inputs of the full adder to add the carry out from the previous bit. Shown below is a 4-bit adder:



Q3. What does an n-bit adder do when $b_0 = b_1 = \cdots = 0$ and $c_0 = 1$?

5 N-bit Adder

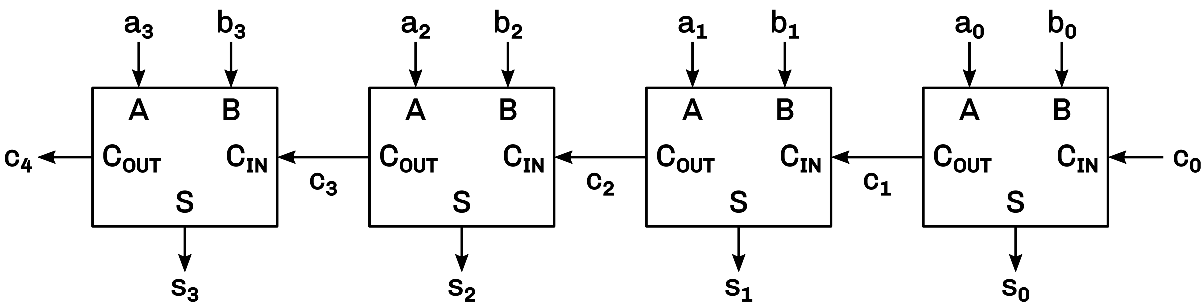
To add values greater than 1 bit, we chain several full adders, using one of the three inputs of the full adder to add the carry out from the previous bit. Shown below is a 4-bit adder:



Q4. What does an n-bit adder do when $b_0 = b_1 = \cdots = 1$ and $c_0 = 0$?

6 N-bit Adder

To add values greater than 1 bit, we chain several full adders, using one of the three inputs of the full adder to add the carry out from the previous bit. Shown below is a 4-bit adder:



Q5. Given, A >= B, What does an n-bit adder do when $b_0, b_1, \cdots$ are complemented and $c_0 = 1$?