Lab 4: Half-adders

Introduction

There are many complex functions that can be derived and built from simple logic gates. One such important function is an adder. An adder is an indispensable part of a Central Processing Unit (CPU). Current microprocessors have the ability to add two binary numbers that are 32 or 64 digits in length. With these adders, it is possible to add numbers from a very large range. The logic circuit necessary to perform this function consists of one half-adder and 31 full adders for a 32-bit CPU. However, in this lab, we will design a circuit that will implement a half-adder. Essentially, the adding [two binary numbers] is the most basic arithmetic operation. This simple addition consists of four possible elementary operations of 0 + 0 = 0, 0 + 1 = 1, 1 + 0 =1, and lastly 1 + 1 = 10. These operations produce a sum that is one digit in length except for the last one, 1 + 1 = 10. In this case, the result includes a carry bit. The carry obtained from the addition of two bits is added to the next higher order pair of significant bits. Because of this, half-adders can be thought of as an operation that performs the addition of two bits (two 1-bit inputs). If we consider the output, a half adder will produce two outputs: one for the solution (S), and one for the carry bit (C).

Objectives

Students are to become more proficient with simplifying logical expression by use of Boolean algebra and Karnaugh maps with respect to the implementation of a half-adder. In addition, students will become more comfortable with breadboard design and implementation.

(50 points) Half-adder design

Design a (1 bit) half-adder that will output the sum and carry. Remember, a half-adder contains *two inputs* (two 1-bit binary numbers) and *two outputs* (again, two 1-bit binary numbers). Include the following in your lab report:

- Truth table by hand (aka don't use the circuit analyzer of Logisim).
- Logical expressions by hand.
- K-map by hand.
- Simplified logical expressions.

(50 points) Half-adder implementation

Using your design from above, implement a half-adder by doing the following and also including these in your report:

- Circuit in Logisim

- On the breadboard, implement the half-adder. We will be using the 7404 (INVERTER), 7432 (OR), and 7408 (AND) chips. Demo this part to the TA.