Title: Design and Implementation of Full-Adder and Half-Adder Circuits Using Basic Logic Gates

Objectives

- To design and implement a Half-Adder circuit using basic logic gates.
- To cascade two Half-Adder circuits to create a Full-Adder circuit.
- To verify the input-output relationships of both circuits by constructing their truth tables.

Introduction

Half-Adder and Full-Adder circuits are key components in digital electronics for performing binary addition. A Half-Adder adds two single-bit binary numbers, producing a sum and a carry output. A Full-Adder builds on this by adding three single-bit binary numbers (two inputs plus a carry-in), generating a sum and a carry-out. These circuits use basic logic gates like AND, OR, and XOR and are crucial for arithmetic operations in digital systems, such as Arithmetic Logic Units (ALUs).

This experiment involves setting up these circuits using the AT-700 portable laboratory and ICs (7408 for AND, 7432 for OR, and 7486 for XOR). The setup includes a breadboard, data switches for inputs, and an LED light to observe outputs. The results are verified by comparing experimental truth tables with theoretical ones.

Procedures

Half-Adder Circuit

1. **Set Up Components:** I installed the Half-Adder circuit components (using 7408 AND, 7432 OR, and 7486 XOR ICs) on the AT-700 breadboard. I ensured correct connections, with each IC's pin 14 connected to +5V and pin 7 to GND.

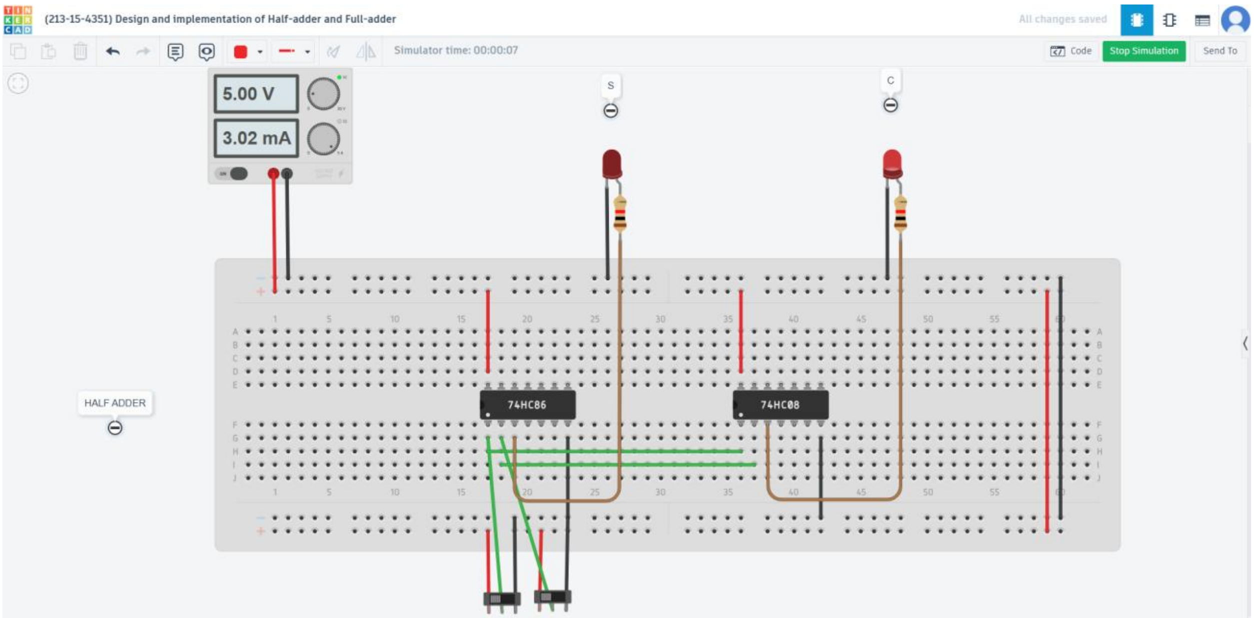
2. **Connect Inputs and Outputs:** I connected Data switches “0” and “1” to input points x and y, respectively. The LED Light’s “0” and “1” were connected to the Carry (C) and Sum (S) outputs, respectively.
3. **Test the Circuit:** I toggled Data switches “0” and “1” between “0” and “1” positions and observed the LED light. A lit LED indicated logic 1, and a dark LED indicated logic 0.
4. **Record Results:** I recorded the observed outputs in the Half-Adder truth table and compared them with the theoretical truth table.

Full-Adder Circuit

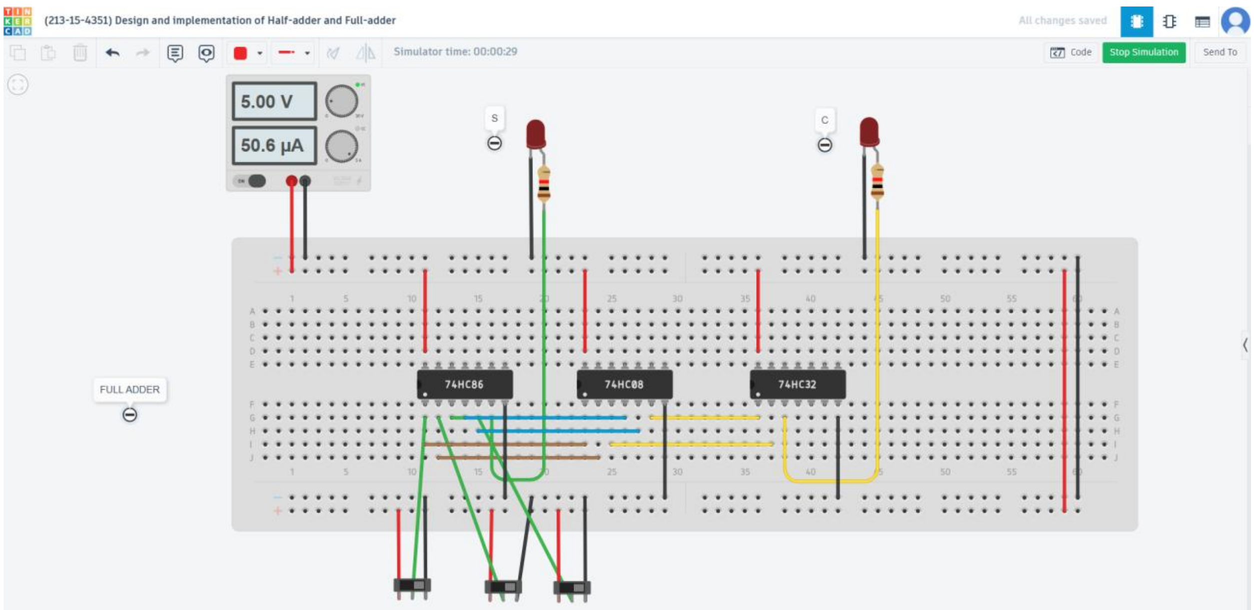
1. **Set Up Components:** I installed the Full-Adder circuit components (cascading two Half-Adders using 7408 AND, 7432 OR, and 7486 XOR ICs) on the AT-700 breadboard. I ensured proper connections, with each IC’s pin 14 connected to +5V and pin 7 to GND.
2. **Connect Inputs and Outputs:** I connected Data switches “0,” “1,” and “2” to inputs A, B, and Cin, respectively. The LED Light’s “0” and “1” were connected to the Carry-out (Cout) and Sum (S) outputs, respectively.
3. **Test the Circuit:** I toggled Data switches “0,” “1,” and “2” between “0” and “1” positions and observed the LED light to note the logic states.
4. **Record Results:** I recorded the observed outputs in the Full-Adder truth table and compared them with the theoretical truth table.

Experiment Pictures

- **Half-Adder Circuit Diagram:**



- **Full-Adder Circuit Diagram:**



Tinkercad Link

https://www.tinkercad.com/things/kbYYZ5xaPlw-213-15-4351implementation-half-adder-and-full-adder?sharecode=wuJNiB-ev52BAEk0tLtQrhxYOukTPs_LtDCicUOwWmM

Experimental Results

I recorded the results based on the LED outputs observed during the experiment.

Half-Adder Truth Table

x	**y**	**Sum ($S = x \oplus y$)**	**Carry ($C = x \cdot y$)**
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Full-Adder Truth Table

A	**B**	**Cin**	**Sum**	**Carry-out**
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

The LED states (lit for logic 1, dark for logic 0) matched the theoretical truth tables, confirming that I correctly implemented both circuits.

Conclusion

I successfully designed and implemented the Half-Adder and Full-Adder circuits using basic logic gates. The Half-Adder was built with XOR and AND gates, while the Full-Adder was constructed by cascading two Half-Adders with an additional OR gate. The truth tables I recorded from the experiment matched theoretical expectations, verifying the circuits' functionality. Using Tinkercad for simulation helped me understand the circuit behavior before setting them up physically. This experiment deepened my understanding of binary addition and how to apply logic gates in digital circuit design.