Introduction to Computing: Task 1
Fall 2018
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Due: Friday 11/30, 11:59pm

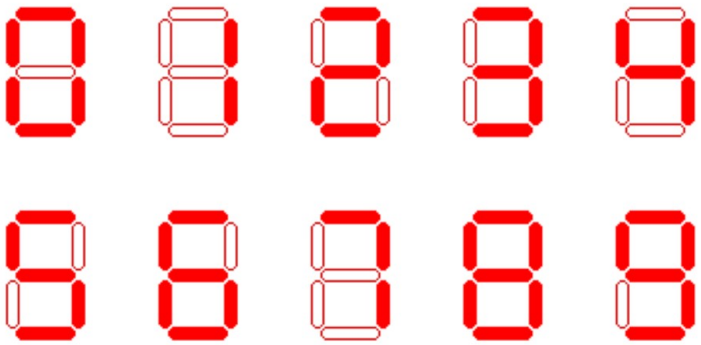
Purpose

In this assignment, you will learn how to use a truth table to represent a system, derive a logic equation from the truth table, and then convert this equation into a schematic. You will design a seven-segment display (7seg) that displays a 4-bit binary number as a decimal number.

Background

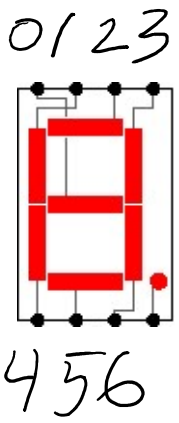
The seven-segment display has 8 total inputs: 7 separately controlled segments and a decimal point (see diagram). When a '1' is passed to a segment, the LED inside the segment turns on, and the segment lights up. This behavior can be used to visually display numbers and (some) letters. For example, in the diagram, if segments 1 through 7 are set to '1', the number "0" is displayed.

The system you will design will take in a 4-bit input and display the corresponding decimal digit on the 7seg. In other words, an input of 0110 will result in a '6' being shown on the 7seg. All ten digits are displayed below – your system must display them EXACTLY as shown in the below diagram.



This assignment will be done using a program called Logisim which runs in a Java environment. Therefore, you will also need a java runtime installed on your machine. All instructions for installation are on the following site: http://www.cburch.com/logisim/download.html

Documentation of 7 Segment Display:



Segment 0, first from left controls the middle horizontal segment.

Segment 1, second from left controls the upper vertical segment on the left side.

Segment 2, third from left controls the upper horizontal segment.

Segment 3, fourth from left controls the upper vertical segment on the right side.

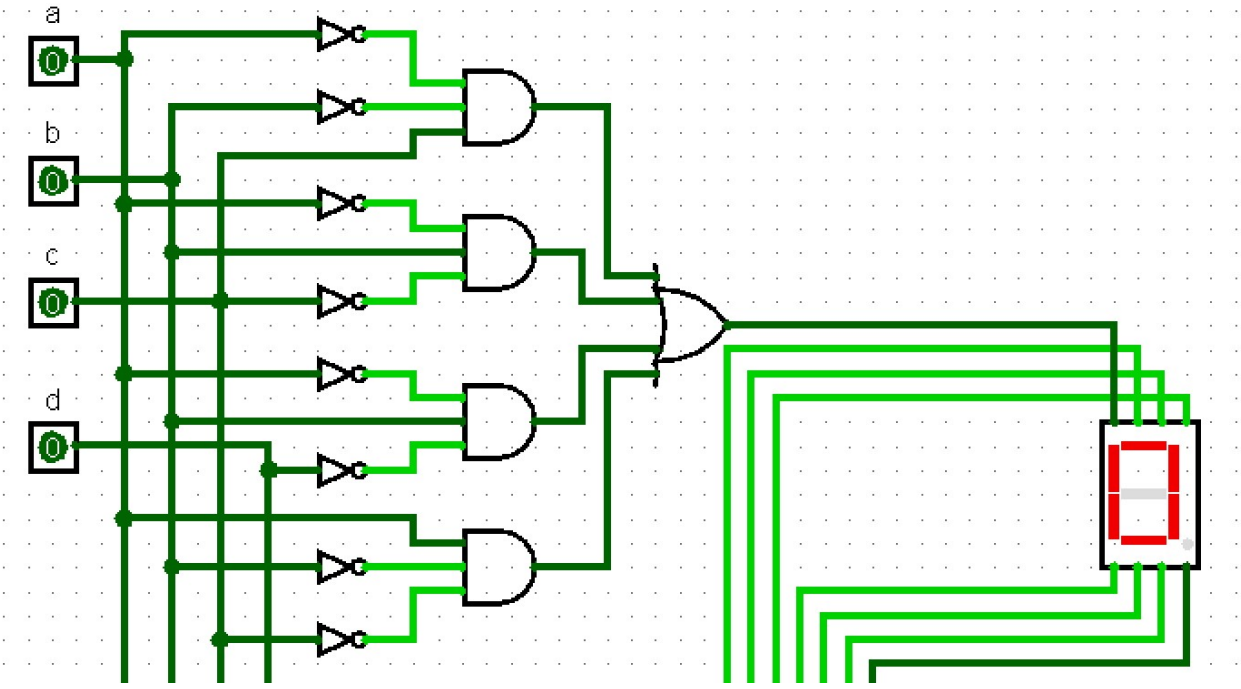
Segment 4, first from left controls the lower vertical segment on the left side.

Segment 5, second from left controls the bottom horizontal segment.

Segment 6, third from left controls the lower vertical segment on the right side.

Segment 7, the bottom right most should remain a 0 or unconnected.

An example of the system operating in Logisim is shown here:



In Logisim, a wire that is carrying a digital high or a ‘1’ will glow a light green. A wire carrying a digital low or a ‘0’ will stay a dark green. If a wire is red, that means it is having a ‘1’ and a ‘0’ written to it simultaneously. Remember, the bottom right connection should remain a ‘0’ no matter the input combination.

Requirements

1. Fill in the following truth table for the 7-segment display indicating whether a segment should be lit for the given input. Again, any input greater than 9 should turn the 7seg off, and the decimal point should always be off.
2. Write the equations for the 7 segments in sum-of-products form.
3. Write the in a Product of Sums form.
4. In Logisim, create a circuit that implements the above truth table using your sum-of-products equations. Your circuit should have 4 inputs and 7 outputs, which should be connected to the correct pins of the 7seg.
5. Connect a ground to the 8^{th} pin (decimal point) on the 7-segment display. (Bottom right)
6. Create a second circuit that implements the 7-segment display using only NAND gates.
7. Answer the following questions:
    1. Why can the circuit be represented using only NAND gates?
    2. Is there any other 1 gate that could have been used to represent our circuit besides NAND?
    3. Why is SOP a convenient form when implementing logic using NANDs?
    4. Is it possible to convert an SOP expression into POS form? If so, which Boolean law(s) makes it possible? If not, why not?
    5. Which Boolean law allows one to convert AND gates into NANDs and ORs into NORs? Give an example of either conversion.

Input	BCD	Segment0	Segment1	Segment2	Segment3	Segment4	Segment5	Segment6	Segment7
0	0000								
1	0001								
2	0010								
3	0011								
4	0100								
5	0101								
6	0110								
7	0111								
8	1000								
9	1001								
10	1010								
11	1011								
12	1100								
13	1101								
14	1110								
15	1111								

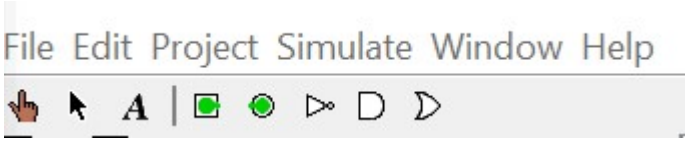
Grading

1. Compile your finished schematics, truth table, circuit/system screenshots, answers to the questions, and any Boolean algebra/simplifications you do into one PDF and submit it on Canvas. No late submissions will be accepted.
2. The following will be the criteria on which your system is graded

Criteria	Point Total
Completed Truth Table for 7 Segment Display	20
SOP Reduced Form	10
POS Reduced Form	10
Working 7 Segment Display for all 15 inputs	30
Implementation using NAND gates	20
Question Section	10

Helpful Hints:

1. The main gates you will need are AND, OR, and NOT as well as some pins for generating inputs. These are all located at the top of the Logisim window in this menu:



2. Logisim is open source software and has an online tutorial if you feel stuck on how to use the program. The tutorial is located here: http://www.cburch.com/logisim/docs/2.7/en/html/guide/tutorial/index.html

3. The valid 10 as well as the invalid 6 inputs will be tested so be sure to account for the cases for 10-15.
4. You must use the 9 with a tail and the 6 shown below or the truth tables will not match up