ECEN 240 Lab 3 – Logic Gates

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Purposes:

- Review the basic logic gates.
- Learn how to use a Computer Aided Design (CAD) tool for digital logic simulation.
- Learn how real-world problems may be solved by solving a simple digital design problem.
- Learn how to implement a digital circuit using the 74xx family of logic gates

Procedures:

Part 1. This portion of the lab is intended to be completed after **Lesson 3 part 2**. Please do the "Getting Started with Logisim Evolution" tutorial found on the "Logisim Evolution" page of the "Course Resources" module to become familiar with *Logisim Evolution*.

Review the reading and class slides about the basic logic gates. Fill out the truth tables that follow with the expected results for each type of gate, then using *Logisim Evolution*, verify the expected results for each of the following gates:

- Two input NAND gate
- Two input NOR gate
- NOT gate
- Two input AND gate
- Two input OR gate
- Two input XOR gate

NAND gate

A	B	Expected Output	*Logisim* Output
0	0	1	1
0	1	1	1
1	0	1	1
1	1	0	0

NOR gate

A	B	Expected Output	Logisim Output
0	0	1	1
0	1	0	0
1	0	0	0
1	1	0	0

Not gate (inverter)

A	Expected Output	Logisim Output
0	1	1
1	0	0

AND gate

A	B	Expected Output	Logisim Output
0	0	0	0
0	1	0	0
1	0	0	0
1	1	1	1

OR gate

A	B	Expected Output	Logisim Output
0	0	0	0
0	1	1	1
1	0	1	1
1	1	1	1

XOR gate

A	B	Expected Output	Logisim Output
0	0	0	0
0	1	1	1
1	0	1	1
1	1	0	0

To check your work and demonstrate mastery, take Lab 3: Quiz 1
(12 points)

Part 2. This portion of the lab is to be completed after **Lesson 3 part 2**.

A laptop microprocessor is to have a circuit built into it which will sound an alarm for low charge on the battery when the cord is not plugged in, and also control a CPU fan for high temperature when the battery is not too low. The inputs and outputs for this circuit are described in the table below.

	Inputs			Outputs	
	Power Cord	**Low Voltage**	**Temperature**	**Alarm**	**Fan**
0	Cord <u>not</u> plugged in	<u>not</u> low voltage	<u>not</u> high temp	alarm <u>not</u> on	fan <u>not</u> on
1	cord plugged in	low voltage	high temperature	alarm is on	fan is on

The exact operation is defined by the following truth table:

Inputs			Outputs	
Cord	**Low Voltage**	**Temp**	**Alarm**	**Fan**
0	0	0	0	0
0	0	1	0	1
0	1	0	1	0
0	1	1	1	0
1	0	0	0	0
1	0	1	0	1
1	1	0	0	0
1	1	1	0	1

Your task is to design the combinational logic circuit that will operate as described in the truth table above.

Start with the derivation of the equation for the alarm and simplify as needed. From the truth table, note that the alarm turns on only when the cord is not plugged in and the voltage is low (the status of **Temp** does not impact the output). Our equation looks like:

Alarm = (low voltage) AND (cord not plugged in)

Inserting the actual inputs into the alarm equation gives us

Alarm = (Low Voltage) AND (NOT (Cord))

Though it is possible to simplify the equation for the alarm by inspection, you are asked to go through the exercise of simplifying Boolean Equations using theorems. To make the equation easier to read, assign a single letter to represent each of the signals. Start with the un-simplified equation for **Alarm**, as shown:

C = Cord
V = Low Voltage
T = Temperature

Alarm = C'•V•T' + C'•V•T

Use the simplification theorem: $XY + XY' = X$
Substitute **X** with **C'•V**, and **Y** with **T.** The simplified equation for Alarm is:

Alarm = C'V

Next, write the un-simplified equation for the fan output with respect to the inputs:

Fan = C'V'T + CV'T + CVT

Simplify the equation using Boolean theorems. Leave the equation in a sum-of-products form:

Fan = V'T+CT

Verify that your simplified equations are correct by filling in the outputs based on only on the equations. Then compare with the original truth table.

Inputs			Outputs	
Cord	Low Voltage	Temp	Alarm	Fan
0	0	0	0	0
0	0	1	0	1
0	1	0	1	0
0	1	1	1	0
1	0	0	0	0
1	0	1	0	1
1	1	0	0	0
1	1	1	0	1

To check your work and demonstrate mastery, take Lab 3: Quiz 2
(12 points)

Part 3. Logisim Evolution Circuit.

In the real-world implementation of this circuit, the digital inputs would be coming from sensors and electronic circuits and the outputs would control an alarm and fan. In Logisim we use 'input pins' to provide inputs to your digital circuit. The input pins represent a sensor, push button or some other type of switch. The Logisim 'output pins' show the output of your digital circuit and represent LEDs, or signals going to control some device.

Implement the Boolean equations for the alarm and fan using logic gates in *Logisim Evolution* following these steps:

- Place 3 input pins and two output pins. Use the following pin names:

Input Pin Names	Output Pin Names
Cord	Alarm
Voltage	Fan
Temp	

- Place the components (AND gates, OR gates, Inverters), making sure that the correct number of pins is configured for each gate.

- Connect wires. Part of your grade will be on neatness, so try to make a circuit diagram that is easy to follow!

- Add your full name directly below your circuit. To do this, select the "*A*" from the toolbar at the top left, and place the cursor below the circuit. Type your name and change the font size if necessary so your name is clearly legible.
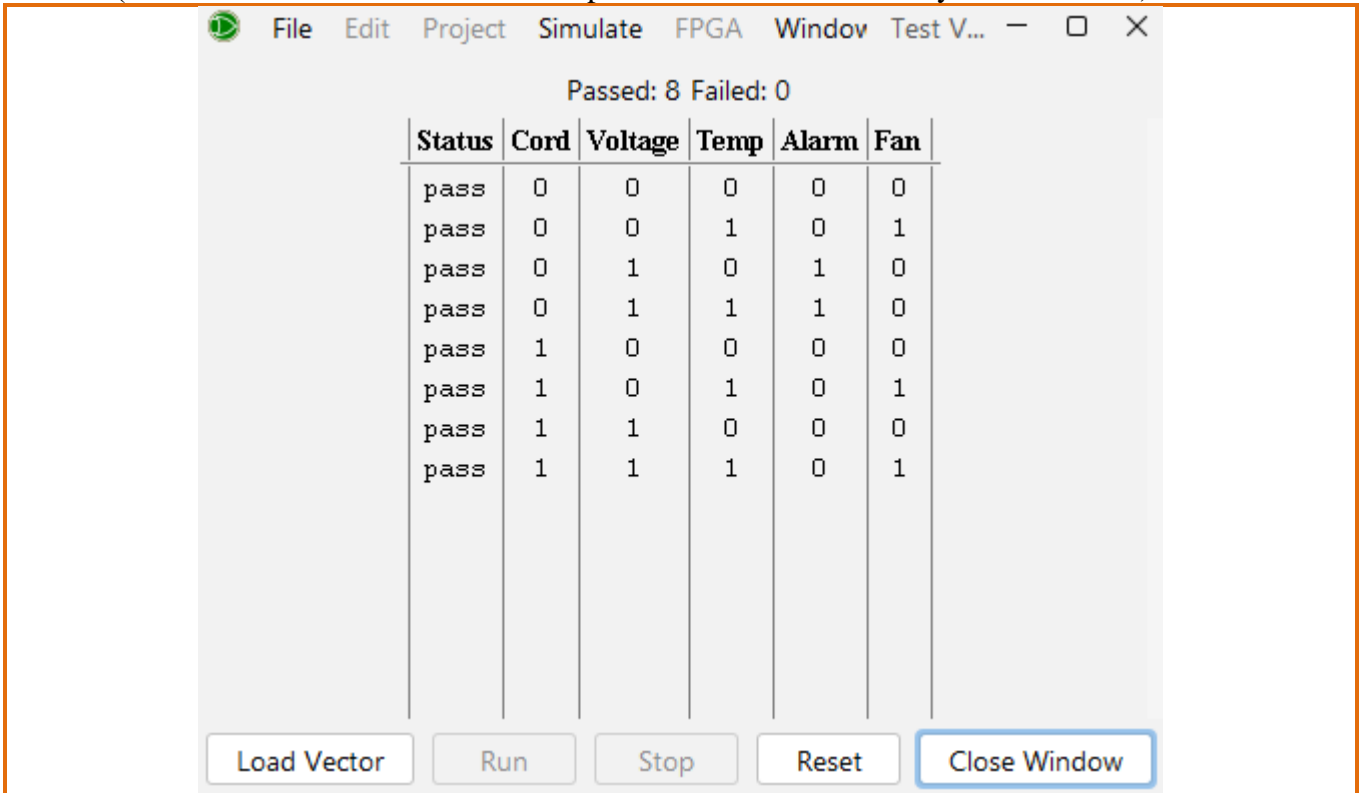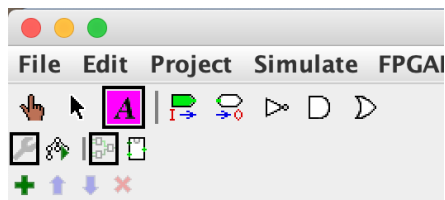

- Test your implementation (try all of the possibilities) and make sure the circuit works as expected.

Part 4. After you have completed the implementation of your laptop fan and alarm circuit, you will need to verify its functionality using the "test vector" tool available in *Logisim Evolution*.

- Download the test file called "alarm_and_fan_test.txt" found in the Lab 3 module in *ILearn*.

- Place the file in your *Logisim Evolution* folder.

- Run the "Test Vector" tool from the "Simulate" menu of *Logisim Evolution*.

- Select "Load Vector" and navigate to the "alarm_and_fan_test.txt" file.

- The tool will display a truth table showing the tests that passed and the tests that failed. Keep working on your circuit until there are no failures.

- Take a "snapshot" of the window showing your test results, and paste the snapshot in the submission box below (the "snipping tool" may be used in Windows, or "cmd-shift-4" in Mac OSx).

(The "test vector" border box will expand to fit a screen-shot of your test results)

File   Edit   Project   Simulate   FPGA   Window   Test V...   —   ☐   ✕

Passed: 8 Failed: 0

Status	Cord	Voltage	Temp	Alarm	Fan
pass	0	0	0	0	0
pass	0	0	1	0	1
pass	0	1	0	1	0
pass	0	1	1	1	0
pass	1	0	0	0	0
pass	1	0	1	0	1
pass	1	1	0	0	0
pass	1	1	1	0	1

| Load Vector | Run | Stop | Reset | Close Window |

Snapshot of Test Vector Results (10 points)

Take a "snapshot" of the circuit (including your name), and paste the snapshot in the submission box below (the "snipping tool" may be used in Windows, or "cmd-shift-4" in Mac OSx). You can resize the circuit using the up and down arrows found at the bottom-left corner.

Auto	100%
100%	
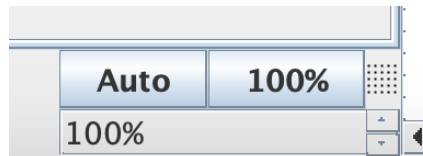
Paste the snapshot in the border box below.

(The circuit diagram box should expand to fit the size of your screen-shot)
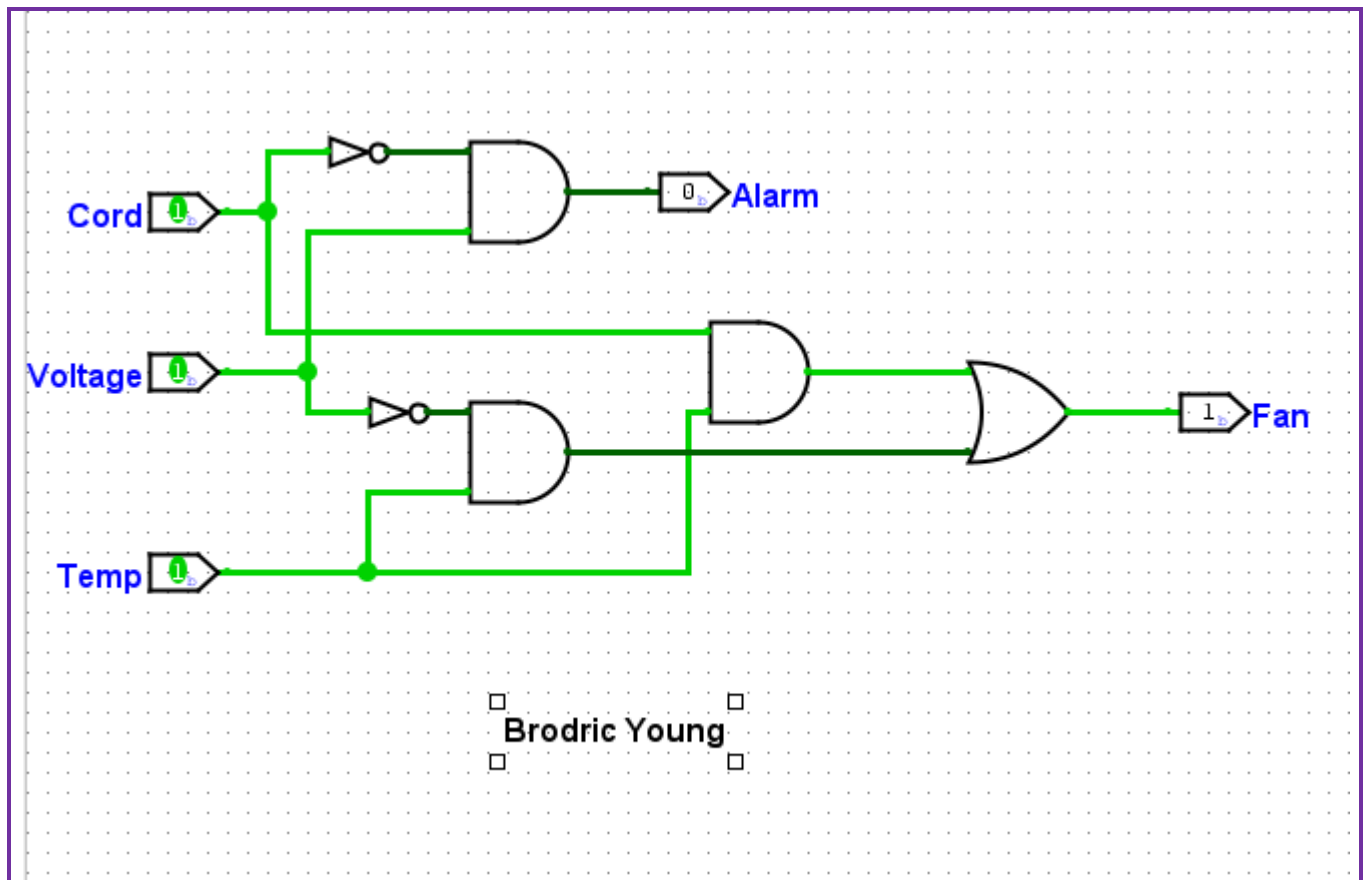
Snapshot of Logisim Evolution Circuit (20 points)

Part 5. 74xx family of logic gates

The 74xx family of logic gates is a family of integrated circuits (ICs) that implement all of the basic logic functions. Lab 3 Quiz 3 will link to a set of data sheets that you will use to become familiar with the function of each pin on the key components.

To learn about 74xx logic gates, take Lab 3: Quiz 3

(12 Points)

Part 6.   Build the laptop fan and alarms circuit with 74xx logic gates and demonstrate the functionality to a lab assistant or instructor.

To pass off your circuit, take Lab 3: Quiz 4

(20 points)

Part 7. Conclusion statement.

Write a brief conclusions statement that discusses all of the original purposes of the lab (found at the beginning of this lab document). Please use complete sentences and correct grammar to express your thoughts. Please comment on each of the purposes of the lab:

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(The conclusions box will expand as you write)

Conclusions:

In this lab, we reviewed the basic logic gates by looking at the diagrams to understand what the different pins of the gates do so our circuit works and doesn't release any magic smoke. We used Logisim to simulate our circuit first to make sure it functions how we wanted before trying to physically build it. Our circuit itself was based on a real-world problem involving three different scenarios with certain combinations resulting in a certain action which we were able to solve in creating this circuit. We gained a lot more experience with the 74xx family of logic gates by using them to solve the real-world problem and careful prior study so as not to release any magic smoke. So overall, the lab went really well and was very educational.

Conclusion Statement (12 points)

Congratulations, you have completed Lab!
You may now submit this document.