SANTA CLARA UNIVERSITY	ELEN 21 Spring 2017	Dr. Sally Wood, Dr. Samiha Mourad, Dr. Radhika Grover

Laboratory #1: Introduction to Logic Gates

For lab sections Friday, April 7 and Tuesday-Thursday April 11-13

I. OBJECTIVES

- To learn how to work with the breadboard and connected sensors, output components, and integrated circuits (chips) with logic gates.
- To translate a problem statement into a logic circuit.
- To design, test, and implement a logic circuit based on a functional specification.
- To explore simple logic circuits implemented with standard logic chips.

PROBLEM STATEMENT

You are to design the controller for an outdoor light that functions both as an ordinary light and also as a motion activated light and alarm. This is how it should operate:

- If the manual switch S is on, then the outdoor light, L, is on.
- Besides the manual switch input, there is a motion detector, M. When M is activated the light turns on.
- If motion is detected but the light is already on because S is on, then a second output A, an alarm, is turned on.

II. PRE-LAB - due Friday, April 7 at 11am

1. Review background from lecture on logic gates, switches and standard digital chips.
2. View the reference "Three IC Pinouts" to get familiar with the ICs you will be using in lab.
3. Based on the problem statement:
   (a) Make a truth table for the two outputs L and A from inputs M and S. The inputs and outputs are 1 when active or "on" and 0 when not active or "off". List all possible combinations of input values for M and S.
   (b) For each input combination in the truth table figure out what the output should be from the operational description of the controller function.
   (c) Implement the **logic** circuit using **NOT, OR, and AND gates** to obtain the outputs. Draw the logic schematic for your design.

III. LAB PROCEDURE

Please demonstrate each part of the experiment to your TA before proceeding to the next part.

Part I: Working with the breadboard

View the reference "Breadboard Connections" to get familiar with the breadboard you will be using in lab.

1. Testing the eight LED pairs:
   (i) There are 8 pairs of Red and Green LED on this breadboard. Using a single wire, connect +5V (Vcc) to the first LED on the breadboard and observe what happens with the LED pair. Test the other LED pairs the same way to be sure that they all work.
   (ii) Remove the connection to +5V and reconnect the wire from the first LED to ground (GND) and observe the results. Repeat for the other pairs to verify that they function in the same way. Remove all wires when you are done.

   Observations: What voltage level causes each LED of the pair to be on? Inside the breadboard the other side of red LED is connected to either ground or +5V to complete the circuit. An LED will be bright only if there is a voltage difference across it. To what level must the red LEDs be connected internally? What levels are the green LEDs connected to internally?

   NOTE: If any LED pair behaved in a different way from the others, advise your teaching assistant. We will be using these LEDs to indicate how our circuits are functioning and incorrect feedback from the LEDs would make circuit debugging harder.

2. Eight Logic Switches:
   (i) In the lower left part of the breadboard there are eight logic switches, which are often used as inputs for logic circuits. Use a single wire to connect S1 to LED 1. What happens to the red and green LED1 as the switch moves UP and DOWN?
   (ii) Test the remaining S2-S8 and determine if they function correctly. Remove all wires when you are done.

3. Clock:
   (i) Set the top frequency rotary switch for the function generator in the upper left part of the breadboard to '1'. Set the dial beneath it to the middle position with the pointer straight up. Connect the TTL output of the function generator to LED4 in the center of the LEDs. What do you observe? Count the number of times the red LED turns on in a 30 second interval and record it.
   (ii) Move the rotary dial to '10'. Describe what you observe on the LED.
   (iii) Repeat for 100. Based on visual inspection of the LEDs, what does the output look like ? What is actually happening?
   (iv) At the maximum value of 100K for the rotary switch what do you observe on the LEDs? How would you explain this?

4. Seven segment displays:

   NOTE: There are two seven segment numeric displays in the lower right corner of the breadboard. They will not be used in laboratory. However, with no connections, they should display a "00". If this display goes off, your breadboard has lost power.

   If you accidentally connect +5 to ground, (this can happen) then you must remove that accidental connection to continue using the board.

Part II: Working with digital chips/ICs (Integrated Circuits)

The laboratory assistant will supply you the components you need.

1. View the reference "IC Power Connections" to get familiar with how to place the IC on the breadboard and how you will power it.
2. TURN OFF the power on your breadboard. Find the notch which indicates where the pin numbers start, and align all the chips with this end up.
3. Insert the chips you will be using in a single line straddling the center trough of one of the four white breadboard strips. Do this by placing the chip across the trough so that each pin rests in one of the holes in the breadboard. Then push the chip down at the center, firmly but gently, making sure all pins go into the holes next to the trough.
4. Ground connection: Connect the left most vertical column of this strip to ground using a blue/black wire and using a small blue/black wire connect the upper and lower columns together. (There is no internal connection across the centerline where the mounting screws are.) Using short blue/black wires connect the ground pin of each chip to the nearest hole in the grounded vertical column. (NOTE: The ground pin may be a different pin on components with different numbers.)
5. Power connection: Connect the right most vertical column of the strip to +5V using a red wire and using a small red wire connect the upper and lower columns together. Using short red wires connect the power pin of each chip to the nearest hole in the vertical column connected to +5V. (NOTE: The power pin may be a different pin on components with different numbers.)

Part III: Building a Logic circuit

1. **General guidelines**
   - You will be using one of the switches on the breadboard (labeled S1 to S8) for your Switch S.
   - You will be given a motion detector for the other input M.
   - An LED will function as the light, L.
   - The buzzer will function for the alarm, A.
2. **Constructing the circuit**
   - Connect all the other components (LED, buzzer, motion detector) to the ICs.
     - Get the motion detector from your parts kit and a black paper cylinder. Look at the bottom of the motion detector, and identify the three pins labeled -, +, and OUT. There may be a piece of protective foam covering the pins; if so, carefully remove and save it.

       Note: The other pins on the bottom of the motion detector, labeled "H" and "L", have a jumper on them; do not move this jumper.

       Place the small paper cylinder over the dome of the motion detector, pointing directly up. This will reduce the field of view. **When the motion sensor is first powered on, do not make any motion for at least 10 seconds, while the sensor initializes.**

- The buzzer is a small black cylinder with two pins coming out of one end. Insert the buzzer into the breadboard, making sure each pin is in its own line. The side of the cylinder has a + sign near the positive pin which takes the input from the circuit. The shorter pin must be connected to ground.

- Wire Inputs, ICs, and Outputs to match the schematic (completed for prelab). *Something to remember:* Only in the ground and voltage connections on the breadboard do the connections go up and down. Also, the top half of the breadboard is not connected to the bottom half.

3. **Testing the circuit**
   - Connect the inputs to switches and step through the various combinations on your breadboard to make sure the circuit functions correctly.
   - Record the truth table observed on the LED and alarm for the various inputs combinations.
   - Debug the circuit until the correct truth table is obtained. Record all the circuit faults you found and fixed.

IV. REPORT

The report should be completed with your lab group and turned in at the beginning of the next lab.

Write an introduction about what your group accomplished during the lab.
Include your graded Pre-lab work.

Write the procedures your group took to complete the construction and testing of your motion sensor circuits.

Was the circuit you ended up with the same as one you had drawn in the pre-lab? If not, describe what you changed and include the new schematic. Try to include a picture of the actual circuit your team built on the breadboard.

Answer the following:

- Suppose the alarm system is functioning in such a way that the alarm (A) is activated as soon as motion is detected. List the possible issues with this system and how could you determine if the system is acting incorrectly.

- Suppose the alarm system is operating in such a way that the alarm (A) goes on continuously regardless of the state of the other inputs. List the possible issues with this system and how you could fix this issue.