cs281: Introduction to Computer Systems

Lab01 – Intro

Assigned: Jan. 22, Due: Wed., Jan. 29

Overview

The objective of this lab is to introduce you to the environment that we will be using as part of the hardware lab sequence in this course. In particular, you will learn about the *breadboard* prototyping stations and about the *Arduino*, a system for supporting embedded processor control. We will start by exploring the features of the breadboard and then will integrate use of the Arduino with the breadboard. You are to write a lab report that is to be submitted by the Wednesday (in class) following the lab. It should include sections for an introduction, methodology or experiment setup, results, and conclusion. You should answer any questions asked below as part of your lab report. Assume your audience for the lab report are reasonably intelligent sixth graders.

Breadboard Basics

1. Obtain a breadboard and an Arduino kit. Be sure they have matching letter labels. These two items (breadboard and Arduino kit) will belong to your lab group for the duration of the semester. It is important that you are careful with your materials so they last the semester.

2. Plug in the breadboard and turn it on. Peruse the board. There are a number of things we will not be using. Most importantly, the only power supply we need is +5 volts. NEVER hook a wire to any of the other voltages. Make sure all appropriate switches are set to TTL or +5. Follow from the +5 Volt Peg in the upper right of the breadboard to the main breadboard proper. The breadboard is structured so certain holes are wired together underneath the breadboard, but others are isolated from each other. Your first task is to understand what is wired (underneath, or by wires above) to where.

3. Find the set of onboard *Logic Indicators*. There are eight of them on the right hand side, and you can use them to determine HIGH or LOW voltage from a location on the breadboard by connecting a wire from the location of interest to one of the eight Logic Indicators. Start with a location where you believe +5 volts is wired to, and test it. Also test a location where you believe GND is wired. Were you right?

4. Continue tracking down where +5 and Ground are available throughout the board. Write down your findings in your lab report. Also note (in a generalization based on your experimentation) which holes are neither HIGH nor LOW. Notice the groove down the middle of each board section. You need to figure out how the little holes on either side of the groove are wired. Devise a series of experiments to do this. Summarize your experiments and conclusions.

5. A *circuit* is a complete path from +5V to GND with intervening devices and gates. Our first circuit, shown in Figure 1, will light an LED; we will create two of these circuits. Get two LEDs and two 330 Ohm resistors. We will wire each circuit using the diagram shown in Figure 1. Note that an LED is direction dependent. The ”long” side must be connected to the +5 and the short side to the GND side. Since current only flows in one direction through an LED, the circuit will not operate if the LED is backwards. Wire both circuits according to the diagram; you should see both LEDs light.

6. For one of the two LED circuits, we will change the input from +5 to the function generator as shown in Figure 2. Locate the function generator on the left side of your breadboard. Set the dial to a square

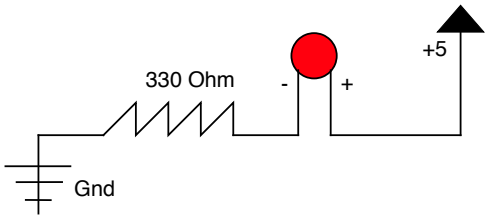

Figure 1: Circuit 1: Led + Resistor

wave with a 1 Hz period. Remove the wire from Vcc (+5) on the LED and connect it to the output of the function generator. When you turn on the breadboard, you should see the LED blink on and off. What happens when you change the period knob? What does 1 Hz mean? What does 5 Hz mean?

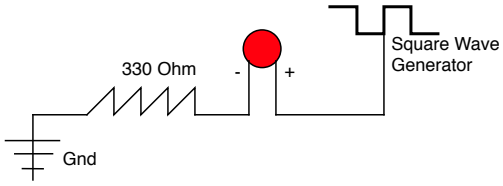

Figure 2: Circuit 2: Square Wave Generator

7. In the next step we introduce a logic gate, the inverter. Obtain an 7404 IC and examine the spec sheet for the 7404 inverter. You will see that the upper right hand corner is to be connected to Vcc and the lower left corner to GND. Notice the notch on the inverter which indicates the ”top”. Place your inverter so that it spans one of the troughs on the breadboard. Wire Vcc and GND. Select one of the inverter input/output pairs. Connect the inverter using Figure 3. One LED should be connected to the input (Switch 1) while the other LED should be connected to the inverter output. Turn on the breadboard and note your observations of the LEDs.

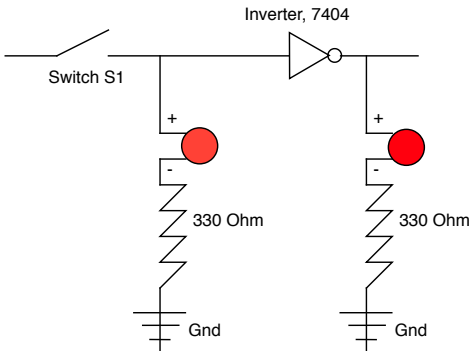

Figure 3: Circuit 3: Inverter

8. Next put the 7408 chip onto the breadboard. This chip provides 4 independent AND gates, each with two inputs and one output. See Figure 4. First wire VCC and GND to the chip, using the spec sheet to guide you. Then wire the output pin for one of the AND gates to the +LED. Wire the first input pin of the AND gate to the first switch, S1, at the bottom-left of the breadboard, and the second input put of the AND gate to the second switch, S2. By hand, toggle through all four combinations of HIGH and

LOW for the two input switches. Does the lighting of the LED correspond to the truth table of the AND operation? If it does not, then debug your circuit.

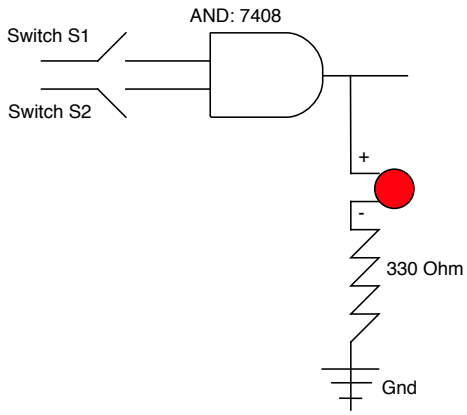

Figure 4: Circuit 4: And Gate

Arduino Control

One of the uses of an embedded controller, like the Arduino, is that we can specify a behavior for controlling a circuit and can then have the circuit operate independently (autonomously) of any manual input. So in this part of the lab, we will develop a fairly straightforward equivalent way of driving the circuit you have already implemented on the breadboard.

If you have not already done so, get an Arduino controller and the USB cable from your kit. Then follow these instructions:

1. From your laptop, go to `www.arduino.cc` website. Download the arduino IDE interface.
2. Plug the USB cable from the laptop to the socket on the Arduino.
3. From the Dock or LaunchPad, start the Arduino IDE.
4. Wire pin 13 on Arduino to second the input pin on AND gate, replacing the input from the second switch. The first AND input should remain with the first switch.
5. Connect a wire from GND on the breadboard to GND on the Arduino. This should be the pin adjacent to Pin 13 on the Arduino, not the two GND pins on the other side of the Arduino.
6. In the Arduino Sketch IDE, type in the following C++ code:

```
const int P = 13;
const int A = 1000;
const int B = 1000;

void setup() {
  pinMode(P, OUTPUT);
}

void loop() {
  digitalWrite(P, HIGH);
  delay(A);
  digitalWrite(P, LOW);
  delay(B);
}
```

7. Compile and verify your C++ code by clicking the *Verify* button (with "Checkmark" icon) at the top-left of the interface. If compilation is not successful, fix any syntax errors indicated.

8. On the Arduino board, toward the center, there are two mini-LEDs marked Tx/Rx. Observer these LEDs while you click the *Upload* button (the right arrow next to the Verify button). Describe what happens with the TxRx and with your circuit once the upload is complete.

9. Experiment with your program by changing the values of A and B. Infer the units of the values for A and B. Can you change the value of P?

10. Unplug the USB tether between the laptop and the Arduino. What happens?

11. Now unplug the ground wire from the Arduino. Insert it into one of the other two GND pins in the "Power" section of the Arduino. Also run a wire from +5 on the breadboard to the +5 connection adjacent to the two GND pins that you just connected to. What happens? What is the difference between the previous configuration and this one? What does this mean as far as *where* the c program you wrote is actually running?