Lab 9: Sensor Characterization Lab (Digital)

Objectives

This lab introduces the methods and importance for characterizing sensors. Students will learn about how the Arduino communicates and receives data from a digital sensor. Students will characterize an ultrasonic sensor and observe how to control the sensor with either the MakeBlock shield or just wires.

Materials

1) Arduino Uno

2) MakeBlock Shield

3) MakeBlock Ultrasonic sensor

4) Wires for Building Circuits

Theory

Figure 1: MakeBlock Ultrasonic Sensor

Sensor Characterization

Sensor characterization is the process of taking measurements from a sensor under controlled conditions. Once a sensor has been characterized, a sensor can be used in an experimental setup. The following parameters are required to understand before characterizing a sensor:

- physical quantity to be measured
- sensor output type (analog or digital)
- sensor parameters (sensitivity, operation range, necessary signal processing, etc.)

The process for obtaining data from sensor with a digital output is a little more complicated than from an analog sensor. For the arduino, the digital pin transitions between *input* and *output*. In the *output* mode, a LOW-HIGH-LOW signal is sent to prepare for the measurement. In the *input* mode, the function *pulsein()* function reads either a HIGH or LOW value and waits for the signal to change. The amount of time (in microseconds) for the signal to change is the output from the *pulsein()* function.

Ultrasonic Sensor

The ultrasonic sensor measures distances through sound (like sonar or radar). Specifically, the sensor produces a high frequency sound and waits for the sound to reflect off an object and return (like an echo). Based on the speed of sound and time between the sound being sent and received can be used to calculate distance.

$$Distance(m) = Sound\ Speed \left(\frac{meters}{seconds}\right) \times time\ (seconds)$$

$$Distance(ft) = Sound\ Speed \left(\frac{feet}{seconds}\right) \times time\ (seconds)$$

The speed of sound is approximately:

$$Sound\ Speed = \frac{340\ m}{s}$$

$$Sound\ Speed = \frac{1130\ ft}{s}$$

Laboratory Exercises

Ultrasonic Senor (with shield)

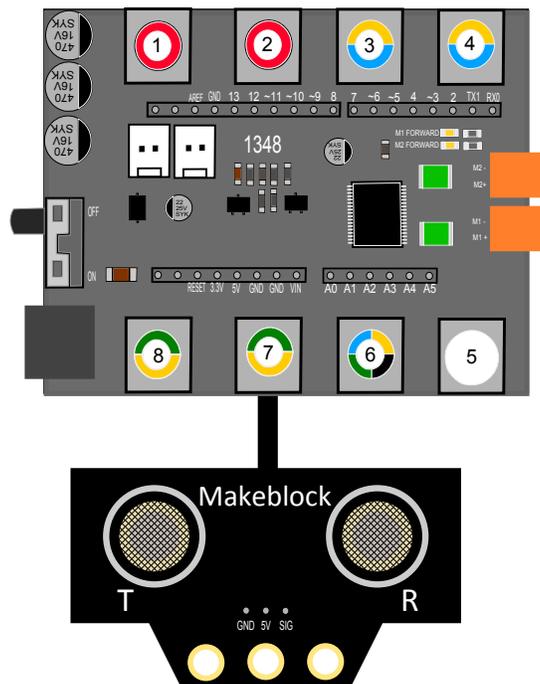1. Attach the MakeBlock shield to the Arduino UNO. Connect the Ultrasonic sensor as seen in Figure 2.

Figure 2: Ultrasonic Sensor Connection

2. Place the ultrasonic sensor some distance away from and pointing towards some flat object (monitor, toolbox, binder, etc.). With some measuring device (ruler, tape measure, etc.), measure the distance from the object to the ultrasonic sensor in centimeters and inches.

3. Upload the MakeBlock *TestUltrasonicSensor* example. Open the serial monitor. If necessary, change the baud rate in the serial monitor to 9600.

4. Perform a percent error calculation of your measured distance to the sensor's output. Use the theoretical value as the distance you measured.

$$\% \ error = \left| \frac{Theoretical \ Value \ - \ Experimental \ Value}{Theoretical \ Value} \right|$$

5. As a group, discuss what could cause this error.

6. When complete, disconnect the ultrasonic sensor from the MakeBlock shield.

Ultrasonic Sensor (with wires)

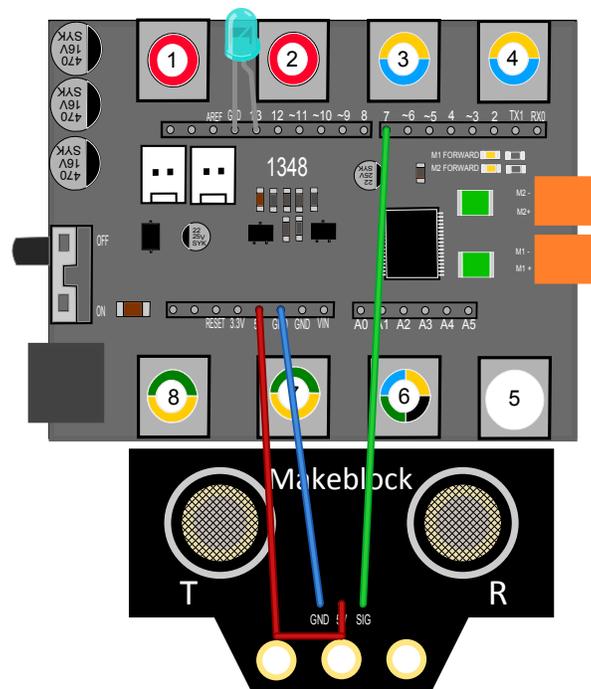1. Connect the ultrasonic sensor and LED as seen in Figure 3.

Figure 3: Ultrasonic Sensor Connection

2. Place the ultrasonic sensor some distance away from and pointing towards some flat object (monitor, toolbox, binder, etc.). With some measuring device (ruler, tape measure, etc.), measure the distance from the object to the ultrasonic sensor in centimeters and inches.

3. Upload the *Ultrasonic* code supplied by TAs.

4. Open the serial monitor. If necessary, change the baud rate in the serial monitor to 9600.

5. Now modify the program to turn on the LED if the ultrasonic sensor reads a value less than 10 cm.

6. Discuss how the ultrasonic sensor could be used in your project. When complete, share your ideas with a TA.

7. Unassemble the parts.

8. Be sure you understand all the steps completed in this lab before leaving.