Lab 8: Sensor Characterization Lab (Analog)

Objectives

This lab introduces the methods and importance for characterizing sensors. Students will learn about how the Arduino interprets an analog signal. Students will characterize an accelerometer by attaching the sensor to a servo motor and taking readings at different angles.

Materials

1) Arduino Uno
2) MakeBlock Shield
3) Virtuabotix Accelerometer
4) MakeBlock Servo
5) MakeBlock Servo Driver
6) Wires for Building Circuits

Theory

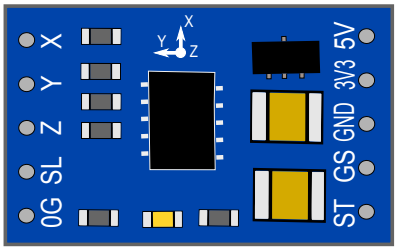

Figure 1: Virtuabotix Accelerometer

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.)

Sensors that have an analog output produce a voltage which is proportional to the measured value (like a thermometer and liquid height). The arduino measures the voltage and then converts the voltage into a number (analog to digital converter). The code below is an example of the *analogRead()* function.

```
1 xval = analogRead(xpin);
```

The output from the *analogRead()* function produces integer values between 0 and 1023. Therefore, the resolution for a sensor with a maximum output voltage of $5V$ is:
$5V/(1024\ units) = 4.9\ mV/unit$.

Accelerometer

There are a variety of sensor types that measure acceleration: piezoelectric, micro-electro-mechanical system (MEMS), capacitive, thermal. The Virtuaboticx Accelerometer is a has a MEMS chip that can measure acceleration in three directions. While stationary, the accelerometer can measure how the gravitational vector aligns with the specific sensing axis (X, Y, or Z).

Laboratory Exercises

Sensor Identification

1. Load the MakeBlock servo example. Modify the program to set the angle to 0. Unplug the Arduino from the computer.
2. Loot at Figure 2. Cover the steel bar with electrical tape to have a non-conductive part. Attach the accelerometer to the bar on the covered section.
3. Attach the bar to the servo so that the arm lies parallel to the table.

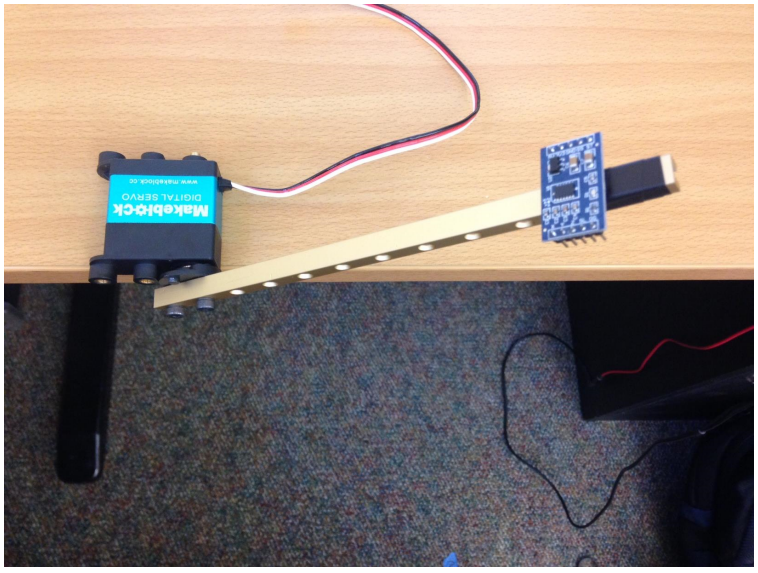

Figure 2: Accelerometer and Servo

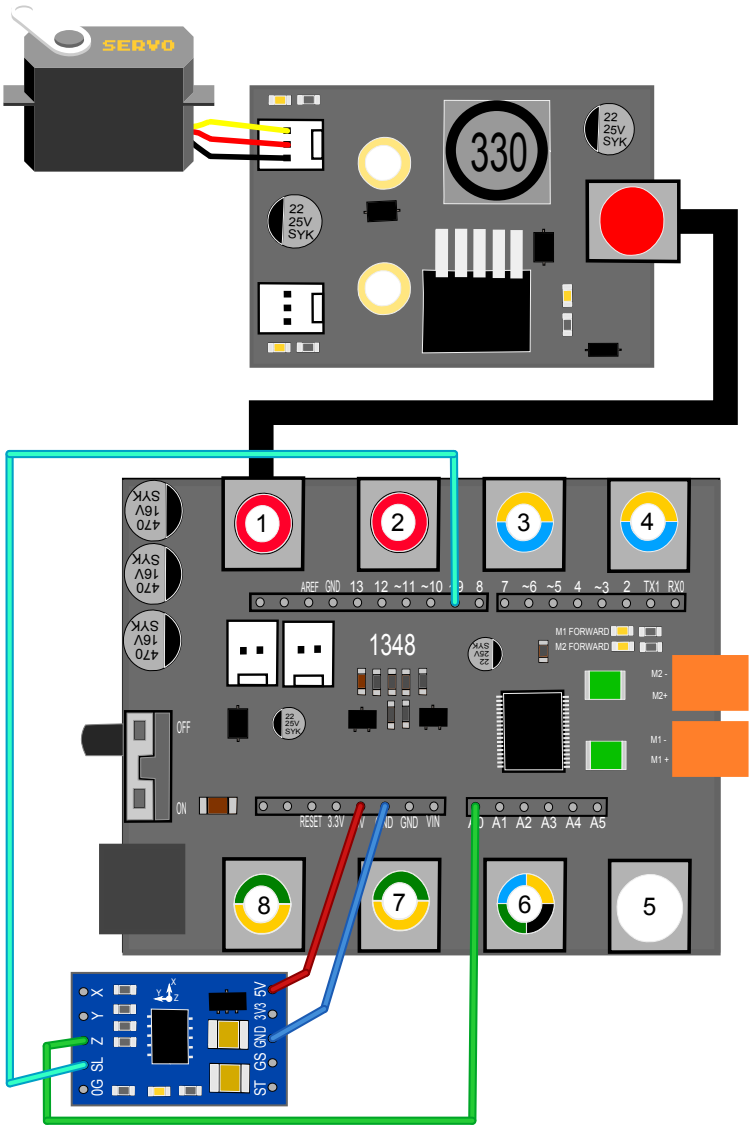

Figure 3: Experiment Wiring Diagram

4. Wire up the experiment as seen in Figure 3.
5. Program the servo to start from 0 degree to 180 with an increment of 5 degrees per second. Also set pin 9 to HIGH. Print the angle value and output of A0 to the serial monitor.
6. In each step, the Arduino should read the Z value of the accelerometer and print the value to the serial port.

7. Write the numbers from the serial port to the Table 1.

Angle (°)	**Z-value**
0	
5	
10	
15	
20	
25	
30	
35	
40	
45	
50	
55	
60	
65	
70	
75	
80	
85	
90	
95	
100	
105	
110	
115	
120	
125	
130	
135	
140	
145	
150	
155	
160	
165	
170	
175	
180	

Table 1

8. Import all the numbers in the Table 1 to the excel sheet and plot the numbers.
9. Fit the best polynomial curve with maximum of fifth order.
10. Now go back to sketch pad, make a function the to control the servo with the out put of accelerometer.
11. Now the servo should work as a slave device for accelerometer. Attach the gripper to the servo's head.

12. Now try to make the servo go to the opposite angle of accelerometer ($180° - angle$).
13. Attach the accelerometer to the body of servo. Run the program and explain what is happening.
14. Email your plots to TAs.
15. Unassemble the parts.
16. Be sure you understand all the steps completed in this lab before leaving.