

Calibrating a Sensor

Introduction

Vernier sensors utilize natural phenomena to create an electric signal that correlates to a sensor reading. For example, strain gauges are devices that change their electrical resistance depending on how much tension is applied to the instrument. You can therefore determine the amount of force being applied by measuring the voltage of the strain gauge.

In the “Using Sensors with Arduino” activity, you started with the sensor reading (the count) from the Arduino and converted that to a voltage. In this activity you will complete the process by creating an equation to convert the voltage to an actual sensor reading.

Objectives

- Understand how a sensor works
- Convert the output of the Arduino® into a sensor reading

Materials

SparkFun® RedBoard (or equivalent) with USB cable and power supply
Vernier Analog Protoboard Adapter or Vernier Interface Shield
Vernier Gas Pressure Sensor
Computer or Chromebook™ with Arduino software

Procedure

To get started with this activity, follow these steps:

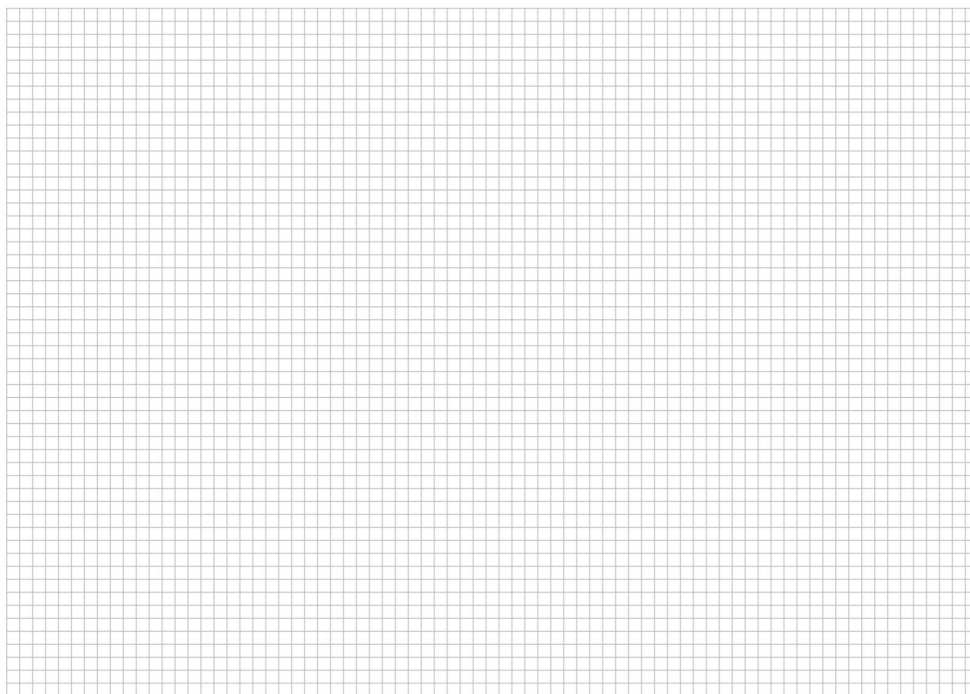
1. Open the Arduino IDE software and connect your Arduino and sensor.
2. Select the board and COM port from the Tools menu.
3. Open the sketch you saved in “Using Vernier Sensors with Arduino”.

You previously modified this sketch to convert the count from the Arduino board to a voltage between 0 and 5 volts. This is because the majority of Vernier’s LabQuest sensors operate on a 5V power supply. The sensors require a 5 volt source and output a signal that ranges from 0 to 5 volts. The relationship between the sensor’s voltage and the measurement (in proper sensor units) can be determined by evaluating the voltage at known values for the sensor.

Activity 3

For example, when the Gas Pressure Sensor is at rest at 101.3 kPa (1 atmosphere), it registers a voltage of 2.46 V. When the sensor is measuring a pressure of 202.6 kPa (2 atmospheres), the voltage is 4.42.

It will be useful to graph these data points. In the following empty graph, label the axes and set the scale. The x-axis should be the voltage and the range will be from 0 V to 5 V. Determine an appropriate scale for the y-axis. Mark the pair (2.46 V, 101.3 kPa) and the pair (4.42 V, 202.6 kPa).



Rather than relying solely on our data, try conducting a quick experiment to determine two data points for this graph. Your two data points will be the voltages at your current atmospheric pressure and at a pressure as close to zero (a vacuum) as possible.

1. Compile and upload the sketch and open the Serial Monitor.
2. Remove the syringe from the sensor (if it was connected) and note the voltage in the Serial Monitor.
3. Find a barometer or look up a local weather source online and determine the atmospheric pressure in your location. Be sure to convert it to units of kPa, if necessary.
4. Compress the syringe as far as possible and screw it onto the sensor connector.
5. Carefully draw the syringe plunger back as far as you can while maintaining the airtight connection. Note the voltage in the Serial Monitor. The pressure inside the vacuum is close to zero.
6. Add these data points to your graph.

Based on these few data points is it reasonable to think that the relationship between voltage and the sensor reading is linear?

Assume for the moment that this relationship is linear and extend the line to cover the range of the sensor: What do you expect the pressure to be when the voltage is 3.5 V? _____

It turns out that the Gas Pressure Sensor (and a many other Vernier sensors) do have a linear calibration curve. Use the data points provided and/or this graph to help you create an equation that converts the voltage from a Gas Pressure Sensor into proper sensor units (kPa) and write that in the space provided:

It is important to note that not all of our sensors have a linear calibration curve. For example, temperature probes have relatively complex calibration curves involving the inverse of the cube of the natural log of the measured resistance.

Now try the following:

1. Modify the sketch to calculate the actual sensor reading in proper sensor units for your sensor.
 - a. In the loop() function of your sketch, declare another variable “sensorReading.” This variable will need to be “declared” as a “float”. It should look like this:


```
float sensorReading = ...
```

Include a mathematical function (that you determined previously) to convert the voltage to a pressure reading in place of the “...”. **Note:** Don’t forget to end the line of code with “;”.
 - b. Change the code to print this value instead of the voltage.
 - c. Test it by uploading and running the sketch. Determine an appropriate method to verify the sensor readings.
 - d. Save this sketch with a unique name.
2. Go to <https://www.vernier.com/manuals/gps-bta/> and read the section on How the Sensor Works within the sensor’s user manual.

Optional Extension

Identify an electronic sensor that uses a different technology from the Gas Pressure Sensor. Conduct some investigative research online to determine how the sensor works. Document your findings.