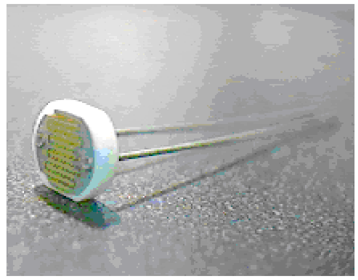
Light Sensor



A light sensor is a device for measuring the intensity or brightness of light. One of the most common and least expensive detectors that can be used when building a light sensor is a *photoresistor*. Photoresistors, also called light detecting resistors (LDR) are made from cadmium sulfide (CdS) cells that are sensitive to visible and near infrared light. The resistance of a CdS cell varies inversely with the amount of light incident upon it – bright light causes a low resistance between the two leads of the cell while low light results in a higher resistance. When a photoresistor is placed in a voltage-divider circuit, proportional changes in light intensity can be measured with the Vernier Analog Breadboard Cable.

DESIGN OBJECTIVES

- Build a sensor to measure changes in light intensity
- Build a voltage-divider circuit with a photoresistor
- Use a Vernier Analog Breadboard Cable to make the necessary connections between the light sensor circuit and the lab interface
- Convert voltage values to a proportional measure of light

MATERIALS

Vernier computer interface	photoresistor
Vernier Logger *Pro* software	5 kΩ resistor
computer	breadboard
USB cable	jumper wires
Vernier Analog Breadboard Cable	

BACKGROUND

A voltage divider is a linear circuit consisting of two resistances (in this activity, a resistor, R_1, and a photoresistor, R_P) wired in series with a supply voltage (+5 V). The output voltage at a point between the resistances (V_0) will be a fraction of the applied voltage. For the circuit shown in Figure 1, if $R_P = R_1$, then V_0 should measure approximately 2.5 V.

The value of the upper resistor, R_1, will determine the range (or swing) of the sensor's output voltage, V_0. R_1 should be larger than the photoresistor's minimum resistance (brightest light), but smaller than the photoresistor's maximum resistance (dimmest light). A multimeter can be used to find

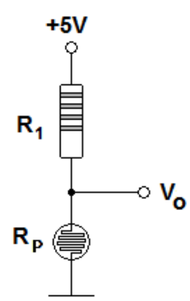


Figure 1 Voltage-divider circuit

the resistance values for a particular photoresistor when exposed to bright and dim light. When the photoresistor's minimum and maximum resistances are known, the following equation can be used to calculate an approximate value for the upper resistor. The value of the upper resistor need not be exact; choosing a standard resistor closest to the calculated value will suffice. We used a 5 kΩ resistor in our example circuit.

$$R_1 = \sqrt{R_P \min \times R_P \max}$$

CONSTRUCTION

Build the voltage-divider circuit

1. Insert the circuit end of a Vernier Analog Breadboard Cable into the breadboard.
2. Connect the 5 kΩ resistor between the +5 V and SIG1 pins on the cable.

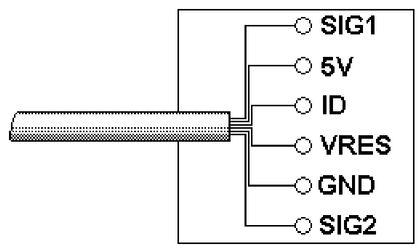


Figure 2 Vernier Analog Breadboard Cable pin-out

3. Connect the photoresistor between the SIG1 and GND pins on the cable. Photoresistors are bidirectional so either wire can be connected to the signal line.

Connect the sensor to the interface

1. Connect the Analog Breadboard Cable to Channel 1 on the interface.
2. Connect the interface to the computer.

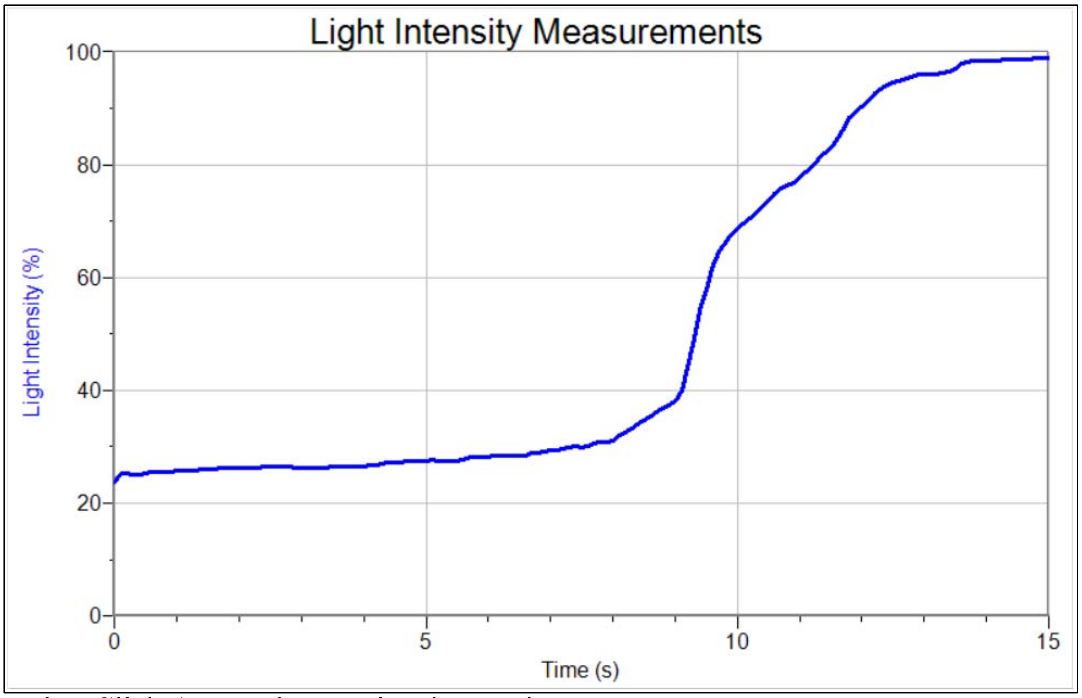
SOFTWARE SETUP

1. Start Logger *Pro*.
2. Choose Set Up Sensors from the Experiment menu.
3. In the CH1 list, select Choose Sensor. From the Voltage list, select Raw Voltage (0–5 V).

   Tip: *Values for electric potential will be displayed in the digital meter. When you place your hand over the photoresistor, the values should increase.*

4. Create a calculated column to perform the calibration (refer to the detailed Calibration section below).
5. Click ▶ Collect to begin data collection. Place your hand about 12 inches above the photoresistor and then slowly bring your hand down until it covers the surface of the detector.

6. To display light intensity measurements on the graph, click the y-axis label and select Light



Intensity. Click Autoscale to resize the graph.

Figure 3 Light intensity measurements

CALIBRATION

1. To convert the raw voltage measurements made by the Analog Breadboard Cable to a percentage change in light intensity, you will need to determine the minimum and maximum voltage readings returned by your photoresistor. Shine a small flashlight on the photoresistor or aim it at a nearby window. When the potential reading stabilizes in Logger *Pro*'s digital meter, record this value under minimum potential.

Photoresistor	Potential (V)
Minimum – V_{min}	
Maximum – V_{max}	

2. Place your hand over the surface of the photoresistor. When the potential reading stabilizes in Logger *Pro*'s digital meter, record this value under maximum potential.

3. Choose New Calculated Column from the Data menu.

4. Enter **Light Intensity** for the Name of the new column and **%** for the Units.

5. The light intensity equation must be entered into the Equation box. To do this, substitute your recorded values for V_{min} and V_{max} into the following equation

$$\% = \frac{Potential - V_{\min}}{V_{\max} - V_{\min}} \times 100$$

Note that the default name in Logger *Pro* for the voltage readings from the photoresistor is “Potential” (found by clicking the Variables button).

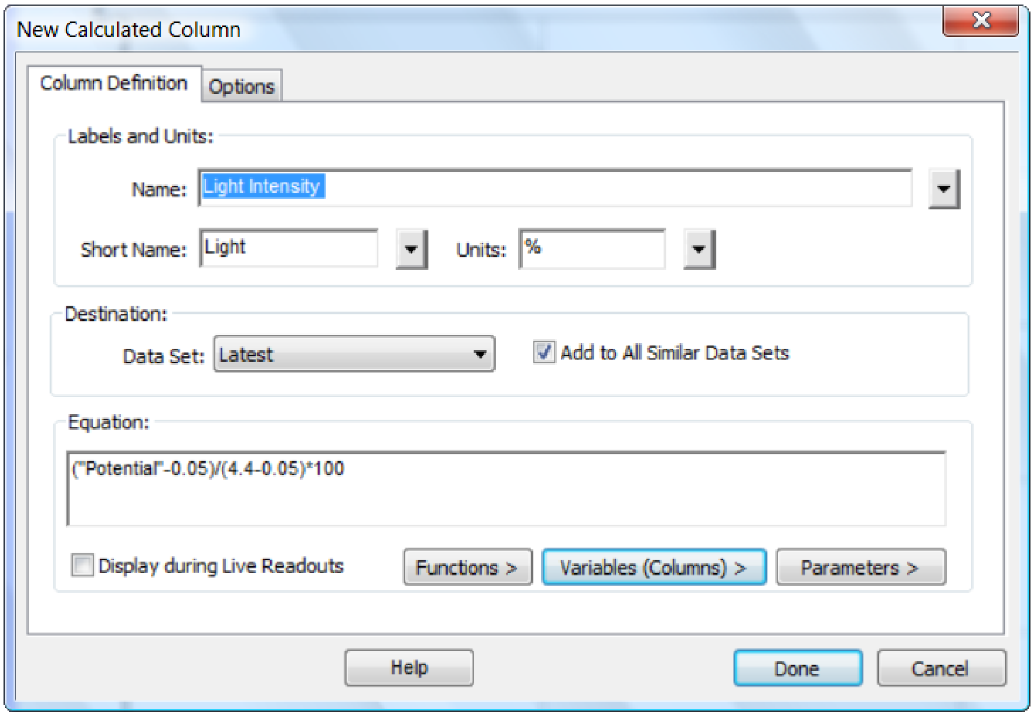


Figure 4 New calculated column dialog box

TIPS

1. Radio Shack sells a 5-pack of CdS photoresistors (catalog #276-1657). You can also find photoresistors at online electronics stores, such as Mouser and Digikey. Almost any photoresistor will work for this activity. The major differences between various brands are response time and the range of resistance values.

2. The light sensor circuit should return a nice range of values between 0–5 V when you shine a small flashlight on the photoresistor or place your hand over it. If the values appear to be reaching the limits too quickly, increase the size of the upper resistor.

3. Avoid using superbright light sources or shining the photoresistor directly at the sun when calibrating your sensor.

TROUBLESHOOTING

1. Check that you have connected the photoresistor and resistor to the proper pins on the Analog Breadboard Cable.

2. Make sure the Analog Breadboard Cable is plugged into CH1 on the interface, and that the interface is connected to the computer via the USB cable.

3. The Analog Breadboard Cable does not have auto-ID capability. You must set it up in the Set Up Sensors dialog box.

APPLICATIONS

1. Some people confuse photoresistors with *phototransistors*. When light strikes a photoresistor, its resistance changes; but when light strikes a phototransistor, its gain is affected. Photoresistors are typically used as analog light sensors capable of reading a wide range of values, but phototransistors are more likely to be used as digital switches. A typical application for this type of switch is a dusk-to-dawn light. When the sun goes down, the light turns on, and when the sun comes up, the light turns off. Try building your own dusk-to-dawn light using your light sensor, a small wattage light bulb, and the Vernier Digital Control Unit (DCU). The DCU provides on/off control of simple devices, such as lights, motors, fans, etc. Logger *Pro* includes an option that allows you to set a threshold value for the DCU based on a sensor reading. If you do not have a DCU, you can build a circuit with a photoresistor and a regular transistor to simulate a phototransistor.

2. Use your light sensor to investigate how light intensity varies with distance from the light source. Use a clear glass light bulb for the source, such as that from a penlight. Make sure the filament axis of the light bulb is horizontal and pointing directly at the photoresistor. During data collection, pull the light sensor slowly and steadily away from the light bulb. There should be no reflective surfaces behind or beside the bulb (a dark room aids in obtaining good results). After data collection, use the Curve Fit analysis feature in Logger *Pro* to determine a mathematical relationship.