Lab #4: Analog signals

Purpose:
In this lab you will build a system with three circuits: a photodiode (sensor) circuit, a variable brightness LED circuit and a user-controlled potentiometer circuit.

What you will need:
1. Arduino board (and USB power cable)
2. Breadboard for building external circuits
3. Circuit components: jumpers, photodiode, 2 LEDs, resistors, button and potentiometer
4. Digital voltmeter (DVM)

Notes: Do NOT use digital pins 0 or 1 on the Arduino. These are special pins that are reserved for communication and using them may cause your board to malfunction in a very ambiguous way that is hard to diagnose. You should be able to use any of the other pins without problem.

Online resources:
1. https://learn.adafruit.com/all-about-leds/the-led-datasheet

Tasks:
1. Build a photosensor circuit using a photodiode (or photoresistor) and implement looped averaging to reduce noise.
2. Build a circuit using the potentiometer (the variable resistor) and measure the voltage using an analog input.
3. Build an LED circuit whose brightness is controlled by the potentiometer.

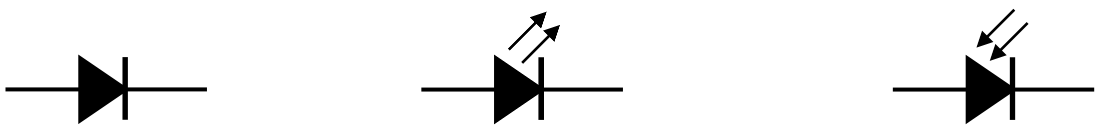
Tips:
1. We have been working with the photodiode circuit. We want a variable signal. Does that mean we want to be connected to a digital input or an analog input.
2. The potentiometer circuit works kind of like the button circuit in that we are measuring the voltage between the potentiometer and the resistor that is in series with it. We also want to measure a continuous voltage range here so it should be setup much like the photodiode.
3. Lastly, we want an LED whose brightness is controlled by the voltage at the potentiometer. To do this we are going to use a new function on the board. Notice how some of the digital pins have a "~" next to them. This means that those pins have PWM capability and are useful for very quickly blinking an LED on and off very quickly, like the code that we wrote a few weeks ago, only much easier to use. To tell this pin to use its PWM function we can do an analogWrite(pin, value) where pin is the pin number for the LED and value is the value we want to write to it. For the PWM pin, a value of 0 means that it is off and a value of 255 means that it is on 100%.
4. In order to convert the potentiometer signal to a PWM signal we will need to do some math to get the right range. Take a look at your output values from the potentiometer using the serial monitor or the serial plotter, and then convert those max and min values to try to use the whole 0-255 range (approximately).

Lab report:

Think of this device like two devices in one: it is a photosensor that monitors how much light is being produced somewhere, and a second device composed of a dimmer control and an LED. Your lab report should describe each of these devices, including circuit diagrams for each and a series of

**IMPORTANT: Make a short video recording of your Arduino showing how adjustment of the potentiometer control the brightness of the LED and is recorded by the photosensor.

Recall that the circuit symbol for diode-like devices is as follows:



Regular diode   Light-emitting diode (LED)   Photodiode (light sensor)

Setup

Please include the following elements in your report:

1. Circuit diagrams for each of your circuits. If you are not sure how to represents a potentiometer (variable resistor) then please look that up in the textbook or elsewhere.

2. A short description of what each circuit does and how the LED and potentiometer circuits work together.

3. Use three different values of resistance for the photodiode and list the max and min ranges you get when the LED is at max and min brightness. Use this to justify your circuit design.

4. Attach a copy of your Arduino code at the end of the report or as a separate file.

Data analysis

1. Use your digital voltmeter to measure the actual resistance of the fixed resistor in series with the potentiometer and record this value. Make 5 measurements of the potentiometer resistance (at different settings) and measure the current flowing through this circuit for each. Use this information to make a plot comparing your measurements of current against the theoretical value you determine using Ohm's law or Kirchoff's loop rule analysis. This means that your plot should have two lines on it, an experimental line (showing the current) and a theoretical line (with the current calculated using your measurements of resistance). Consider whether these two curves are "in agreement" with each other.

2. Include a screenshot of your plotter output that shows the variation in signal as you manually vary the LED from low to high brightness.

Conclusions
Reflect on these things:

1. Your LED brightness is being varied by a PWM function. Why does this not show up in your photodiode measurements?

2. An important aspect of precision scientific measurements is the idea of electrical isolation. This means that every measurement we make affects the rest of the circuitry in a system, possibly by doing weird things like putting noise (small voltage fluctuations) onto the ground plane on a circuit board that is ideally a steady voltage reference. This can become a problem when one is making measurements from many devices and the noise from one measurement can influence the others. This is especially problematic when the measured signals are small, perhaps in the mV or μV range, and we need to very carefully record each measurement on a computer.

One way to electrically isolate one circuit from another is to use something called an opto-isolator (or sometimes an electro-optical isolator) that communicates information from one circuit (the experimental device) to another circuit (the data recording device) using light instead of electrical signals. Discuss how the circuit we built contains the essential components of an opto-isolator.