SENSORS AND ACTUATORS

LED AND FOTODIODE

Laboratory Guide

IDENTIFICATION

Weekday	Date	Hour	Group #	Students
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INTRODUCTION

A LED is a semiconductive P-N junction that emits light when energized (light-emitting diode). That light is not monochromatic like in a laser. Instead, its spectrum occupies a narrow bandwidth. The light emitted by a LED is produced by energetic interaction of the electrons on the material. In any directly polarized P-N junction, holes and electrons recombine. That recombination leads to a release of energy as light or heat by the free electron when it binds with the material. The wavelength of the emitted light depends on the band gap of the semiconductor material. By directly polarizing the junction one "pushes" the electrons and holes together leading to their recombination.

A photodiode is a semiconductive device used to convert light into an electrical signal. There are different types of photodiodes, all based in a junction between doped semiconductor materials. Their operation is based on the photoelectric effect, that is, the incident radiation makes some electrons in the valence band jump into the conduction band and to be part of an electric current. Electromagnetic radiation (including light) is thus converted into an electric current.

If a P-N junction is directly polarized (positive battery terminal at the "p" side), one has a current flowing from anode (p side) to cathode (n side). If electromagnetic radiation impinges in that junction with the appropriate wavelength there is going to be an additional current in the same direction. This current will, however, be much smaller than the current one has when there was no electromagnetic radiation (dark current).

If the junction is inversely polarized, the current that flows through it in the absence of radiation is almost null. When radiation impinges in the junction electron-hole pairs are created in both sides of the junction and the electrons that are in the conduction band flow toward the cathode (n side) and the holes toward the anode (p side). One has, therefore, a current flowing from cathode to anode.

For this class we want to create a pulsed infrared light stream that will be detected by a photodiode and properly conditioned into a voltage.

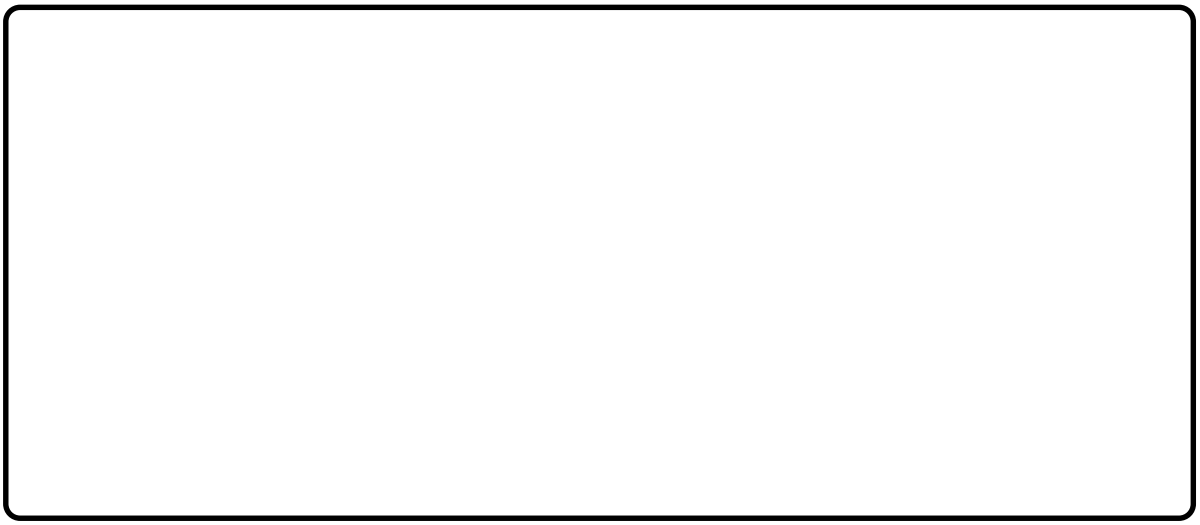
You should use the LED and photodiode to detect when someone crosses the threshold of a door. You should design the electronic circuits so that the distance between LED and photodiode is as large as possible.

Recommended reading: Book Sensors and Actuators by Francisco Alegria, sections 8.4 and 8.9.

EXECUTION

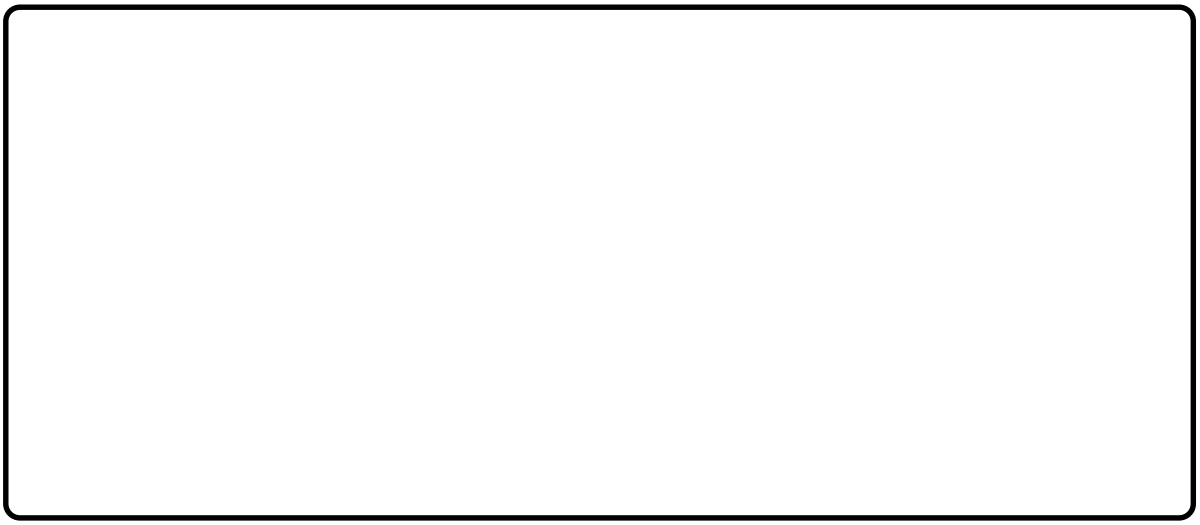
1) Energizing the LED

Design the electronic circuit for the LED (Fairchild QED423) so that it can emit as much light as possible in a pulsed fashion using an Arduino microcontroller. Draw the schematic. Present the nominal LED current and the radiant intensity in those conditions.



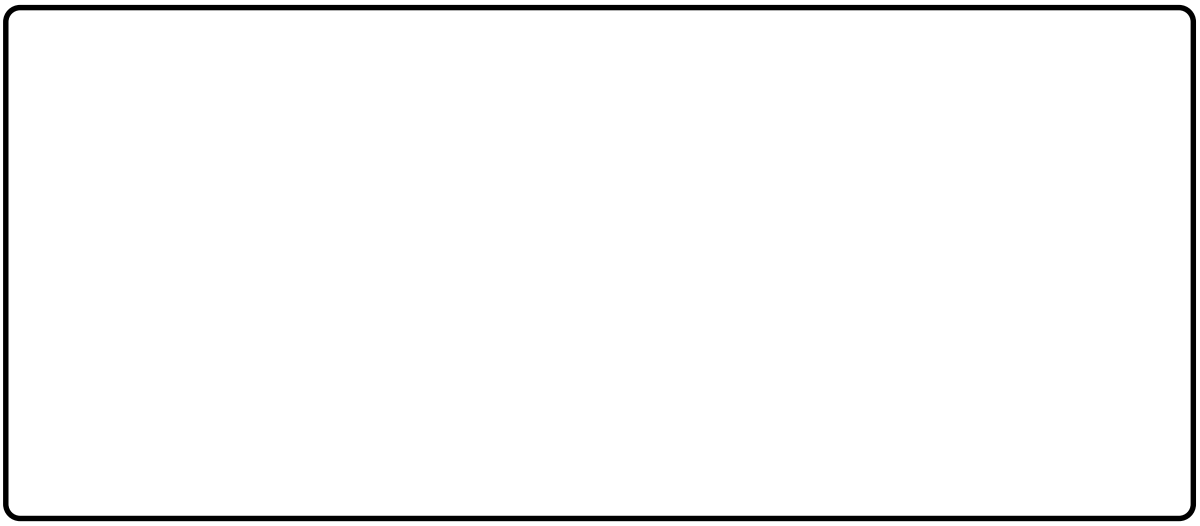
2) Photodiode Signal Conditioning

Use a monolithic photodiode and single supply transimpedance amplifier, model OPT101 from Texas Instruments. To receive the light emitted by the led. Connect the output of the amplifier to an Arduino microcontroller that displays the output voltage in the PC console. Present the schematic and the computations for the output voltage of the amplifier when i) no Light reaches the photodiode and ii) when light from the LED placed 70 cm away reaches the photodiode.



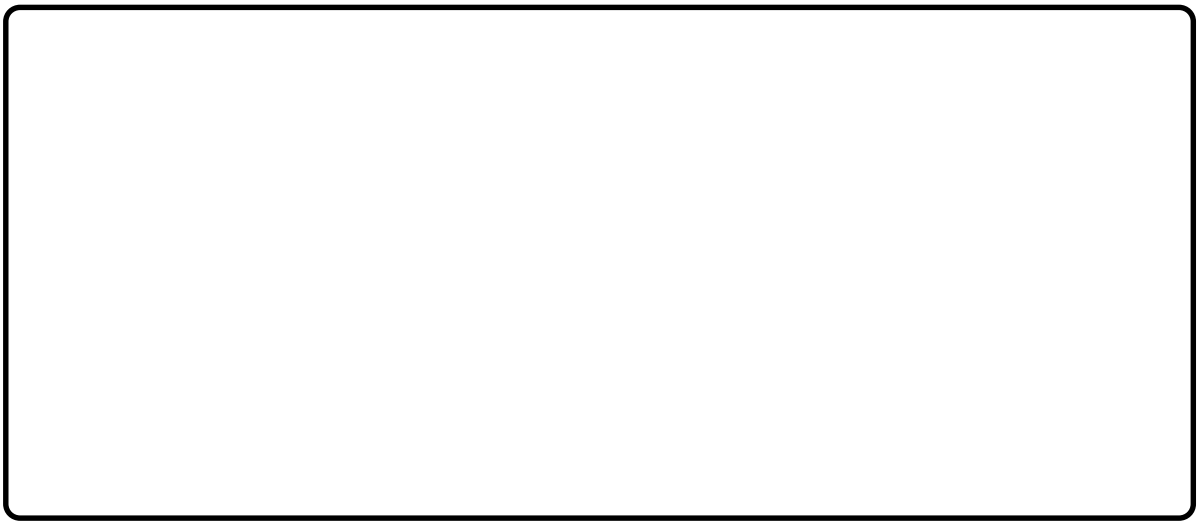
3) Experimental Setup

Assemble the designed circuit and measure the voltage at the output of the amplifier in the two conditions mentioned earlier. Compare those values with the ones computed before.



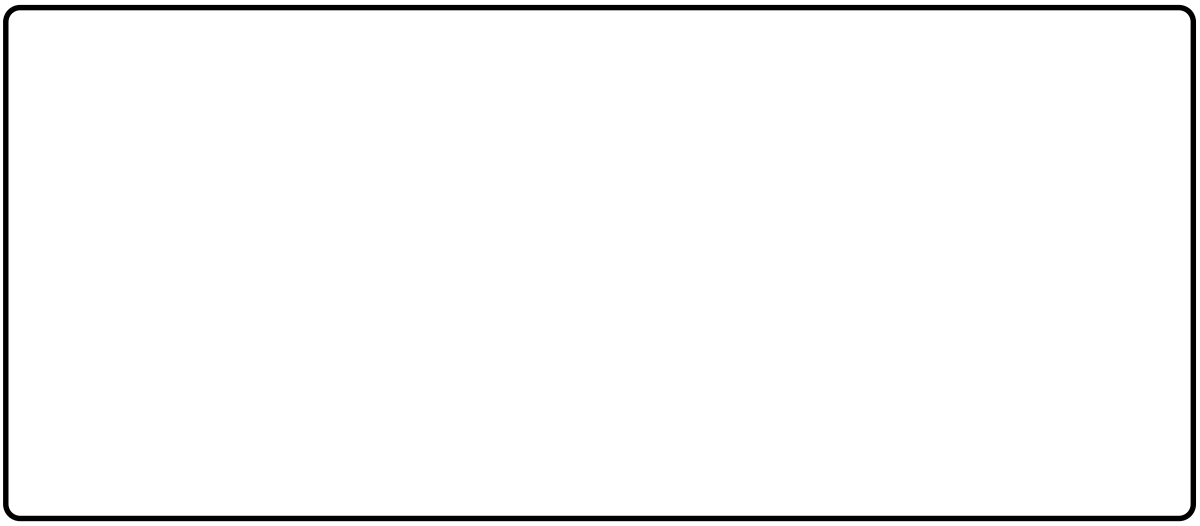
4) Maximum Operating Distance

Determine the maximum distance between LED and photodiode that you can have and still be able to detect when someone crosses the door threshold. Point out any changes that you might have made to the electronic circuits used.



5) Photodiode Directivity

By measuring the amplifier's output voltage and rotating the photodiode in the horizontal plane, determined the half-angle of the photodiode. Compare it with the value read from the datasheet.



MATERIAL

- Two Arduino Uno microcontrollers.
- 1 infrared LED Fairchild QED423.
- 1 CJMCU-101 OPT101 Analog Light Sensor
  Light Intensity Module Monolithic Photodiode.