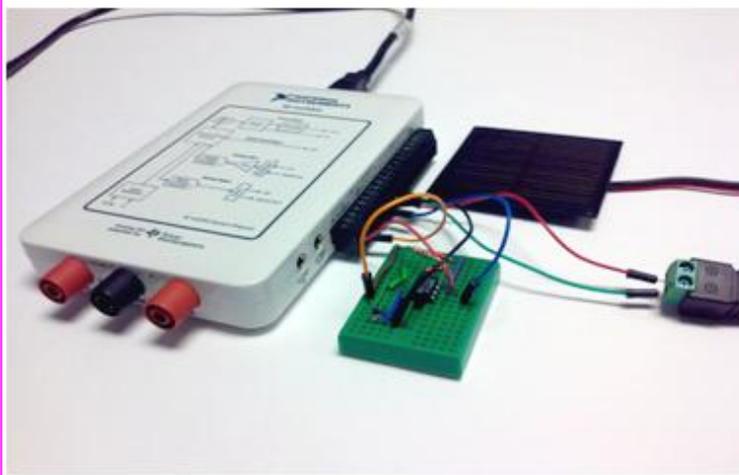


Lights Out!

Core Concept Instructor Set

nPoints
BY NTS PRESS



Photodiode
and solar cell

Materials:

myDAQ

2 Solar Cells (2V/200mA)

2 Photodiodes

2 1M ohm Resistors

1 1k ohm Resistor

1 220 ohm Resistor

2 UA741CN Op Amps

Learn It!

Photodiodes are semiconductors that are able to produce a current when exposed to light. Photodiodes share similar characteristics to regular p-n junction diodes, in fact a regular p-n junction diode conducts a current when exposed to light as well.

Photodiodes are simply optimized in order to take advantage of that effect. Since the photodiode does generate current when hit with light it could also be optimized to produce a significant amount of current, this is the basis for solar cells. Solar cells operate in what is called photovoltaic mode while

photodiodes used just for light detection are often operated in photoconductive mode. Photodiodes are used in a wide array of light detecting applications from light sensing headlights in automobiles to optocouplers.

In this module you will explore the photodiode as well as the solar cell in both a detection circuit and energy harvesting simulation. You will gain an understanding of how a photodiode can be used to detect position as well as how a solar cell can best be used to generate power.

“Photodiodes are used in a wide array of light detecting applications from light sensing headlights in automobiles to optocouplers.”

Build It!

Photodiodes emit a small amount of current when light hits them. Things can be done such as using comparators to generate high and low signals when light is present or a series of the sensors can be monitored and actions can be taken when one is being shaded. Both of these cases apply an action to when the current emitted by the photodiode reaches a certain level. Let's trigger different actions using the amount of current read from a photodiode.

Optical Therenin

Step 1: Build the amplifier circuit shown in Figure 1. This circuit will create a usable output voltage based on the small current provided by the photodiode. The output voltage will be limited by the voltage rails of your myDAQ and any change in the output load will not negatively impact the photodiode current.

Step 2: Build a second version of the circuit built in the previous step. These two circuits will be used to control the frequency and amplitude of a sound being played.

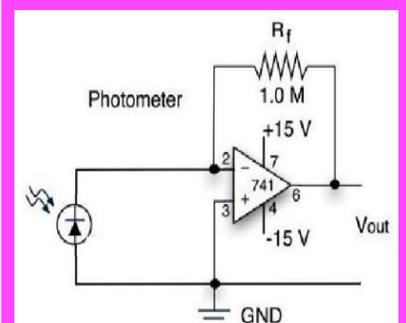


Figure 1 Voltage amplifier circuit

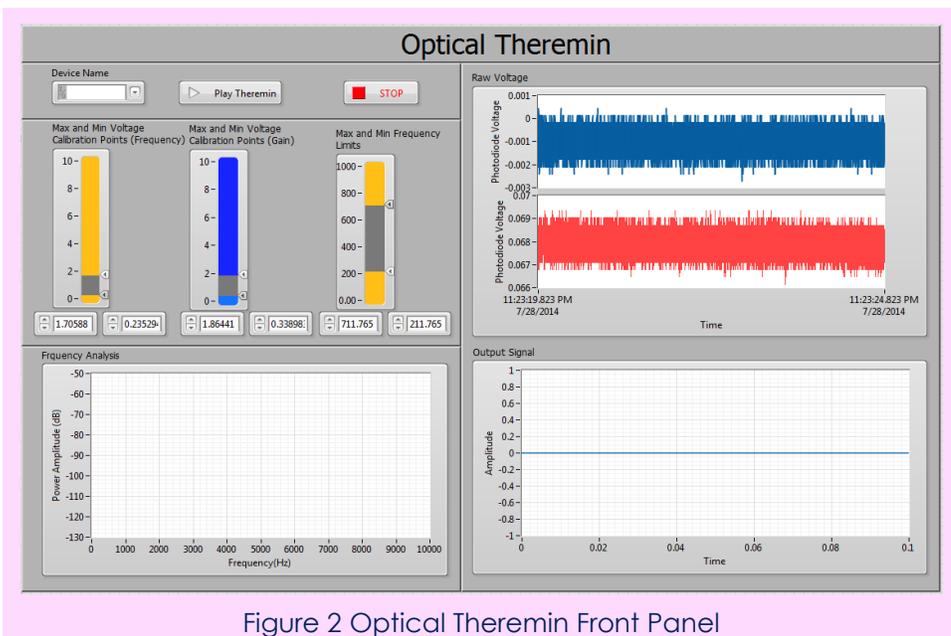


Figure 2 Optical Theremin Front Panel

Step 3: Connect the outputs of both photodiode amplifier circuits to your myDAQ AI0 and AI1 (see Figure 3 for reference). Open the Theremin demo for myDAQ.vi found in the Photodiode directory. The demo uses AI0 to control gain and AI1 to control frequency.

Step 4: You will need to calibrate your VI to your photodiodes. To do so, leave both photodiodes uncovered and adjust the top slider of the "Max and Min Calibration Points" control for both Gain and Frequency based on the voltage read on the "Raw Voltage" graph indicator.

Step 5: Completely cover the photodiode connected to AI0 and adjust the bottom slider of the Gain control. Repeat this for the second photodiode and the frequency control.

Guiding Questions:

- What is the benefit of measuring a signal differentially? What can be introduced on a signal when measured single ended?
- What is the gain provided by the amplifier circuit, what configuration is being used?

Step 6: Now that the values are in the correct range press the "Play Theremin" button, place both hands above the photodiodes and begin experimenting with the height of each hand, taking note of the impact on the output signal frequency and amplitude.

Step 7: Examine the block diagram. The code is executing in a while loop in order to run continuously. Data from the two photodiodes is acquired and passed to a function to take the average of the two signals respectively. That information is then passed to subvis that place the raw data values within the range determined by the calibration done previously. This information is then used to generate the output wave which is both displayed and passed to the computer soundcard.

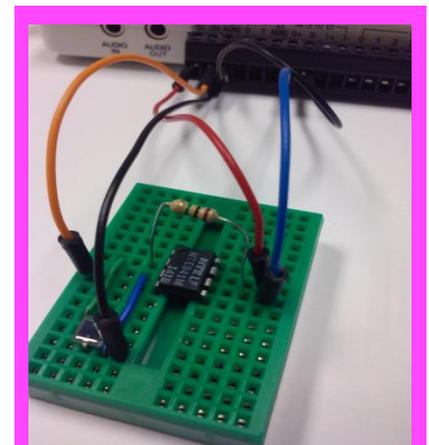


Figure 3 Photodiode amplifier

Solar Power Source

A solar cell is essentially a photodiode that is operating in photovoltaic mode. As light hits this pn junction, it is able to move electrons to higher energy levels which leave positively charged holes behind. This separation of charge causes a potential difference, or voltage, to form in the solar cell which can be used as a power source for circuits. Let's explore two different configurations of solar cells to see how best to use solar energy.

Step 1: Build the series circuit in Figure 6 with your two solar cells using the series connection of the 1k and 220 ohm resistors as a load. Connect this circuit to your myDAQ with AI0 measuring total voltage across the two resistors and AI1 measuring the

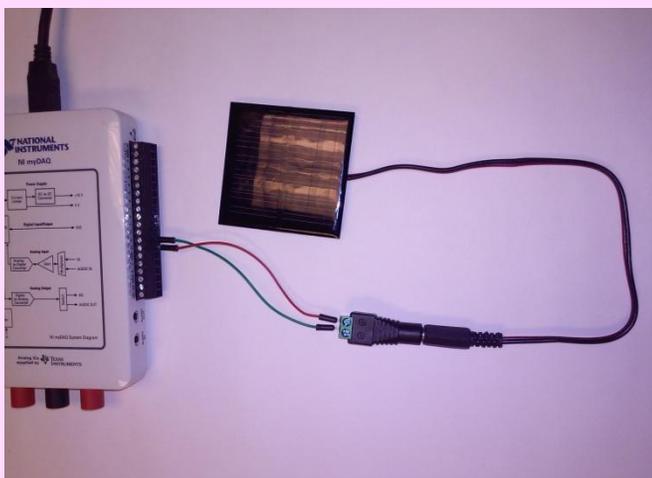


Figure 4 Solar Cell connection

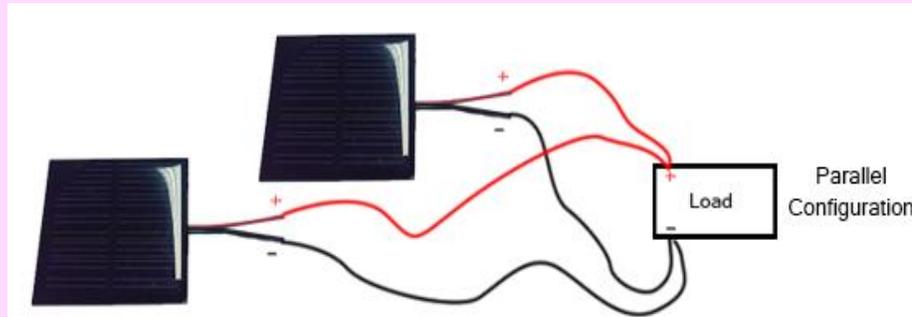


Figure 5 Solar cells in parallel for increased current capacity

Guiding Questions:

- How much power is your solar cell rated for? What resistance would be needed in order to reach the maximum current output?
- Design a solar panel capable of generating 6W of power using solar cells with the same specifications as the ones used for this module.
- Research solar cells, list and explain the challenges and solutions associated with putting solar cells in series and parallel.

Expand it!

- Devise a way to use the digital lines with your photodiodes to make a system that can determine the relative position of an object along a certain length. This can be developed into a system that can track position either in a linear or planar fashion.
- Use a combination of solar cells to create an energy harvesting system with a capacitor bank and network of switches to add and remove loads

voltage across the 220 ohm resistor to calculate current.

Solar Cell voltages add in series while their currents remain the same. If the load you apply to the solar cells exceed the current limit then the total voltage will begin to drop in order to lower the power supplied. In order to increase the current capacity of your solar cells you must put them in parallel. Figure 5 shows solar cells in parallel. Single solar panels are usually built by putting many solar cells in series to increase the voltage output. Multiple solar panels are then placed in parallel in order to increase the current capacity of the system as a whole. Open and Run the Solar Cell demo.vi.

Step 2: Cover each solar cell and observe how it impacts the overall voltage and current. Completely cover a single solar cell while leaving the other completely uncovered and note how this affects the overall power of the circuit.

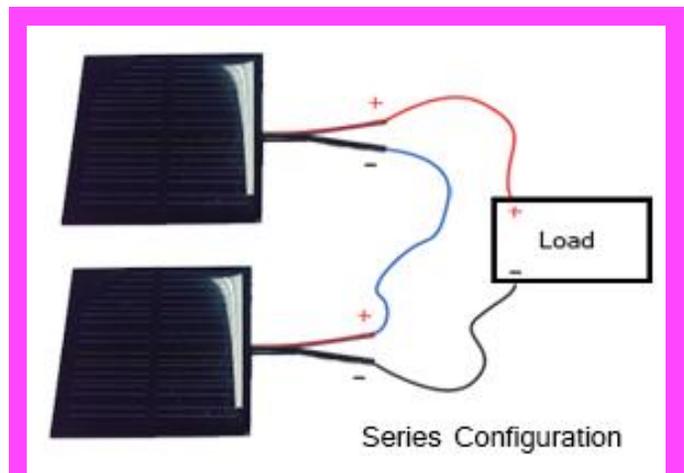


Figure 6 Solar cells in series for increased voltage

Research It!

Tinker Learn and Do – Lab 10: Optical Theremin

http://download.ni.com/pub/devzone/tut/lab10_theremin.pdf

Photodiode Theory of Operation

<http://www.aptechnologies.co.uk/support/photodiodes/photodiode-theory-of-operation>

Photo detectors

<http://hyperphysics.phy-astr.gsu.edu/hbase/electronic/photdet.html>

Photodiodes

<http://www.ni.com/white-paper/14839/en/>

How Solar Cells Work

<http://science.howstuffworks.com/environmental/energy/solar-cell.htm>