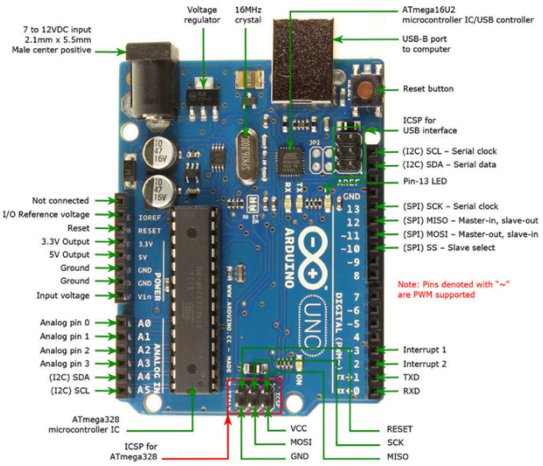
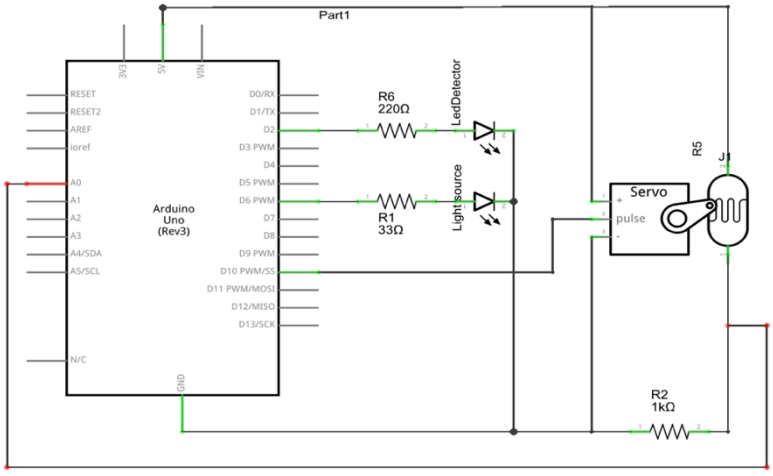
MPPT Algorithm and Photocells

Solar Tracker Sequence





LEVEL: ADVANCED

DEVELOPERS: Eric Ho, Khai Tran, and Phuong Truong

ADVISOR: Professor Truong Nguyen, ECE

REFERENCES: Dual Axis Solar Tracker by OpenSourceClassroom

PROJECT SEQUENCE: Solar Tracker

LAST UPDATED: 09/13/17

REQUIRED DOWNLOADS / INSTALLATION

1. Latest version of Arduino: https://www.arduino.cc/en/Main/Software
2. Latest version of Sublime Text Editor: https://www.sublimetext.com/

A NOTE FROM THE DEVELOPERS

Dear Students,

The ECE 196 course and Project in a Box team would like to credit the original work of Solar Tracker to OpenSourceClassroom. We were inspired by their work and have selected their project to be the inspiration of choice for one of the class projects. As always we would also like to thank the Makers and Inventors behind Arduino, Sparkfun, Instructables, and Sparkfun for their simple tutorials that have been selected in our beginner section of the project. In this sequence, students will learn how to build two different types of solar trackers! We wish our engineers luck on optimizing the design and improving the presentation of the project via documentation and development. As always, have fun!

Sincerely,
P.I.B. Team

INTRODUCTION

In the third part of the project sequence, students will develop the maximum power point tracking algorithm (MPPT) for the laser cut 3D printer, and complete the Dual Axis Solar Tracker by OpenSourceClassroom. Your goal is to build and compare these two solar trackers to determine which one is better. Good luck!

OVERALL LEARNING OBJECTIVES

- Basic Circuits
- Building Libraries
- Learning Arduino C

REQUIRED PROJECT PARTS (ALL)

Product Name	Vendor URL	Quantity	Notes
Arduino Uno	Sparkfun	1	
Breadboard	Sparkfun	1	
Solar Panel	Sparkfun	1	
Microservo	Sparkfun	2	
Jumper Wires	Sparkfun	1	

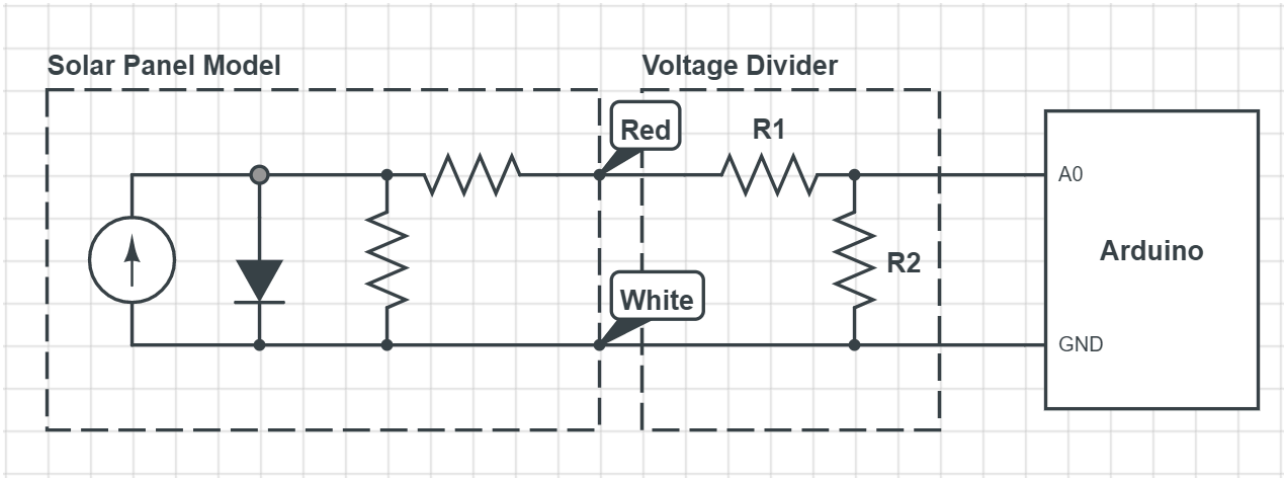
REQUIRED PROJECT TOOLS/EQUIPMENT

- Laptop Computer

CHALLENGE #1: MPPT Algorithm

Objective: The sun moves about 15 degrees per hour. The efficiency of the amount of power generated from the solar panel depends on the amount of sunlight hitting the solar panel and the load in which the power is being delivered. The objective of this project is to implement a MPPT algorithm to have the solar tracker automatically track the location where the solar panel generates maximum power.

1) Cut the barrel plug on the solar panel and strip the outer wire. Strip the two inner wires (red: power, white: ground) and solder them to jumper wires. Use the Arduino analog pin to read the voltage of the solar panel. Since solar panel can generate a maximum output voltage of 6V and the Arduino analog pin can only read up to 5V, you will need to create a voltage divider to record the voltage generated from the solar panel for up to 5V. Multiply the values read by the analog pin by the inverse ratio of the voltage divider to get the correct voltage generated by the solar panel.
   Note: You should test the voltage divider with a power supply at 6V to make sure that the Arduino analog pin reads 5V before testing it with the solar panel. The voltage divider must work before implementing the MPPT algorithm.

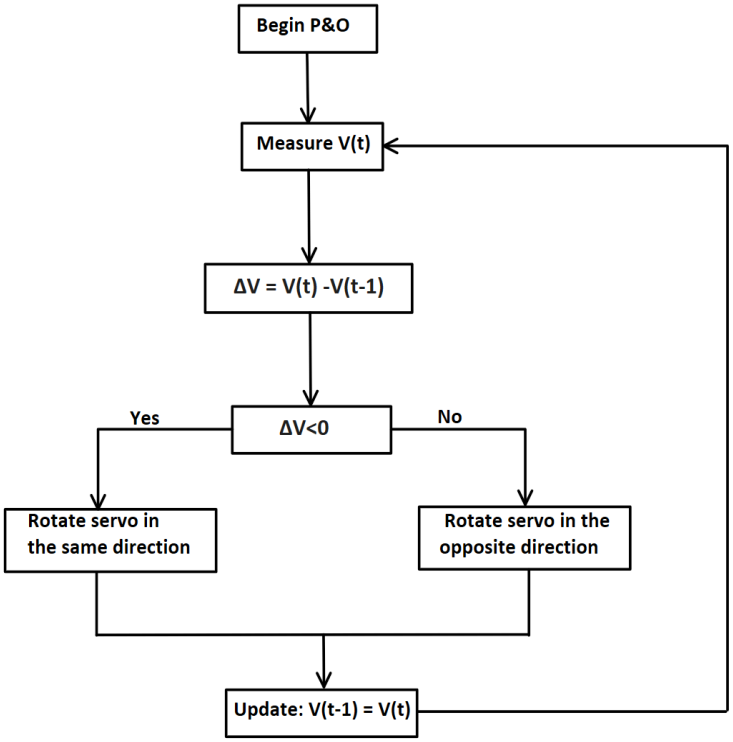


2) Once the voltage divider works, you will write an initial optimum position code in the setup loop. The solar tracker will first sweep radially with the solar panel tilted at an angle of around 20 degrees. Have bottom servo sweep from 0-180 while the top servo is set to around 20 degrees and record the voltage. Once the voltage data from the sweep is collected, the servo will move to the position of the maximum voltage. Then you will do a tilt sweep by sweeping the top servo from 0-180 while having the bottom servo fixed at the optimal position. Once the voltage data from the tilt sweep is collected, the servo will move to the position of the maximum voltage.
   Note: The position of the panel might not face directly at the optimum position because of the fluctuation in the voltage. A filter can be applied to smooth out the voltages and correct any offset position of the solar panel.

3) Once the solar tracker is at its initial maximum position, the “perturb and observe” method, combined with the filter, can be used to track the maximum position with varying light movement. When implementing the perturb and observe method, you will only be using the tilt sweep to find the maximum output voltage. The servo will tilt a certain degree of your implementation at a choice of your speed to record a voltage and compare it to the previous voltage reading. Once the voltages are compared, the servo will move to the position with the higher voltage. This algorithm will continue to loop to find the maximum power point.

Perturb and Observe Method:

In this method, the change in the output power is observed by increasing or decreasing the voltage. During a cycle, if the voltage difference decreases, then the voltage step will change in the same direction as the previous cycle and check if the voltage continues to increase. If the voltage difference increases, then the voltage step will change in the opposite direction. This process is repeated until solar panel reaches the maximum power point and oscillates around this point. This project will use the Perturb and Observe method to track the maximum output voltage.



Filters:

The voltage reading of the solar panel fluctuates and the data is noisy. In order to smooth the data, a median filter can be applied. The median filter takes a small sample of the overall data and finds the median. The value will be stored into a new set of data that will smooth out the voltage of the solar panel making it easier to detect the maximum output voltage. Other filters such as the mean and threshold filter can be applied to smooth out the noise.

Terminology:

Arduino Voltage Sensor: The Arduino can read an analog input voltage of up to 5V. If the source generates a voltage greater than 5V, a voltage divider can be used to make the output voltage sense 5V.

Maximum Power Point Tracking Algorithm: The maximum power point is the point that delivers the highest output power. The maximum power point tracking process tracks the point that maintains the power transfer to the load at optimal efficiency. There are many different ways to implement the MPPT algorithm: Perturb and Observe, Incremental Conductance, Fuzzy logic controller, etc. The simplest method to implement is the Perturb and Observe method.

CHALLENGE #2: 3D Printed Solar Tracker

Objective: In the last part of the project, you will complete the 3D printed solar tracker by finishing the tutorial found on Thingiverse. http://www.thingiverse.com/thing:53321

You have optimized its mechanical design, but what about its electronic circuitry? What other filters can you add to improve stability of the servo motors? Do your best to optimize this design.

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Which solar tracker turns out more efficient? Why?

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REFERENCES

1. Please visit Sparkfun to learn more about how breadboards work!
   https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard

2. The Arduino website is a very good resource for grasping circuits and Arduino in general. Use the following link and click on the “Learning” tab, where you will find how to get started, tutorials, and other useful references!
   https://www.arduino.cc/en/Main/Documentation#

3. SparkFun is a vendor that sells a variety of platforms, one of them Arduino. Luckily, they have great resources on the site to help you learn Arduino.
   https://learn.sparkfun.com/tutorials/what-is-an-arduino

4. Adafruit is a DIY (Do-It-Yourself) vendor that sells and utilizes a variety of platforms. Luckily, they have a section dedicated to Arduino! Simply click on the “Learn” tab and follow the Arduino links. It will take you to a large amount of projects for you to build on your own!
   https://www.adafruit.com

5. Instructables is a good project-based resource with a variety of platforms just like Adafruit. Check the website out for more interesting projects!
   http://www.instructables.com