The Robust Heliotropic Servo Design for Concentrated Photovoltaic Systems (HCPVS)

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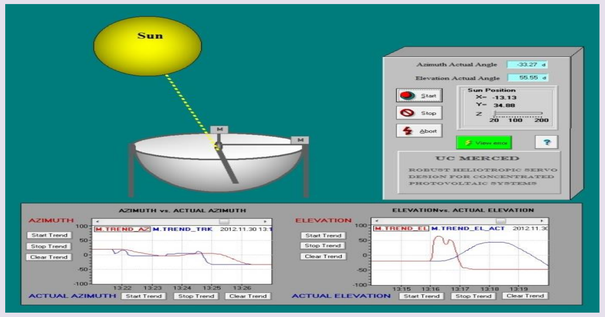
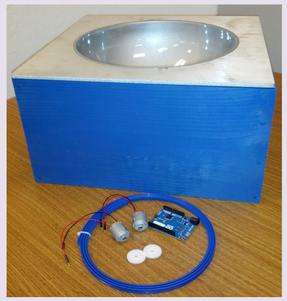
Simulation



A simulation of the Robust Heliotropic Servo Design for Concentrated Photovoltaic Systems was created using Advanced Motion Controls Click&Move® software. The simulation tracks the "Sun", by moving the rod along the inside of the dish, so as to maintain 2/5 of the hemisphere's radius and a parallel orientation to the Sun's rays. This is accomplished by using two separate servos to adjust the azimuth and elevation of the rod, controlled by AX1 and AX2 respectively. The equivalent ratio of both these axes to real coordinates is 10,000 counts to one revolution, and one degree of movement. The actual elevation and azimuth are compared with the corresponding orientation of the target via trend graphs, which show the transient response of the system in terms of system input and output.

PROTOTYPE CONSTRUCTION



- 16"x16" Aluminum cover with a 12" diameter hole cut in the center.
- 12" diameter reflective bowl.
- 10" height base constructed of pine.
- Arduino Uno-R3
- 2- 5v DC Motors
- Flexible gear track and gears
- Not Pictured
  - Rotating base for 14" diameter track.
  - Rod and gear system.
  - Photodiodes

References

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3. Thompson, Caroline. "The Effects of the Angle of Sunlight on a Solar Panel."*LIVESTRONG.COM*. Ed. JPC. N.p., 8 Aug. 2010. Web. 23 Apr. 2013.
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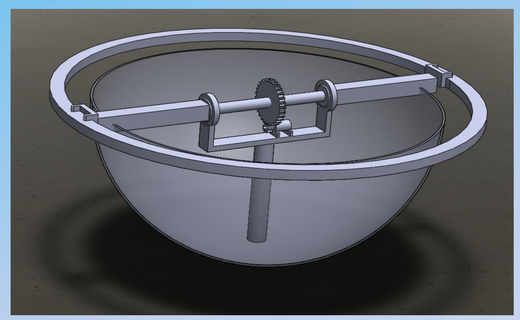
Abstract

The Robust Heliotropic Servo Design for Concentrated Photovoltaic Systems, or HCPVS, is an advanced solar energy collector. The HCPVS implements a control system to move a solar cell to the focus point of the sun's concentrated rays. This enables a less expensive, lower footprint, lightweight, and highly efficient solar energy collection system compared to traditional solar collection systems. The reduction in area utilized to generate power enables green energy to be collected on a smaller scale suitable for modular application in traditional urban landscapes less isolated from direct human use. Lower volumes of photovoltaic material will significantly reduce the waste materials from cell replacement over a standard lifespan. Implementation of this device will advance solar technologies to be more efficient and robust in applications.

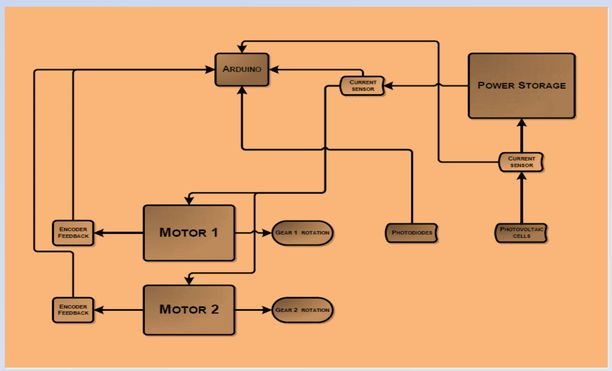
3D Model of the System



The latest model of the system. Each component is being built in small sections to be 3D printed for testing and calibration. Here you can see a motor that rotates the photovoltaic rod around the center axis. The outer circle will also rotate although this is not shown here

SYSTEM MODEL

This is the system model of the HCPVS encoder feedback combined with the photodiodes allows the Arduino to calculate the position of the rod move it accurately to be parallel with the sun



Concept of the HCPVS

It has been shown that a rod with its pivot-point at the hemisphere's center, and kept in parallel with the sun's rays, should always have light concentrated at approximately 2/5 of the hemisphere's radius[8]

Maximum solar collection efficiency is achieved only within a small range of the rod's positional accuracy. Since the system only moves the rod (~Ø.02-.025m x .2m) with a small cluster of photovoltaic cells at the tip, it takes a fraction of the energy to keep the system at optimal positioning; in comparison, a standard solar collector must move an array of solar cells (typically 1m x 2m), in order to achieve comparable results.

The HCPVS can be designed to be easily moved without the need of elaborate setup, essentially "out-of-the-box" technology. With a high resolution, low latency tracking system, the collector's position has the potential to be dynamic, while maintaining maximum efficiency.

Solar Panel Efficiency

- Solar Panel efficiency depends on [1]:
  - Manufacturers of the solar panels
  - Panel orientation
  - Roof and panel pitch
  - Temperature
  - Shade
  - Azimuth and other variables
- According to PurSolar and Electrical resource, most of the solar panels have an efficiency of 14-18%[2]

Solar Panel Efficiency of Days and Angle of Sun

- Most of the sunlight during a clear day will be gathered from the solar panel around the noontime[3]
- During the nighttime, solar panels do not produce any electricity. [4]
- Solar panel's efficiency is less than 18% during the winter months [5]
- Solar Panel Plus's evacuated tubes increase in efficiency in the morning and afternoon when the sun's angle is within the range of 40 and 80 degrees from perpendicular [6]