Solar Powered Self Watering Plant System

Author: Kenneth M. Serrano Rodriguez
Advisor: Bernardo Restrepo
Department of Mechanical Engineering

Abstract

1 out of 8 Americans call apartments home. Most apartments' space is limited. Also, people's time is compromised in many activities. This project aims to create a solar powered self-watering plant system, which enables people with limited time and space to have their own inside compact garden with minor supervision. Plants have a specific optimum soil relative humidity range for growing. For the project, parsley and basil were sowed. Soil moisture sensors were used to monitor the relative humidity range of the plants. When out of it, a water pump would automatically flow water to the plant until the humidity range was met. A Matlab code was developed and used to specify the capacity needed for the solar power system, taking into consideration all power loads. The project developed could supply the water needs to the plants for them to grow healthy and being energized with solar power.

Introduction

- Several people around the world enjoy growing plants.
- Most population lives in apartments, where the space is limited.
- This project focuses on creating a system that enables people with this space limitation and time restriction to grow a healthy plant in a confined space.

Background

- Energy from the Sun can be converted into electricity using photovoltaic (PV) cells.
- PV cells transform sunlight into direct current (DC) electricity.
- The solar conversion process and necessary elements are represented in Figure 1.

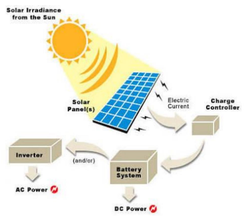

Figure 1
Representation of Solar Energy being Converted into DC and AC Electricity

Problem

Objectives

- Create a Matlab code that enables to escalate the solar system specifications based on the quantity of the desired plants.
- Design and create a system that can supply correct amount of water automatically to two plants (basil and parsley).
- Design and create a system that feeds water to basil and parsley plants using solar power as its power source.

Methodology

Solar System Design

Equations 1-8 were used for the solar system design. These calculations enabled to specify the solar system's capacity.

$$= \#\ of\ plants \times Current \times \frac{Q}{\frac{Hours}{Day}}\ [A-hr] \quad (1)$$

$$Wattage = W = Q \times Voltage\ [W-hr] \quad (2)$$

$$\sum W = W_{pump} + W_{moisture\ sensor}\ [W-hr] \quad (3)$$

$$P = \frac{\sum W}{peak\ sun\ hours}\ [W] \quad (4)$$

$$P_c = \frac{P}{e}\ [W] \quad (5)$$

$$\#\ of\ solar\ panels = \frac{P_c}{P_r} \quad (6)$$

$$Amp-hr\ per\ day = \frac{\sum W}{B_v}\ [Amp-hr] \quad (7)$$

$$B_c = \frac{\frac{Amp-hr}{day} \times DDOS}{ADT}\ [Amp-hr] \quad (8)$$

System Design Components

Figure 2
Compact Water Pump

Figure 3
Soil Moisture Sensor

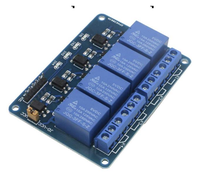

Figure 4
4-Channel Relay

Figure 5
Solar Power Manager

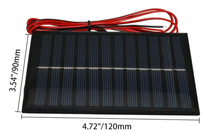

Figure 6
Solar Panel

Figure 7
Microcontroller

Project Schedule

To complete the project on-time, the following activities and deadlines in Table 1 were used as reference.

Table 1
Project Schedule

Activities	Status	Limit Date	Priority
Necessary Calculations	Done	3/15/24	X
System Design Components - Order	Done	3/22/24	
System Design Components - Delivery	Done	4/5/24	
System Coding	Done	4/19/24	
System Setup/Assembly	Done	4/26/24	X
System Test & Debug	Done	5/3/24	
Data Acquisition	Done	5/17/24	

Results and Discussion

Matlab software was used to develop a code that enables to escalate the solar system specifications based on the quantity of the desired plants. For two plants, the output is shown in Table 2.

Table 2
Solar System Specifications for Two Plants

Parameters	Output
Number of plants	2 plants
Number of solar panels	1 panel (1.4W output rating)
Number of batteries	1 battery (3.7V/1.8A-hr capacity)
Allowable depth limit	80%
Desired days of storage	1 day

These specifications were used as reference and the solar system was created as shown in Figure 8.

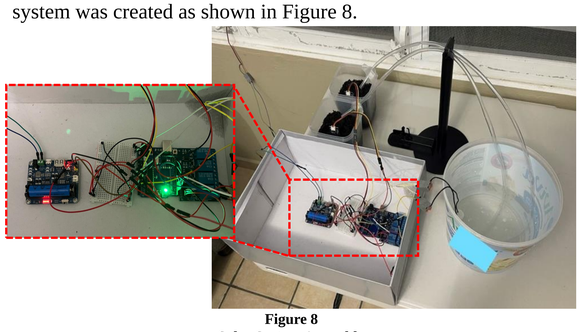

Figure 8
Solar System Assembly

After a period of 28 days, plant height vs. time data was acquired for both plants. The plot is shown below in Figure 9.

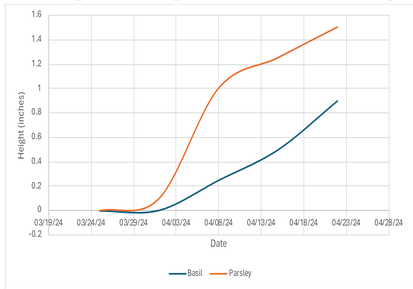

Figure 9
Plant Height vs. Time Plots for Basil and Parsley

It can be noticed that the solar powered self-watering system is providing the correct amount of water, such that both plants are growing.

Also, a picture of the plants on 04/15/2024 is shown below in Figure 10. Both plants are exhibiting a healthy color.

Figure 10
Plants Growth on 04/15/2024

Conclusions

The developed Matlab code enabled to escalate the solar system capacity to the desired number of plants to be irrigated. For two plants (quantity of desired plants to be irrigated), the solar system needs to have one solar panel of 1.4W output rating. Also, it needs one battery of 3.7V for energy storage, where the allowable depth limit of the battery is 80% and the maximum day of storage is one day. The Matlab code can adjust or escalate based on the desired number of plants to be grown.

The solar system created was based on the output specifications of the Matlab code. After assembling all the necessary components, Arduino software was used to establish the logic to engage and disengage the water pumps for flowing water to the plants. After constantly monitoring the plants' relative humidity, if it was out of the established humidity range (40-70% RH), then it would engage the specific water pump to irrigate the specific dry plant and disengage when the RH range was met again.

This self-watering plant system design was energized using solar power, which enables people with limited space to grow healthy plants with minimum supervision. It was shown that the designed and constructed system worked, after monitoring the plants' height vs. time. Both plants grew at a healthy rate and exhibited a healthy greenish leaf color.

Future Work

As for future work, the following mechanisms could be incorporated in the design, however, they would imply a higher power load:

Figure 11
E-Paper Display [13]

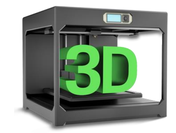

Figure 12
3D Printer [14]

Figure 13
LED Lamps for Plants [15]

Acknowledgements

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[15] Figure 13 PNG: https://brite-labs.com/products/saber-quad