Dual Axis Solar Panel Tracking System

Jason Velazquez jasonvelazquez82@yahoo.com, Raul Martinez raul.martinez02@student.csulb.edu
Professors: Christopher Hirunthanakorn, Dr. Saleh Al Jufout
California State University Long Beach

Abstract

The objective of this project is the development of a dual-axis solar tracking system to optimize solar energy capture. The system utilizes continuous alignment of the photovoltaic panel with the sun's trajectory to maximize energy absorption, facilitating efficient battery charging with integrated overcharge protection and real-time power consumption monitoring. Sunlight intensity is sensed with photoresistors and servo motors actuate the panel's orientation for peak solar irradiance. An Arduino microcontroller serves as the central control unit, processing light-dependent resistor (LDR) data to drive the servo motors for precise dual-axis tracking. Additionally, the Arduino controls a linear motion mechanism to automatically relocate the system when shaded. The system also provides a manual override, allowing users to adjust the linear actuator's position using an integrated joystick. A dedicated charge controller manages the energy harvested by the solar panel to ensure safe and efficient battery storage. A display module provides real-time indication of power output. Overcharge prevention is implemented through a voltage regulation circuit that disconnects the battery at its fully charged state. To enable system initialization from a fully discharged battery, an external power input (socket) with subsequent voltage regulation, allowing the system to become self-sustaining using the panel's generated power. This feature allows the system to operate continuously and keep the system to have its portability. The portability feature is allowed since it will cost less than 30lbs from its overall weight. This project contributes to improved solar energy utilization, increased battery longevity, and a dependable power source with real-time performance feedback, rendering it valuable for sustainable energy solutions.

Objectives

Automatic Rotation: The panel is designed to automatically rotate in both clockwise and counterclockwise directions, likely to follow the light source (following the sun's movement).

Solar Energy Collection & Powering Load: The system gathers solar energy and uses it to store and power a load.

Manual Override: Users have the option to manually control the panel's position in the vertical direction using a joystick due to adverse weather conditions, overriding the automatic system.

Real-time Data Display: The system includes an LCD screen to show live voltage and current data, both when a light source is present and when it's absent. This data is obtained from the power bank.

Energy Storage & Continuous Power: To maintain power even when the light source is removed, the system utilizes energy storage (like a capacitor). This allows for continuous power delivery to the load even when "sunlight" is temporarily unavailable.

Level 1 Requirements

L1.1 The structure will allow the solar panel to move in the vertical when light is shined. During operation, its vertical range is a full 180 degree range with 90 being its starting position. For verification, automated tests will be performed during operation.

L1.2 The structure will allow the solar panel to give it tilt ability when following the light source. During operation, its tilting range is a full 90 degrees with 45 being its starting position. For verification, automated tests will be performed during operation.

L1.3 The structure will allow the solar panel to move in the horizontal axis when light is shined. The horizontal axis will give a range of 0 – 2 ft max. For verification, manual override by the user will be performed.

L1.4 System will track the light source. This would allow for high tracking solar efficiency. Validate the movement response with light source.

L1.5 The system shall have a display to show the solar panel output in real time. Providing user feedback for the system monitoring status. To verify, power values will be measured when the light source is present and removed.

L1.6 The system shall remain operational with actual time, enabling us to observe its functionality without concerns about failures. To verify its performance, we will conduct extended tests lasting between up to 1.5 hours to ensure it continues to function as expected while collecting data within the designated time frame.

L1.7 The system shall continue to power the load when the light source is removed. Ensures the system is maximizing its efficiency by storing energy. To confirm, observations and measurements will be evaluated at the load.

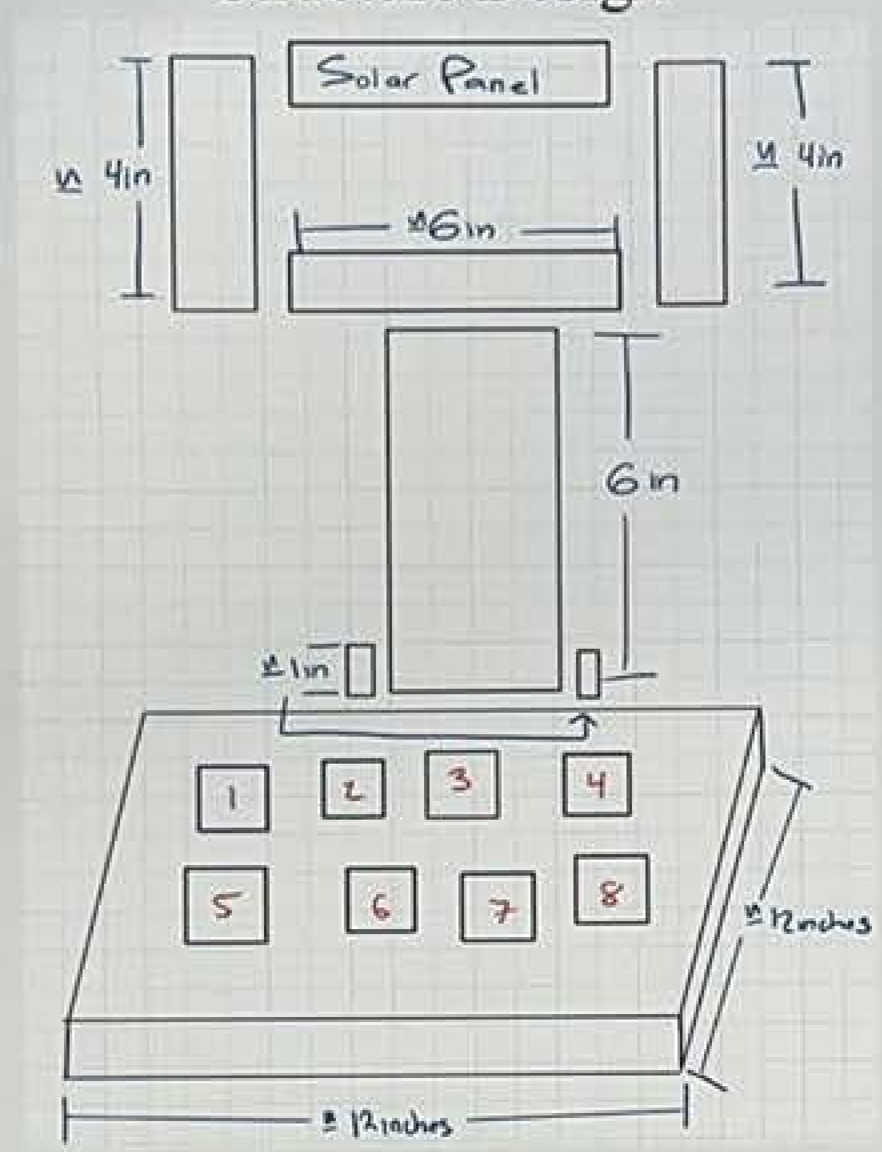
L1.8 An ideal joystick for manual override shall allow user control to only vertical movement of the system. It allows the user to adjust to bad weather conditions or any given circumstance. The actuator's vertical movement will be tested with buttons for verification.

L1.9 The system shall be powered by a lithium ion rechargeable battery pack. For verification, the system stays operational with the help of the battery pack. Lithium ion rechargeable battery pack will also have a voltage display attached to show users the voltage to show when voltage drops below 5V, that's when it's then needed for recharge.

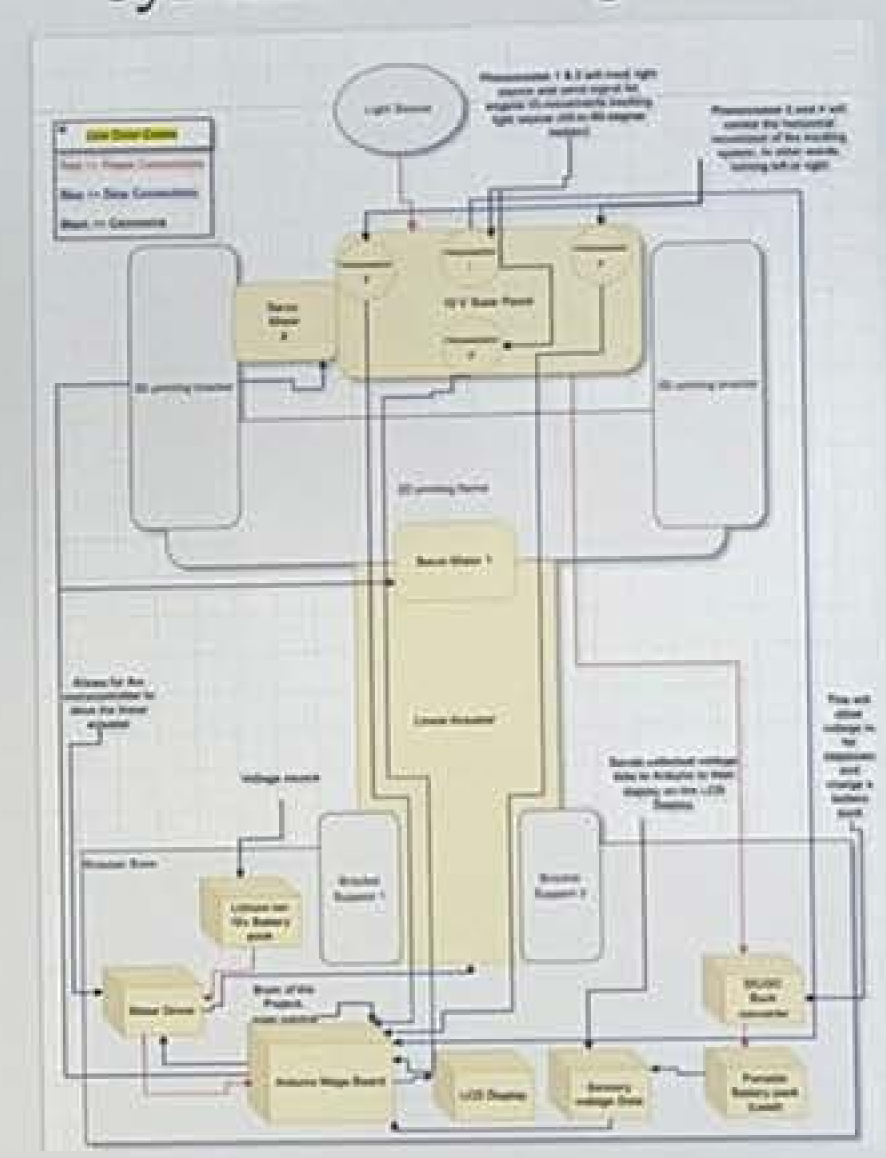
L1.10 The system shall regulate the voltage charging to the battery bank. Preventing any overcharging and damage to the system. Observing the power absorbed on a display screen and ensuring it does not exceed a threshold value.

Diagrams/Figures/Experiments

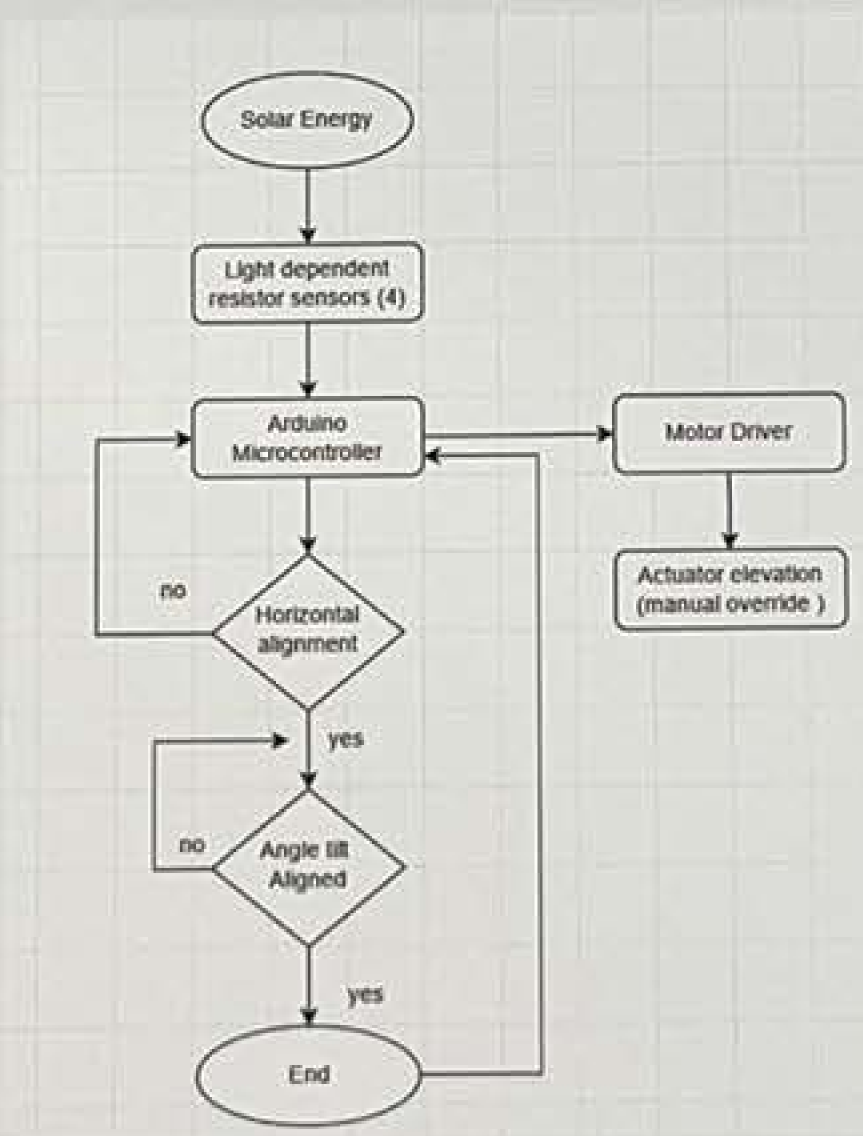
Structure Design



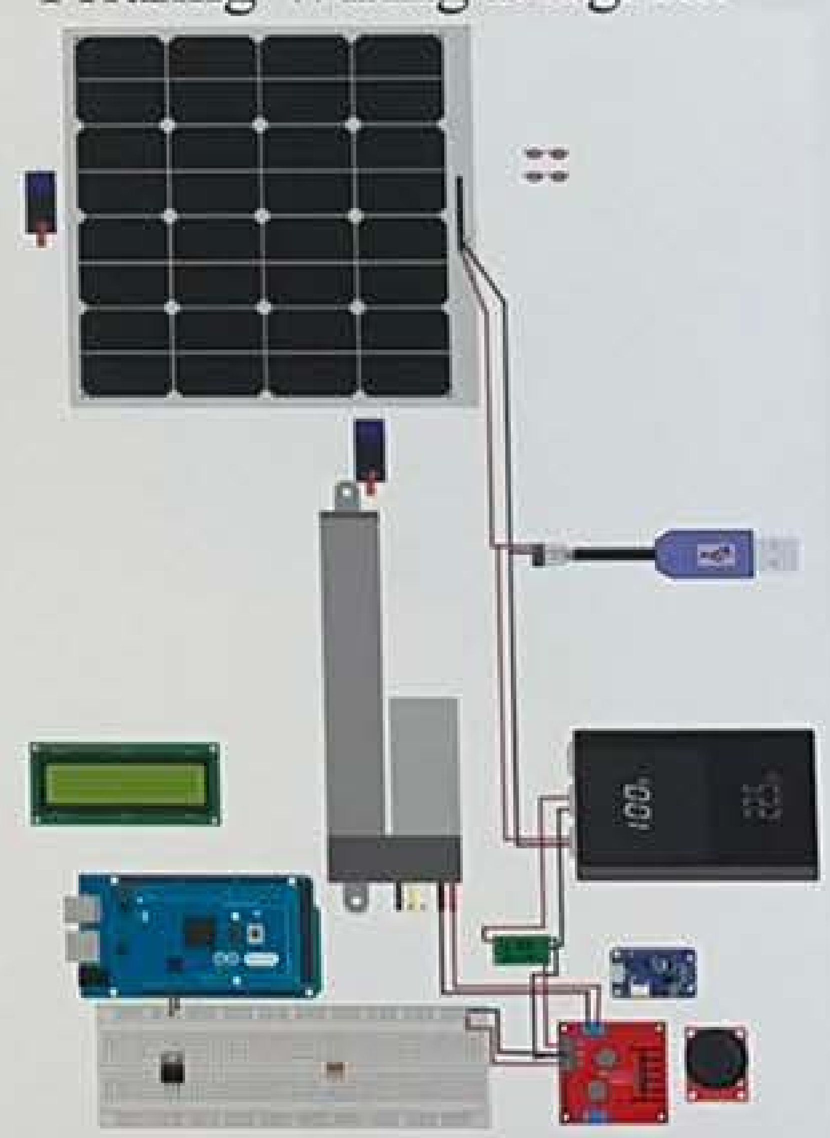
System Block Diagram



Software Flowchart



Fritzing Wiring Diagram



Level 2 Requirements

L2.1 The system will utilize a 12V 2400mAh rechargeable Lithium battery to allow power to flow into the L298N Motor Driver. The motor driver has the ability to output 12V towards the linear actuator & 5V to apply towards the Arduino Mega board. The solar panel outputs 12V, however, would step down the output voltage to a safe 5V into our load (a step down converter would be utilized for this feature). For verification, all systems should be powered on and functioning as expected. This is derived from the project's deliverables (Power Supply/Safety Systems).

L2.2 The system will use an Arduino microcontroller to process sensor data and control motor movements. Ensures the automated tracking movements of the system. For verification, programming tests and debugging will be assessed to confirm the functionality.

L2.3 The LCD screen shall display the voltage absorbed in real time coming from the panel towards the battery bank. This component utilizes a voltage sensor and the microcontroller(Arduino Mega) to display our real voltage time on the LCD screen. During operation, we can test by using a DMM to measure voltage coming from the panel and compare it to the LCD voltage value. For verification, the values should be very close to each other with very little percentage error. This is derived from the project's mission profiles.

L2.4 The Joystick shall be implemented to manually control the tracking system's vertical movement(up & down) at one constant speed. This allows the users to control vertical movement of the linear actuator in the tracking system in case of bad weather conditions. For verification, we will use a joystick to move the system manually instead of automatically being controlled by the microprocessor (Arduino Mega). The placement of this joystick will be onto the corner of the wooden base for easy access for users. This is derived from the project's mission profiles.

L2.5 The system shall incorporate the linear dual actuator, as this solar tracking system requires height adjustment in addition to vertical and horizontal panel movement. For verification, the system should move up and down in response to a light source during operation.

L2.6 The solar panel's power bank(5000mAh, 5V, 2A rated) should be able to use stored energy obtained from the solar panel for charging or power use. To verify, we can power an LED, as our intended load, using only the power bank's obtained/stored power. This is derived under the project's deliverables.

Constraints

- The weight of the solar panel and servos may be limited to 5 lbs and the base frame to 5 lbs as well. Thus, the total of the whole system would be 10 lbs total. This would make the tracking system portable.
- The system will be constrained to a maximum height of 2 feet when the actuator is at full extension. This would make the system more portable.
- The tracking system shall be constrained within the cost of $250
- The project shall be constrained to a completion date no later than May 16, 2025. This includes the project presentation and any related documents that are completed.
- The solar panel shall be constrained to a maximum angularity movement of 120 degrees total with the horizontal axis as its starting position. This means the solar panel would tilt 0 to 60 degrees one side and 0 to -60 degrees to the other side. This totals a full range of 120 degrees.
- The programming code will be written in C++ in Arduino IDE following the C++ standard (ISO/IEC 14882:1998)
- Follow the American Wire Gauge (AWG) standard when defining the diameter of power-carrying wires.

Finalized Prototype