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# AUTOMATED SOLAR PANEL POSITIONING AND MAINTENANCE SYSTEM

**Mrs. Hema C[1], Ullas Gowda J[2], Yashwanth M[3], Yashwanth Patel D R[4], Pramath G[5]**

Professor, Department of ECE, East West Institute of Technology, Bengaluru, India[1]

Student, Department of ECE, East West Institute of Technology, Bengaluru, India[2]

Student, Department of ECE, East West Institute of Technology, Bengaluru, India[3]

Student, Department of ECE, East West Institute of Technology, Bengaluru, India[4]

Student, Department of ECE, East West Institute of Technology, Bengaluru, India[5]

**Abstract:** This project presents a control system to enhance the performance of a solar panel. A dual-axis mechanism is developed that tilts and turns the solar panel to face the highest intensity of light. The system is designed in LabVIEW and implemented on the Arduino Microcontroller. The physical model of the system was built using servo motors, LDRs and wiper. The pilot plant was tested by applying a source of light from various directions and monitoring its response. The solar panel is able to face towards the highest intensity of light with high level of precision. A LabVIEW simulation interface is developed, allowing for comprehensive monitoring and visualization of key performance metrics, including solar panel voltage, current output, and battery status.

**Keywords:** Arduino Microcontroller, LDRs, Servo motor, Solar panel, Wiper, LabVIEW.

## I. INTRODUCTION

The increasing global demand for renewable energy has necessitated the development of innovative solutions to harness solar power efficiently. Solar energy, being abundant and sustainable, offers immense potential as a clean energy source. However, maximizing the energy output of solar panels requires effective tracking of sunlight and maintaining the cleanliness of the panels to prevent energy loss caused by dust, dirt, or debris. This project focuses on the design and implementation of an advanced solar panel system with integrated smart features to address these challenges. The system employs a 9V solar panel mounted on a 3D-printed dual-axis support structure, which enables precise tracking of the sun throughout the day. Using Light Dependent Resistors (LDRs) for light intensity detection and servo motors for movement, the system ensures optimal sunlight exposure, thereby enhancing energy capture. To further improve efficiency, a motorized wiper system is incorporated to automatically clean the solar panel, minimizing energy loss due to dirt accumulation.

Additionally, the system includes a Li-ion battery storage setup with a quick-charge (QC) circuit, allowing for efficient energy storage and utilization. The Battery Management System (BMS) monitors and optimizes energy flow to ensure reliable operation. Real-time monitoring and control are provided through a LabVIEW-based interface, enabling users to track key metrics such as voltage, current output, battery status, and panel cleanliness. The interface also facilitates manual or automated operation of the wiper system, ensuring ease of maintenance. By integrating hardware and software innovations, this project aims to provide a cost-effective and efficient solution for solar energy optimization, contributing to sustainable energy practices and supporting mobile device charging applications.

Moreover, the project incorporates a LabVIEW simulation interface to visualize real-time data such as solar panel voltage, current output, and battery status, facilitating comprehensive performance monitoring. This aspect of the project not only enhances user interaction but also aids in the analysis and optimization of the tracking system's performance. Through this project, main aim to demonstrate the effectiveness of advanced solar tracking technologies in improving the efficiency of solar energy systems. By combining electronics, programming, and renewable energy principles, the dual-axis solar tracking system serves as both a viable solution for enhancing solar energy capture and a valuable educational tool for understanding modern energy technologies.

### 1.1 MOTIVATION

By optimizing the orientation of a dual-axis solar tracking system can increase energy capture by 25-35% compared to single axis solar tracking systems. LabVIEW, with its graphical programming capabilities, offers an efficient platform

 

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for real-time monitoring and measuring performance metrics. This project provides enhanced energy efficiency and real time monitoring capabilities. This project is motivated by the desire to enhance solar energy efficiency through an integrated system that not only tracks the sun but also maintains panel cleanliness. By implementing dual-axis solar tracking, automated cleaning, and energy storage with quick-charge capabilities, this system aims to maximize solar panel output, reduce maintenance costs, and provide a reliable energy source for charging mobile devices in remote locations.

### 1.2 OBJECTIVE

The objective of this work is to interface LDR sensor to Arduino microcontroller to detect and measure light intensity and to provide precise control of angular position, speed, and acceleration in a system using servomotor. Next to develop a LabVIEW interface that monitors real-time performance metrics such as solar panel voltage, current output, and battery status, enhancing user interaction and enabling data analysis. By achieving these objective project focuses on delivering a practical, sustainable solution for off-grid energy generation while promoting autonomy and efficiency through solar tracking, automated maintenance, and real-time energy monitoring. The scope extends from hardware development to software integration, ensuring a complete and functional system.

## II. METHODOLOGY

The primary task for this solar panel installation project involves a systematic approach combining hardware and software design, development, and integration. This section outlines the detailed steps for each component of the system, covering the design, implementation, and integration phases.

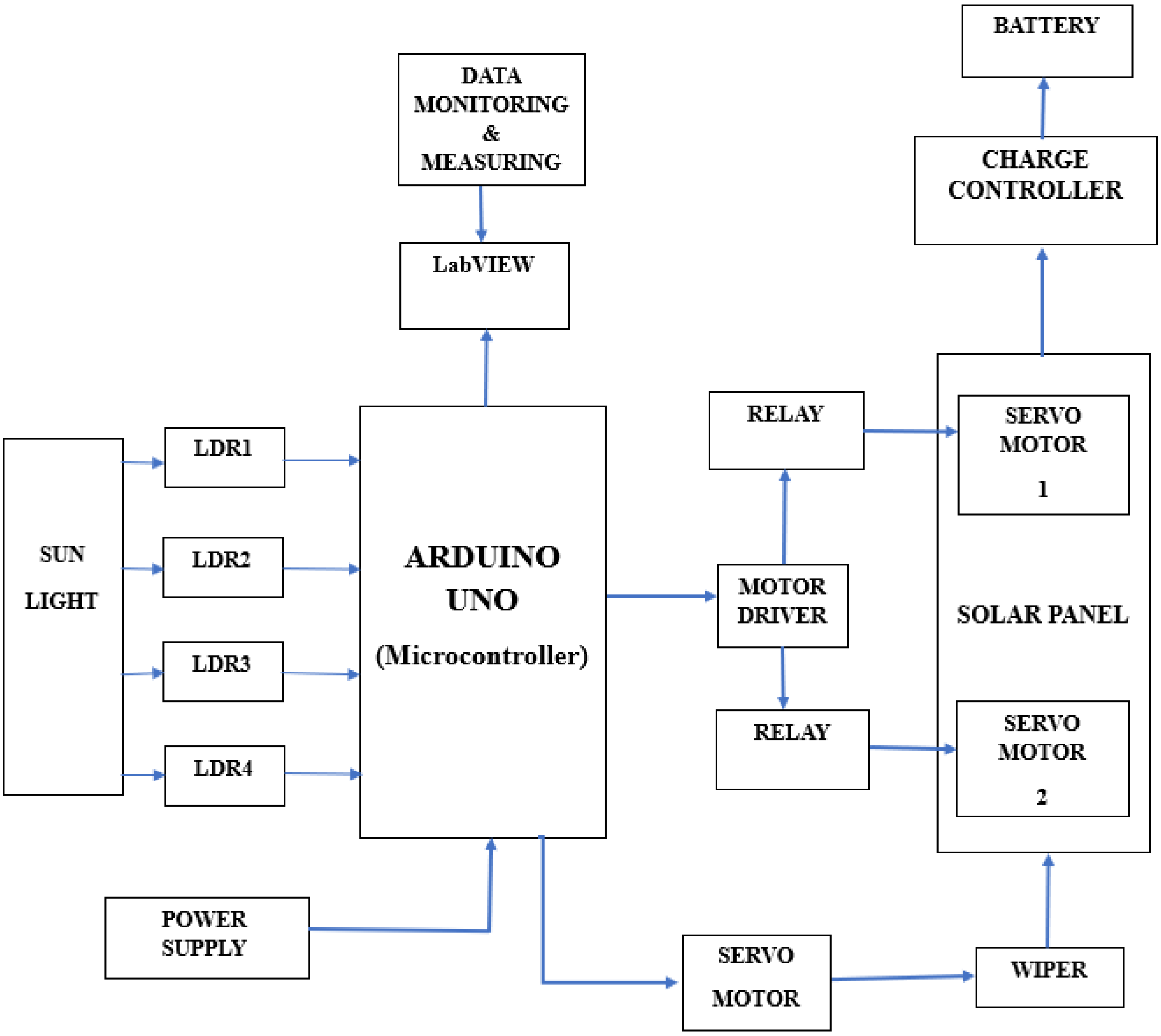


Fig: 1 Block diagram of AUTOMATED SOLAR PANEL POSITIONING AND MAINTENANCE SYSTEM

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**Solar Panel**: A solar panel is a device that converts sunlight into electricity by using photovoltaic (PV) cells. PV cells are made of materials that produce excited electrons when exposed to light. Type: Monocrystalline or Polycrystalline, Power Output: 9V, Efficiency: 15-20% conversion efficiency, Size: Sufficient to meet energy needs for storage and mobile device charging (approximately 6-8 watts), Application: Primary energy source for the system.

**Dual-Axis Movement Support Structure**: 3D-printed plastic (e.g., PLA or ABS) or lightweight aluminium for durability, Design: CAD-designed structure that allows both horizontal and vertical rotation (dual-axis tracking), Components: Bearings and support brackets to hold the solar panel securely and facilitate smooth movement.

**Light Dependent Resistors (LDRs)**: 4LDRs (two for each axis of movement), Function: Detect light intensity from multiple angles to determine the optimal orientation for the solar panel, Specification: -Resistance: 10kΩ (typical value). -Sensitivity: Sufficient to detect small changes in light intensity. -Placement: Around the panel at four strategic positions (e.g., top-left, top-right, bottom-left, bottom-right).

**Servo Motors**: Specification: -Motor Type: DC servo motors (or stepper motors for higher precision). -Torque: Sufficient to move the panel (typically around 1-2 kg/cm for small panels). Rotation Range: ±90° (for both vertical and horizontal axes). -Control Interface: PWM (Pulse Width Modulation) for smooth movement. -Quantity: 2 motors, one for each axis (azimuth and elevation).

**Quick-Charge Circuit**: Specification: -Voltage: 5V output for mobile device charging. -Current: 2A or higher (for fast charging). -Component: A charge controller like the TP4056 or a more advanced circuit to enable fast charging of mobile devices from the stored solar energy.

**Motorized Wiper System:** Specification: -Motor Type: Small DC motors or servo motors for panel cleaning. -Movement: Horizontal movement across the panel surface. -Power supply: Powered by the stored solar energy or directly from the battery. -Design: The wiper system should be able to cover the entire solar panel area, with brushes or rubber blades designed to clear dust, dirt, and debris.

## III. IMPLIMENTATION

### 3.1 Hardware Setup:

**3.1.1 Selection of Solar Panel**: A 9Vsolarpanel was selected based on the project's energy requirements. The 9V panel offers a suitable balance of power output and size for this application, allowing for sufficient energy collection while being compatible with the overall design of the system.

**3.1.2 Design of Dual-Axis Tracking Support**: A 3D model was created using CAD software (e.g., AutoCAD or Fusion 360) for the dual-axis movement support structure. This support was designed to allow the solar panel to rotate both horizontally (azimuth) and vertically (elevation), ensuring the panel stays aligned with the sun throughout the day.

**3.1.3 Integration of LDR Sensors for Light Detection**: Four Light Dependent Resistors (LDRs) were strategically placed around the solar panel to detect the intensity of light from different angles. This sensor array allows the system to determine the optimal position of the panel for maximum sunlight exposure. The LDRs are connected to an Arduino microcontroller, which processes their inputs and calculates the necessary adjustments for the servo motors controlling the panel's movement.

**3.1.4 Servo Motors for Dual-Axis Tracking:** Two servo motors were chosen to enable the dual-axis movement of the solar panel. One motor control the horizontal movement, while the other controls the vertical (elevation) movement. The servo motors are connected to the Arduino microcontroller, which uses a feedback loop based on the LDR inputs to move the solar panel accordingly.

**3.1.5 Motorized Wiper System**: A motorized wiper system was designed to keep the solar panel clean from dust and debris. The wiper mechanism is mounted on top of the panel and moves horizontally across its surface. The wiper is operated either manually or automatically, based on a timer or sensor input, via an Arduino-based control system.

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### 4.1 Software Development:

**4.1.1 Arduino Firmware Development**: The core control logic for the solar tracking system was developed in Arduino C++. The firmware is designed to: Read inputs from the LDR sensors, Calculate the optimal panel orientation based on light intensity, Control the servo motors to adjust the panel's position. Operate the motorized wiper system periodically or based on a user input.

**4.1.2 Real-Time Monitoring Interface**: The system includes a real-time monitoring interface developed using LabVIEW. This interface allows users to: View live data on the solar panel's performance, including voltage, current output, and battery status. Monitor the cleanliness of the solar panel via sensors (optional) or through user feedback. Control the wiper system manually or set it to operate automatically based on predefined parameters.

## VI. RESULT

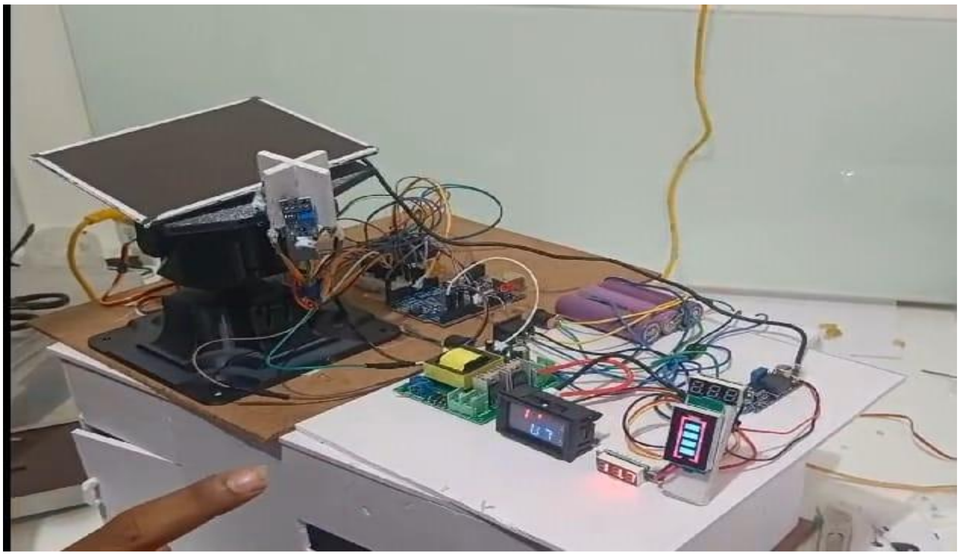

Fig 2: Prototype of model

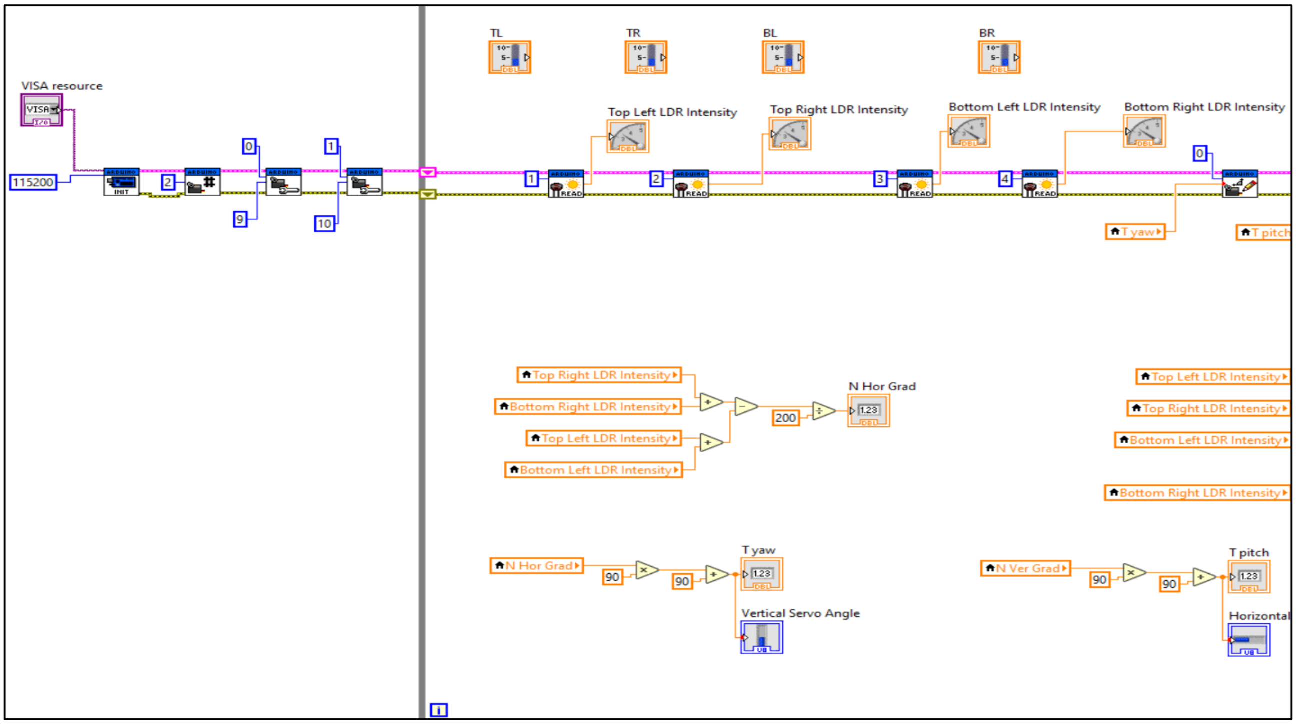


Fig 3: LabVIEW Interface Algorithm

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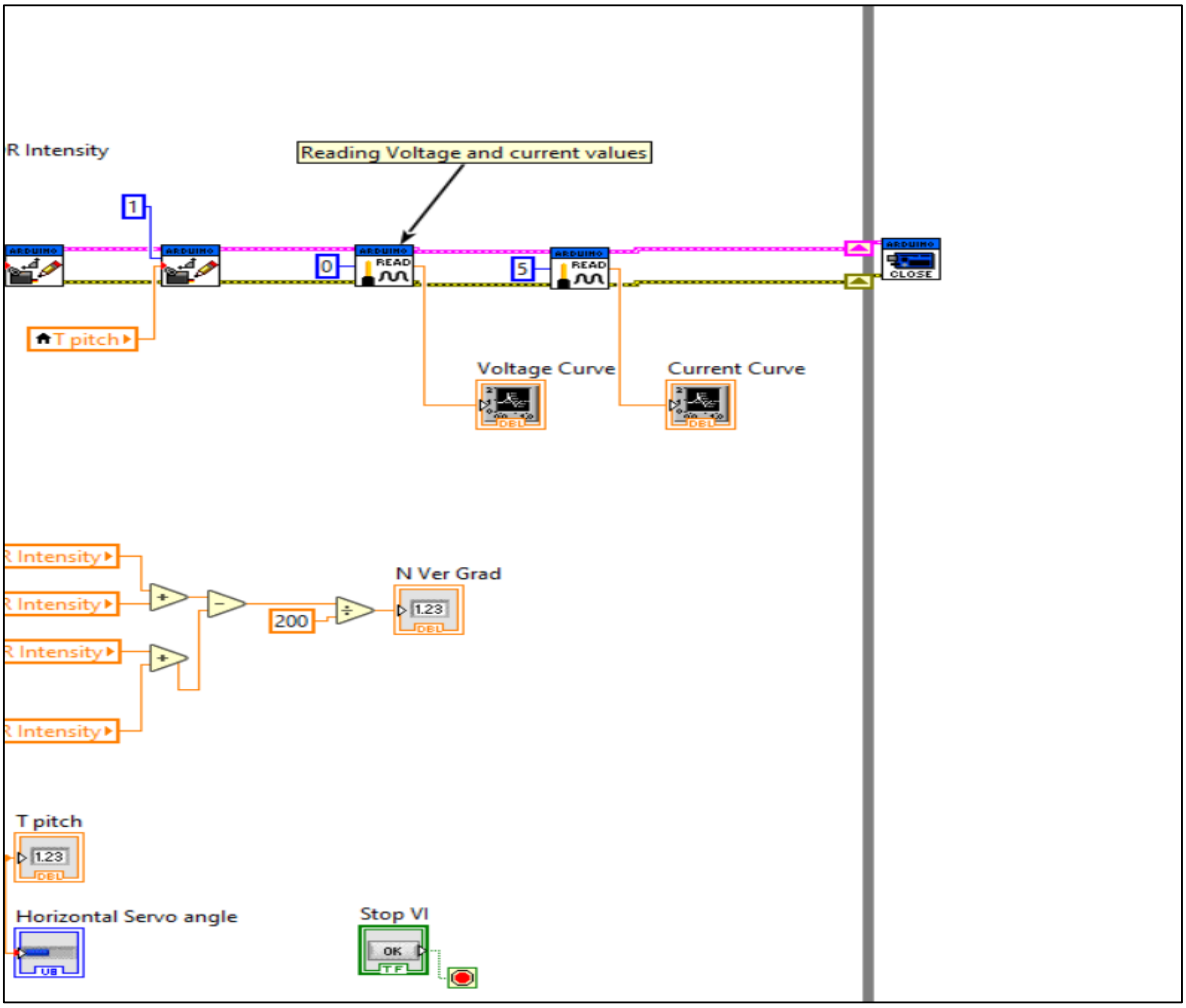


Fig 4: LabVIEW Interface

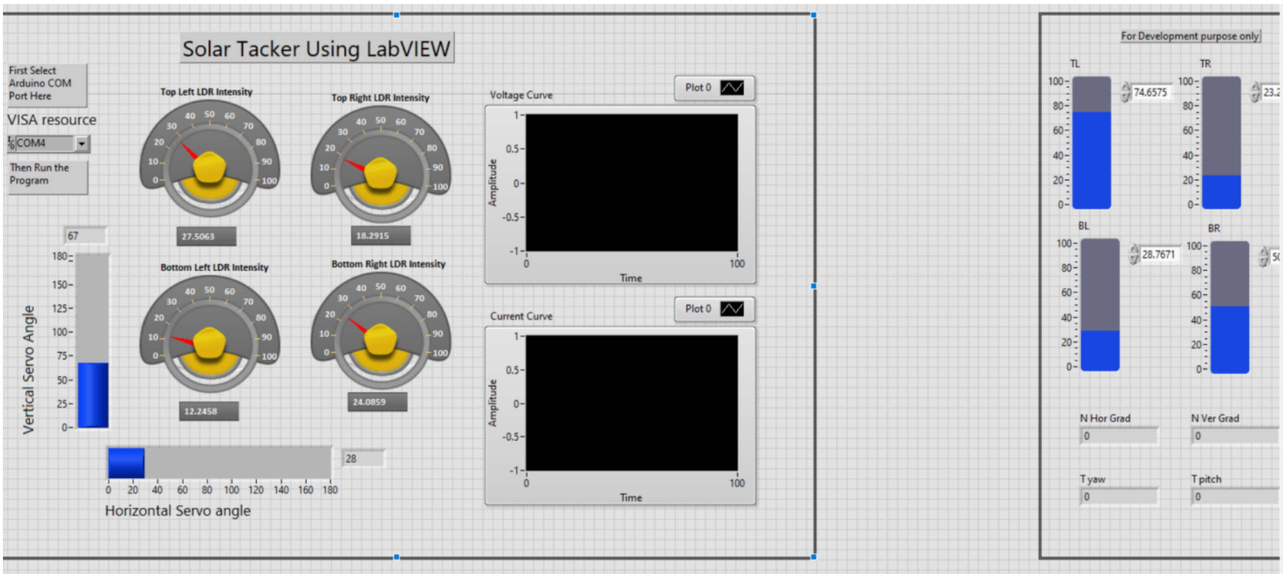


Fig 5: LabVIEW Monitoring and Measuring

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## V. CONCLUSION

The final control scheme chosen for the dual axis solar panel system was a proportional controller with filtered inputs. This allowed the system to move quickly to the position of most intensive light without any overshoot or steady state error. The overshoot was rectified by adjusting the gain on the proportional controller and the zero steady state error was due to the servo's integral action. This combination of filtering and proportional controller performed very well and was able to track and face light as desired. The system itself, however, is limited by the need to attach a USB chord to the laptop and the Arduino. Therefore, when the solar panel rotates enough, the chord becomes tangled up in the system. This can be rectified by using an external battery pack and attaching it to the wooden frame. Another limitation would be the use of this system in actual sunlight. Since sunlight is not nearly as concentrated as a flashlight, the area between the four LDRs is not nearly large enough. Therefore, all of the LDRs would be hit evenly and the solar panel would not move. For future improvements, the system could be implemented on a larger solar panel, thus spreading the LDRs out even further. Larger the distance between the LDRs, more accurate will be the tracking of large light sources such as the sun.

## FUTURE SCOPE

In future this Tilting mechanism with collector can be implemented on large solar plants and also can be operated automatically.

- We can make the work very easy with the help of electric tilting mechanism. We are working on the same to implementing automation for same mechanism with electric or mechanical actuators or components.
- This mechanism can be implemented on the Solar Cookers, Ovens, and Driers and on thermal solar heater.
- The main advantage of such systems is maximum amount of power generated due to the biaxial motion.
- The total cost of tilting and tracking mechanism is less than the 25% that of cost of panel required to generate the same power.
- It produces 2.5 times more power than regular position of the solar panel.

## REFERENCES

[1]. Bhavesh Pandey, Anita Agrawal "Automatic Sun Tracking System Using PSoC" International Journal of Innovative Research in Science, Engineering and Technology Vol. 1, Issue 1, November 2023.

[2]. S. Abdallah and S. Nijmeh, "Two-Axis Sun Tracking with PLC Control," in Energy Conversion and Management, vol. 45, 2023.1931- 1939.

[3]. Rani Molak, Vaishali Pawar, Omkar More, Atul Aradhye "Design Modification of Hybrid Solar Cooker" in International Journal of Advances in Management, Technology & Engineering Sciences Vol. III, issue 1(I), October 2023

[4]. Jeya Ganesh N, Maniprakash.S, Chandrasekaran L., Srinivasan, S.M. "Design and Development of a Sun Tracking mechanism using the Direct SMA actuation" International Journal of Advances in Management, Technology & Engineering Sciences Vol. II, issue 1(II), August 2023

[5]. Kamala J, Alex Joseph "Solar Tracking for Maximum and Economic Energy Harvesting" Kamala J et.al / International Journal of Engineering and Technology (IJET)2022

[6]. Kothari, D. P., and Nagrath, I. J. Modern Power System Analysis (3rd ed.). New Delhi: Tata McGraw-Hill Pub. Co., 2021

[7]. Solar Technologies | Photovoltaic Solar Panels | Thin Film Solar Panels | Solar Thermal. (n.d.) Solar Panels, Photovoltaic Systems, Solar Solutions for Home, Business & Utility-Scale — SunPower. Retrieved August 29, 2021, http://us.sunpowercorp.com/solarresources/howsolar-works/solar-technologies/.

[8]. Hossein Mousazadeh a, Alireza Keyhani a, *, Arzhang Javadi b, Hossein Mobli a, Karen Abrinia c, Ahmad Sharifi b," A review of principle and sun-tracking methods for maximizing solar systems output", a Department of Agricultural Machinery Engineering, University of Tehran, Iran 2021

[9]. N.A. Kelly, T.L. Gibson, Improved photovoltaic energy output for cloudy conditions with a solar tracking system, Solar Energy 83 (11) (2020) 2092-2102.

[10]. G.C. Bakos, Design and construction of a two-axis Sun tracking system for parabolic trough collector (PTC) efficiency improvement, Renewable Energy 31 (2006) 2411-2421. [11] J.C. Costa, Solar thermal facilities, Instituto Nacional de Engenharia, Tecnologia e Inovação – INETI (National Institute of Engineering, Technology and Innovation), 2020. (in Portuguese)