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# Design and Implementation of Arduino Based Dual Axis Solar Tracking Device

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**ABSTRACT:** This research paper presents the design and implementation of a dual-axis solar tracker using Arduino microcontroller. The solar tracker aims to maximize the efficiency of solar panels by continuously orienting them towards the sun throughout the day. The system utilizes two axes of rotation, allowing the solar panels to track the sun's position in both the horizontal and vertical directions. The Arduino microcontroller provides the necessary control and feedback mechanisms to accurately track the sun's movement. The paper includes details about the hardware components, circuit design, and programming logic employed in the solar tracker system. Experimental results and performance analysis are also provided to evaluate the effectiveness and efficiency of the proposed design.

**KEYWORDS:** Solar tracker, dual axis, Arduino UNO and Servo motors.

## I. INTRODUCTION

Solar energy has gained immense significance as a renewable resource due to its abundant availability, environmental friendliness, and long-term sustainability. The Sun, a vast fusion reactor, continuously radiates an enormous amount of energy, offering a virtually limitless source of power. Solar energy systems harness this energy through technologies like photovoltaics and solar thermal, enabling the generation of electricity and heat without depleting finite resources or emitting harmful greenhouse gases. As a result, solar energy plays a pivotal role in mitigating climate change, reducing reliance on fossil fuels, and fostering a greener and more sustainable future.

Efficient energy capture from solar panels is crucial for optimizing the performance and economic viability of solar energy systems. The ability to capture and convert a greater amount of solar radiation directly translates into higher electricity generation and improved system efficiency. Maximizing energy capture not only enhances the overall productivity of solar installations but also contributes to energy cost savings, increased energy independence, and reduced carbon footprint. By ensuring that solar panels receive maximum sunlight exposure throughout the day, energy capture optimization facilitates the transition to clean and sustainable energy sources while supporting energy security and environmental conservation.

Solar tracking systems have emerged as a valuable technology to enhance energy capture from solar panels. Unlike fixed-angle installations, solar trackers enable panels to dynamically follow the Sun's path throughout the day, optimizing their orientation for maximum sunlight exposure. The benefits of solar tracking systems include enhanced energy conversion efficiency, increased overall system performance, improved return on investment, and a more cost-

effective utilization of solar resources. These systems play a vital role in maximizing the potential of solar energy and advancing the adoption of renewable energy solutions.

Dual-axis solar tracking systems represent an advanced technology for maximizing energy capture from solar panels. Unlike single-axis systems that track the sun's movement on a single plane, dual-axis systems can adjust both the tilt and azimuth angles of the panels. This allows them to precisely follow the Sun's path throughout the day, capturing the maximum amount of sunlight available. Dual-axis tracking systems offer several benefits, including significantly higher energy production compared to fixed-angle or single-axis systems. Additionally, these systems optimize energy capture under varying weather conditions, improve system reliability, and enable greater flexibility in solar panel placement. By maximizing energy capture, dual-axis solar tracking systems contribute to the efficiency and economic viability of solar energy installations, making them an important technology in the renewable energy landscape.

## II. METHODOLOGY

### A. CIRCUIT DESIGN

The main light sensors utilized in this project consist of LDRs (Light Dependent Resistors). Two servo motors are mounted on the structure that holds the solar panel. The microcontroller is programmed with an Arduino code to control the system. Here's how the project operates the LDRs serve as light intensity detectors, measuring the amount of sunlight falling on them. Totally there are four LDRs: two positioned at the top and two at the bottom, as well as two on the left and two on the right. For east-west tracking, the analog values from the two LDRs at the top and the two LDRs at the bottom are compared. If the top pair of LDRs receives more light, the vertical servo motor moves in the corresponding direction. Conversely, if the bottom pair of LDRs detects more light, the servo motor moves in the opposite direction. To enable angular deflection of the solar panel, a comparison is made between the analog values obtained from the two LDRs on the left side and the two LDRs on the right side. If the left pair of LDRs receives more light compared to the right pair, the horizontal servo motor moves accordingly. Similarly, if the right pair of LDRs detects more light, the servo motor moves in the opposite direction.

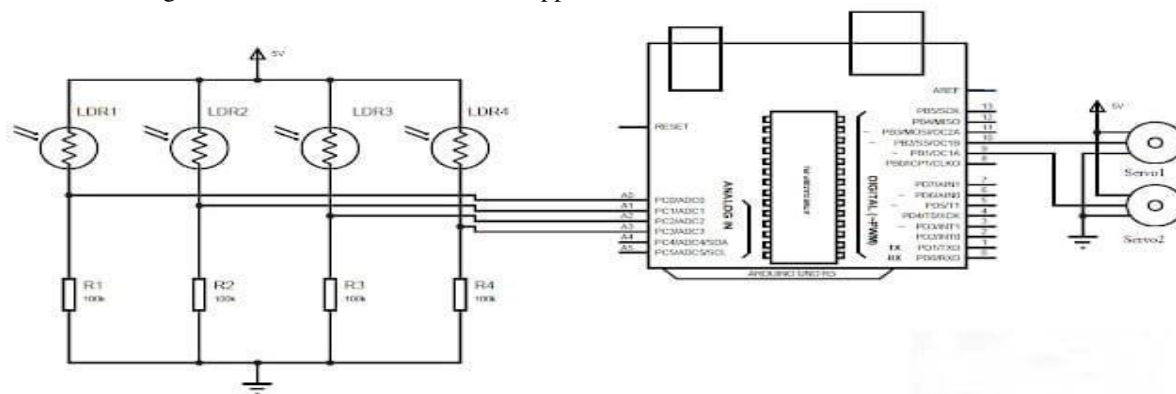


Figure 2.1: Circuit design for dual axis solar tracker

### B. HARWARE DESIGN

The hardware design was a challenging part because we had to mount two servos, one working in east-west direction and other was to work in north-south direction. This was the mechanism we had to impart to our design so we used AutoCAD to design and print our 3 models. We made sure that all the dimensions are correct because we had to mount two sg90 servos to our system. Our 3d model consisted of four main parts they are base, head, arm, and a support.

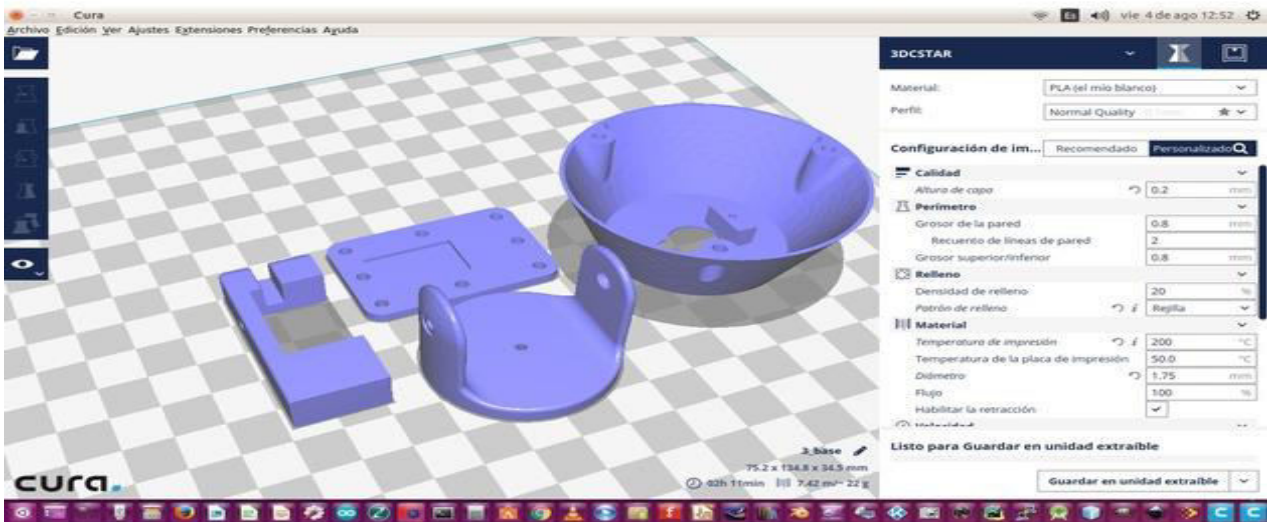


Figure 2.2: Design of 3d models printed

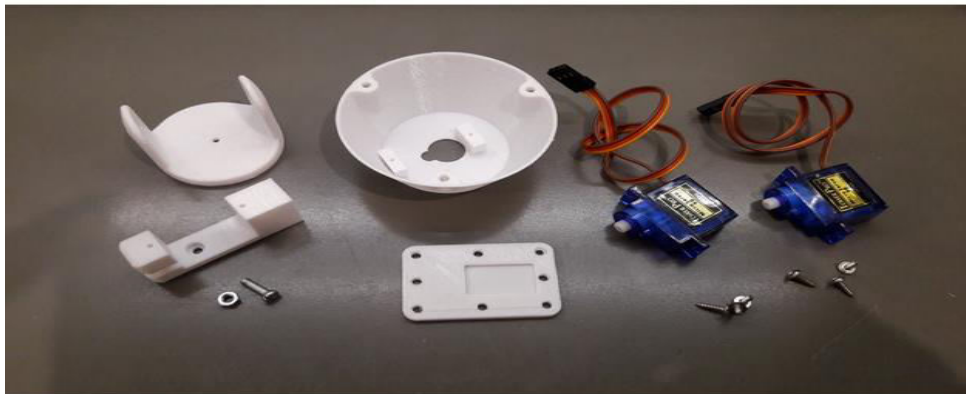


Figure 2.3: 3d models after printing and two sg90 servos

The above figure 2.3 is the output of 3d printed models. This model should be assembled as per our design and solar panels can be mounted on it.

C. BLOCK DIAGRAM

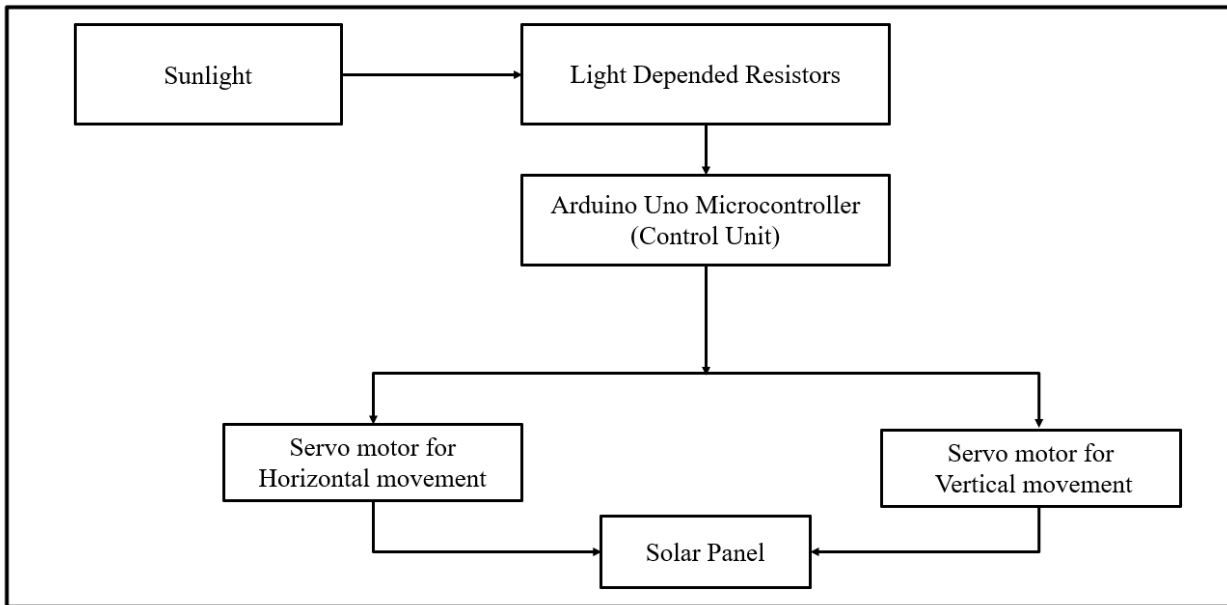


Figure 2.4: Block diagram of the system

In fig 2 the block diagram of Solar Tracking System comprises of a solar panel, Arduino microcontroller, LDR sensors and servo motors. For this system to operate there must be emission of light through the sun. The LDRs serve as the sensors to detect the intensity of light entering the solar panels. The LDR then sends proceedings of the information to the Arduino microcontroller. The servo motor circuit is then constructed. The servo has 3 pins of which the positive side is connected to the +5v of the Arduino microcontroller, negative of the servo is connected to the ground and data point of the servo is connected to the digital point on the microcontroller on which the solar panel will be mounted.

III. IMPLEMENTATION

The Dual Axis Solar Tracking System is a setup that includes several components, such as a solar panel, Arduino microcontroller, LDR sensors, and servo motors. The system relies on the emission of light from the sun, which serves as the primary source of energy. The LDR sensors, or Light Dependent Resistors, act as light intensity detectors. These sensors detect the amount of light entering the solar panel.

The LDR sensors are connected to the Arduino microcontroller, which acts as the central processing unit for the system. The LDR sensors relay the information about the intensity of light they detect to the Arduino microcontroller. The microcontroller then processes this information to determine the direction in which the solar panel should be positioned.

To enable the movement of the solar panel, servo motors are utilized. A precise angular motion is controlled by a servo motor. It consists of three pins: positive, negative, and data. In the servo motor circuit, the positive side of the servo motor is connected to the +5V pin of the Arduino microcontroller. The negative side is connected to the ground (GND) pin. Finally, the data pin of the servo motor is connected to a digital pin on the microcontroller. By connecting the servo motor to the digital pin, the microcontroller can send specific signals to control the servo's movement. The servo motor is attached to the solar panel, allowing the microcontroller to adjust its position based on the sunlight intensity detected by the LDR sensors.

This tracking system operates by continuously monitoring the light intensity detected by the LDR sensors and adjusting the solar panel's position accordingly. By dynamically aligning the solar panel with the sun's position throughout the day, the system maximizes the solar panel's exposure to sunlight, optimizing energy generation.

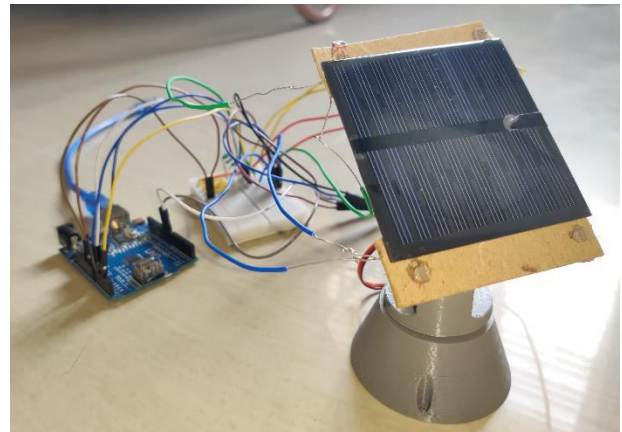
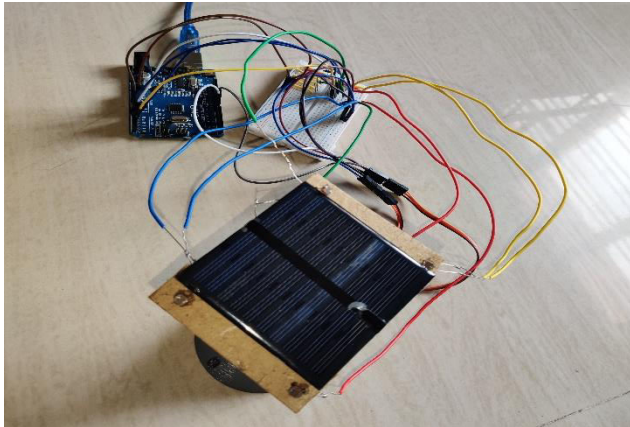


Figure 3.1: Proposed Model of the system

#### IV. RESULTS

Experimental results were observed by placing the designed system in open air. Table 1, 2 & 3 shows the output power for PV systems (stationary module, Single axis tracking and dual axis tracking). The output power data is collected during 8:00 A.M. to 6:00 P.M. In Table IV comparison of output power is shown in the tabular form for three cases.

Table 1: Stationary module

Time	Voltage(V)	Current(A)	Power(Watt)
0800	9.16	0.1	0.92
1000	21.12	1.44	30.41
1200	22.00	1.51	33.22
1300	22.05	1.64	28.87
1500	20.56	1.30	26.72
1600	20.45	1.26	25.76
1800	11.45	0.61	6.98

Table 2: Single Axis Rotation

Time	Voltage(V)	Current(A)	Power(Watt)
0800	4.57	0.001	0.0045
1000	14.7	1.32	19.404
1200	14.27	1.35	19.271
1300	16.47	1.71	27.1
1500	15.4	1.1	17.9
1600	15.9	1.19	18.8
1800	5.3	0.17	0.8



Table 3: Dual Axis Tracking

Time	Voltage(V)	Current(A)	Power(Watt)
0800	7.49	0.01	0.074
1000	15.04	1	15.04
1200	17.14	1.12	19.196
1300	17.70	1.14	20.178
1500	17.77	0.94	16.7038
1600	15.02	0.52	7.8104
1800	6.3	0.1	0.63

## V. FUTURE SCOPE

There are several potential avenues for future research and system enhancements in the field of dual-axis solar tracking systems, including: Development of advanced algorithms: Further refinement of the sun tracking algorithm can improve the accuracy and efficiency of the system, considering factors such as geographic location and real-time weather data.

Integration of smart technologies: Incorporating smart technologies, such as machine learning or artificial intelligence, can enhance the system's adaptability and performance, enabling it to make more intelligent decisions based on changing environmental conditions.

Scalability: Future research can focus on optimizing the design of the system to accommodate larger-scale solar installations and explore ways to improve its scalability and cost-effectiveness.

Integration with energy storage systems: Combining the dual-axis solar tracking system with energy storage technologies, such as batteries or grid-connected storage, can enable better utilization of the generated energy and enhance overall system reliability.

By pursuing these future research directions and system enhancements, the proposed dual-axis solar tracking system can continue to evolve and contribute to the advancement of solar energy technologies, fostering a more efficient and sustainable energy landscape.

## VI. CONCLUSION

In summary, this research paper presented the design and implementation of an Arduino-based dual-axis solar tracking system. The key findings of the study include: The Arduino UNO platform serves as an effective control unit for the solar tracking system, providing a flexible and accessible solution for integration with sensors and actuators. The proposed dual axis solar tracking system utilizes light sensors to detect sunlight intensity and actuators to dynamically adjust the tilt and azimuth angles of the solar panels.

The proposed dual-axis solar tracking system holds significant importance in the realm of solar energy. It offers several advantages, including:

Enhanced energy capture: By dynamically adjusting the tilt and azimuth angles of the solar panels, the system maximizes sunlight exposure, leading to increased energy production.

Improved energy conversion efficiency: The accurate tracking of the sun's position ensures that the panels operate at their optimal angle, improving the overall energy conversion efficiency of the system.

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