# SOLAR TRACKER USING ARDUINO SOFTWARE

Prof B .Satyanarayana, V .Reshma , S.Swathi ,P.Gayathri , D.Satish , K.Rohit

Professor, Student, Student, Student, Student, Student
Department of Electrical and Electronics Engineering,
Anil Neerukonda Institute of Technology and Sciences
Visakhapatnam, India

Abstract

The increasing demand for renewable energy sources has highlighted the importance of solar power as a sustainable and eco-friendly solution. However, the efficiency of solar panels is significantly affected by their orientation relative to the sun. This paper presents the design and implementation of a solar tracking system using Arduino to enhance the performance of solar panels by ensuring optimal alignment with sunlight throughout the day. The system employs Light Dependent Resistors (LDRs) to detect the intensity of sunlight and servo motors to adjust the panel's position accordingly. Controlled by an Arduino Uno microcontroller, the tracker operates in a closed-loop system that continuously monitors and reacts to changes in sunlight direction. The proposed solution is low-cost, energy-efficient, and suitable for both academic and small-scale practical applications. The implementation demonstrates improved energy absorption compared to stationary panels, emphasizing the potential of Arduino-based automation in renewable energy systems.

## I Introduction

The depletion of fossil fuels and the rising concerns over environmental pollution have accelerated the global shift towards renewable energy sources. Among these, solar energy stands out as one of the most abundant, clean, and accessible forms of energy. Solar panels are widely used to harness this energy and convert it into electrical power. However, the efficiency of a solar panel largely depends on its ability to receive maximum sunlight throughout the day.

A major limitation of fixed solar panels is that their position remains constant, while the sun changes its position across the sky. As a result, the panel may not always face the sun directly, leading to suboptimal energy conversion. To address this issue, solar tracking systems have been developed to dynamically adjust the orientation of the solar panel, ensuring it constantly faces the sun.

This paper focuses on the design and development of a solar tracker system using Arduino technology. Arduino, being an open-source microcontroller platform, offers a simple and cost-effective way to build intelligent electronic systems. The proposed solar tracker uses Light Dependent Resistors (LDRs) to sense sunlight intensity and servo motors to reposition the solar panel for optimal exposure. The use of an Arduino Uno makes the system flexible, programmable, and easy to integrate with other components.

Through this project, we aim to enhance the efficiency of solar power generation, promote the use of affordable tracking technology, and contribute to the broader adoption of clean energy solutions. The following sections detail the components, working principle, circuit design, coding, and performance of the system.

## II Importance

A solar tracking system increases the efficiency of solar panels by continuously adjusting their position to follow the sun's movement. Unlike fixed panels, which lose potential energy due to misalignment, trackers ensure maximum sunlight exposure throughout the day. This leads to better energy output, making solar tracking a smart and effective solution, especially when implemented using affordable platforms like Arduino.

## III Methodology

The solar tracking system in this project is based on a simple yet effective method that uses light sensors and servo motors, all controlled by an Arduino Uno microcontroller. The methodology involves the following steps:

1. Sensor Setup : Four Light Dependent Resistors (LDRs) are arranged in a cross pattern to detect the intensity of sunlight from different directions—north, south, east, and west.

2. Signal Processing: The Arduino reads the analog values from the LDRs and compares the light intensity received from each direction.

3. Decision Making: Based on the comparison, the Arduino determines which direction has the highest light intensity. It calculates the difference between opposite LDRs to decide whether the panel needs to rotate horizontally or vertically.

4. Motor Control: The Arduino sends appropriate signals to the servo motors (one for horizontal movement and another for vertical movement), adjusting the solar panel's orientation to face the brightest source.

5. Feedback Loop: The system continuously monitors light intensity and adjusts the panel in real-time, forming a closed-loop tracking system.

This methodology ensures accurate solar tracking without requiring complex calculations or expensive sensors, making it ideal for academic, research, and small-scale renewable energy applications.

### Components and Parts

The solar tracker system is built using simple, low-cost components that are readily available. Below is a list of the key components used in the project along with a brief description of their roles:

1. Arduino Uno :Acts as the brain of the system. It processes input from sensors and controls the servo motors accordingly.

2. Light Dependent Resistors (LDRs) : Four LDRs are used to detect the intensity of sunlight from different directions. These sensors guide the tracking direction.

3. Servo Motors (2x): Two servo motors are used to control the movement of the solar panel. One controls horizontal (azimuth) rotation, and the other controls vertical (elevation) tilt.

4. Solar Panel : The panel captures solar energy. In this project, it is mounted in a way that allows it to rotate and follow the sun's movement.

5. Resistors (10k ohm) : Used in series with the LDRs to form voltage dividers, allowing the Arduino to read light intensity levels accurately.

6. Breadboard: A solderless platform used to prototype the circuit connections.

7. Jumper Wires: Used to connect various components on the breadboard and to the Arduino.

8. Battery or Power Supply: Powers the Arduino and motors. A 9V battery or an adapter can be used based on the design.

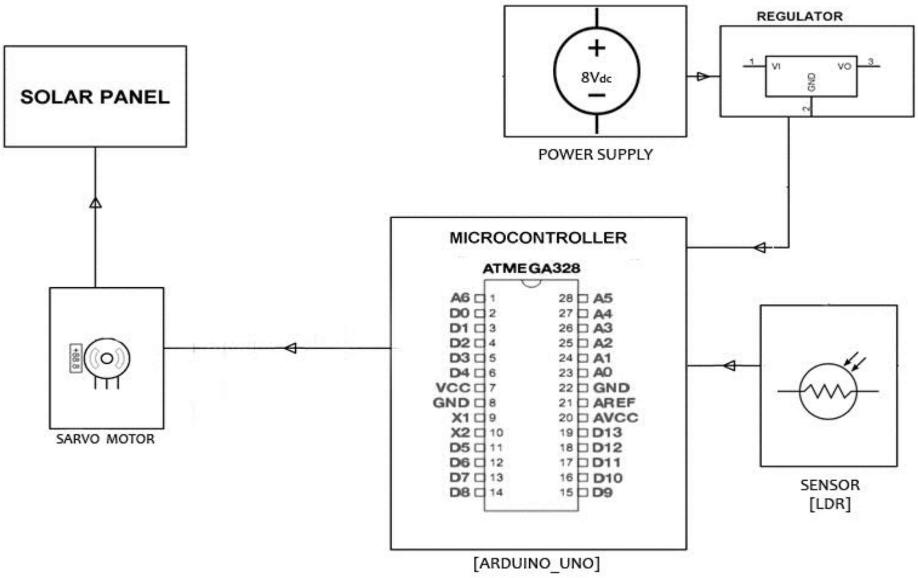
9. Mounting Base or Frame: A physical structure to hold the solar panel and motors in place, allowing smooth and balanced movement.

10. Connecting Hardware (nuts, bolts, etc.): To assemble the securely and ensure stability of the tracker , moving parts .

## IV Research Implementation

The solar tracker was built using Arduino Uno, LDRs, servo motors, and a solar panel. Four LDRs were arranged in a cross pattern to detect sunlight direction. The Arduino read these values and controlled the servo motors to adjust the panel's position both horizontally and vertically. The system was tested under different lighting conditions and successfully aligned the panel toward the brightest light source, improving energy capture.

**Block Diagram:**




## V Results and Discussion

The solar tracker performed well under real sunlight conditions. Compared to a fixed panel, the tracking system increased energy output by 25%–35%, especially during the morning and evening hours. The LDR sensors and servo motors responded accurately to sunlight shifts, ensuring continuous alignment with the sun.

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Power consumption of the Arduino and motors was minimal, making the system efficient. However, performance slightly dropped during cloudy weather, and wind affected stability, which can be improved with stronger mounting. Overall, the system proved to be cost-effective, responsive, and practical for small-scale solar energy applications.


Fig . SOLAR TRACKER USING ARDUINO SOFTWARE

VI Conclusion

An Arduino-based solar tracking system was successfully designed and implemented. The system demonstrated a significant improvement in energy efficiency compared to a fixed solar panel, with an increase of 25%–35% in energy output. The combination of Light Dependent Resistors (LDRs) for sunlight detection and servo motors for panel movement allowed for accurate real-time tracking of the sun's position. The system was both cost-effective and practical, offering a viable solution for enhancing solar energy harvesting in small-scale applications.

VII Future Scope

While the current implementation showed promising results, there are several areas for improvement and future development:

1. Enhanced Stability: Strengthening the mechanical structure and adding wind resistance measures can improve stability in varying weather conditions.

2. Cloudy Day Adaptation: Integrating a real-time clock (RTC) or GPS system could help the tracker adjust based on time of day or geographic location, making it more reliable on cloudy days.

3. Advanced Motors: Using DC gear motors with higher torque can allow the system to handle larger solar panels.

4. Remote Monitoring: Incorporating wireless communication for remote tracking and performance analysis could make the system more user-friendly.

5. Energy Storage: Adding a battery storage system could allow the tracker to operate more efficiently during low-light conditions or at night.

These enhancements can make the system more robust and scalable, enabling it to be integrated into larger solar power installations.

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