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**SMART SOLAR TRACKER USING ARDUINO**

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Mrs. P.R.Gavhane<sup>\*1</sup>, Prasad Jambhale<sup>2</sup>, Digvijay Tapkir<sup>3</sup>, Soham Roham<sup>4</sup>, Vaibhav Shidore<sup>5</sup>

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<sup>1</sup>Lecturer, Department Of Mechatronics , P.Dr.V.V.P. Institute of Technology & Engineering (Polytechnic), Loni Bk., Maharashtra, India.

<sup>2,3,4,5</sup>Department Of Mechatronics, P.Dr.V.V.P. Institute of Technology & Engineering (Polytechnic), Loni Bk., Maharashtra, India.

Article Received: 14 January 2026, Article Revised: 02 February 2026, Published on: 22 February 2026

**\*Corresponding Author: Mrs. P.R.Gavhane**

Lecturer, Department Of Mechatronics , P.Dr.V.V.P. Institute of Technology & Engineering (Polytechnic), Loni Bk., Maharashtra, India.

DOI: <https://doi-doi.org/101555/ijarp.6375>

**ABSTRACT**

Solar energy is one of the most promising renewable energy sources available today. However, the efficiency of conventional fixed solar panels is limited because they cannot continuously face the sun as its position changes throughout the day. To overcome this limitation, this paper presents the design and development of an automatic solar tracking system using an Arduino microcontroller. The system uses Light Dependent Resistors (LDRs) to detect the direction of maximum sunlight intensity. Based on the sensor input, the Arduino controls servo motors that rotate the solar panel to maintain optimal alignment with the sun. This improves the overall energy conversion efficiency of the solar panel. The system operates automatically without human intervention and is built using low-cost and easily available components. The proposed system demonstrates a significant improvement in energy capture compared to fixed solar panels and provides an effective solution for improving solar energy utilization.

**LINTRODUCTION**

The growing demand for energy and the environmental impact of fossil fuels have increased the importance of renewable energy sources. Solar energy is clean, sustainable, and widely available. Photovoltaic panels convert sunlight directly into electrical energy. However, the amount of energy generated depends greatly on the angle at which sunlight strikes the panel.

In conventional systems, solar panels are installed in a fixed position. As the sun moves from east to west during the day, the panel does not remain aligned with the sun, which results in reduced energy generation. To improve efficiency, solar tracking systems are used. These systems adjust the orientation of the solar panel so that it continuously faces the sun.

This project focuses on designing a smart solar tracking system using an Arduino microcontroller. The system uses light sensors to detect sunlight direction and servo motors to adjust the panel position automatically. This improves energy output and demonstrates the use of embedded systems in renewable energy applications.

## II. CONSTRUCTION

The solar tracking system consists of mechanical, electrical, and control components that work together to achieve automatic panel movement.

### Main Components

- Arduino Microcontroller
- The Arduino acts as the control unit. It reads input from sensors and sends signals to the motors to adjust panel orientation.
- Light Dependent Resistors (LDRs)
- LDRs are used to detect sunlight intensity. Their resistance changes depending on the amount of light falling on them.
- Servo Motors
- Servo motors rotate the solar panel in horizontal and vertical directions based on control signals from the Arduino.
- Solar Panel
- The solar panel converts sunlight into electrical energy.
- Power Supply System
- The power system includes a battery, voltage regulator, and charge controller to ensure stable power supply.
- Supporting Components
- Resistors
- Connecting wires
- Breadboard or PCB



### III. WORKING PRINCIPLE

The working principle of the smart solar tracking system is based on detecting variations in sunlight intensity and automatically adjusting the position of the solar panel to achieve maximum exposure to solar radiation. The system uses Light Dependent Resistors (LDRs) as light sensors and an Arduino microcontroller as the control unit to perform real-time tracking. Four LDR sensors are positioned at different sides of the solar panel, typically arranged in a cross configuration (left, right, top, and bottom). These sensors act as light intensity detectors. The resistance of each LDR changes depending on the amount of light falling on it. When exposed to higher light intensity, the resistance decreases, resulting in a change in voltage across the sensor circuit. These voltage variations represent the direction and strength of sunlight.

Each LDR is connected to the analog input pins of the Arduino microcontroller through a voltage divider circuit. The Arduino continuously reads the analog voltage values from all four sensors using its built-in Analog-to-Digital Converter (ADC). These digital values are then processed by the microcontroller.

The Arduino compares the values obtained from opposite pairs of sensors, such as left versus right and top versus bottom. If there is a difference in light intensity between any pair of sensors, it indicates that the solar panel is not perfectly aligned with the sun. The Arduino then determines the direction in which the solar panel needs to rotate in order to face the sun directly.

Based on this comparison, the Arduino generates Pulse Width Modulation (PWM) signals and sends them to the servo motors. The servo motors act as actuators and rotate the solar panel in the appropriate direction. One servo motor controls horizontal movement (azimuth angle),

while the other controls vertical movement (elevation angle). This dual-axis movement allows the panel to follow the sun's path from east to west and also adjust its tilt angle according to the sun's height in the sky.

The system continuously repeats this process throughout the day. As the sun moves across the sky, the LDR sensors detect changes in light intensity, and the Arduino makes necessary adjustments to maintain optimal alignment. This ensures that the solar panel receives maximum sunlight at all times, thereby increasing energy generation efficiency.

To prevent unnecessary movement and improve system stability, a threshold value is programmed into the Arduino. The servo motors only move when the difference in light intensity between sensors exceeds this threshold. This reduces jitter and power consumption.

During periods of low light intensity, such as cloudy weather, sunset, or nighttime, the difference between sensor readings becomes minimal. In such cases, the Arduino does not send movement signals to the motors, and the solar panel remains in its current position. This prevents unnecessary operation and conserves energy.

Overall, the system operates as a closed-loop feedback control system, where the LDR sensors provide input, the Arduino processes the data, and the servo motors adjust the panel position accordingly. This automatic tracking mechanism ensures continuous alignment with the sun and significantly improves the overall efficiency of the solar energy system compared to fixed solar panels.

#### **IV. ADVANTAGES**

- The proposed system offers several advantages:
- Improves solar panel efficiency
- Increases energy generation
- Fully automatic operation
- Low-cost implementation
- Easy to design and maintain

#### **V. APPLICATIONS**

- The smart solar tracking system can be used in various areas such as:
- Residential solar power systems
- Agricultural irrigation systems
- Rural electrification
- Educational and research projects

- Remote monitoring systems

## VI. LIMITATIONS

- Mechanical parts may wear over time
- Requires proper installation and alignment
- Initial setup cost is higher than fixed systems
- Performance may be affected during cloudy weather
- Requires periodic maintenance

## VII. FUTURE SCOPE

Integration with IoT for remote monitoring

- Use of GPS-based tracking
- Addition of weather protection mechanisms
- Use of stepper motors for higher precision
- Development of large-scale industrial tracking systems
- These improvements can make the system more reliable and suitable for commercial use.

## VIII. CONCLUSION

The smart solar tracking system developed using Arduino provides an effective method for improving solar panel efficiency. By automatically adjusting the panel position based on sunlight intensity, the system ensures maximum energy capture throughout the day. The use of simple sensors and microcontroller makes the system affordable and easy to implement. This project demonstrates how automation and embedded systems can be used to enhance renewable energy systems. The proposed system can contribute to improving solar power utilization and promoting sustainable energy solutions.

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