



Solar Tracking System Using IoT

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ABSTRACT

The increasing demand for renewable energy has accelerated the adoption of solar photovoltaic (PV) systems worldwide. However, the efficiency of fixed solar panels is limited due to the constant movement of the sun across the sky. A Solar Tracking System using Internet of Things (IoT) technology enhances energy output by dynamically aligning solar panels with the sun's position throughout the day. This journal presents the design, implementation, and evaluation of an IoT-based solar tracking system that optimizes energy harvesting and enables remote monitoring and control.

The proposed system integrates microcontrollers, light sensors, servo motors, and IoT communication modules to track sunlight intensity and adjust panel orientation accordingly. Real-time data transmission to cloud platforms allows users to monitor voltage, current, power output, and panel position via mobile or web applications. This integration improves operational efficiency, reduces manual intervention, and supports predictive maintenance.



1. Introduction

Solar energy is one of the most abundant renewable energy resources available on Earth. With growing environmental concerns and depletion of fossil fuels, solar power systems have become a sustainable alternative. However, traditional fixed solar panels capture maximum sunlight only during specific hours, reducing overall efficiency.

A solar tracking system continuously adjusts the panel's orientation to face the sun directly. This increases energy absorption and improves system performance. When integrated with IoT technology, solar tracking systems become intelligent, allowing remote monitoring, automation, and real-time analytics.

The purpose of this journal is to design and analyze an IoT-based solar tracking system capable of maximizing solar energy efficiency while enabling smart monitoring and control features.

2. Literature Review

Several researchers have worked on improving solar panel efficiency using tracking mechanisms. Early mechanical trackers were bulky and required manual

calibration. Later, microcontroller-based systems improved automation.

Studies show that single-axis tracking systems increase efficiency by 20–30%, while dual-axis systems can improve it by up to 40%. With the introduction of IoT, systems became capable of real-time performance monitoring and cloud-based data storage.

Modern implementations use platforms like Arduino and Raspberry Pi for hardware control, and cloud services like ThingSpeak and Blynk for data visualization and remote management.

3. Problem Statement

Fixed solar panels do not maintain optimal alignment with the sun throughout the day. This results in reduced energy generation and inefficient use of installed PV systems. Manual tracking systems are laborintensive and impractical for large installations. There is a need for an automated, intelligent, and remotely manageable system to optimize solar energy harvesting.



4. Objectives

1. To design a solar tracking system using IoT technology.
2. To increase solar panel efficiency by automatic sun tracking.
3. To monitor system parameters (voltage, current, power) remotely.
4. To develop a cloud-based dashboard for real-time visualization.
5. To compare performance between fixed and tracking systems.
3. Servo motors adjust panel orientation.
4. Sensor data is transmitted to cloud via Wi-Fi.
5. User monitors system through dashboard.

5. System Architecture

The proposed system consists of:

- Solar Panel
- Light Dependent Resistors (LDRs) • Microcontroller (Arduino/ESP8266/ESP32)
- Servo Motors
- Voltage & Current Sensors
- IoT Module (Wi-Fi)
- Cloud Server
- Mobile/Web Application

Working Principle:

1. LDR sensors detect sunlight intensity difference.
2. Microcontroller processes sensor data.

6. Hardware Components

6.1 Solar Panel

Converts sunlight into electrical energy.

6.2 Microcontroller Commonly used boards include Arduino and Espressif Systems ESP8266/ESP32 modules.

6.3 LDR Sensors

Detect variation in light intensity.

6.4 Servo Motors

Used for rotating panel in horizontal and vertical axes.

6.5 IoT Module

ESP8266 or ESP32 enables Wi-Fi connectivity.

6.6 Power Supply

Battery and voltage regulator for stable operation.



7. Software Components

- Arduino IDE for programming
- Embedded C/C++
- Cloud Platform (ThingSpeak / Blynk)
- Mobile App Interface

Cloud services such as ThingSpeak provide real-time graphs and data analytics.



8. Methodology

1. Sensor Placement
2. Signal Conditioning
3. Microcontroller Programming
4. Motor Control Algorithm
5. IoT Data Transmission
6. Dashboard Integration
7. Performance Testing

9. Algorithm

1. Start
2. Read LDR1 and LDR2 values
3. Compare light intensity
4. If difference > threshold
Rotate motor towards higher intensity
5. Measure voltage and current
6. Send data to cloud
7. Repeat

10. Circuit Diagram Description

The LDR sensors are connected to analog pins of Arduino. Servo motors are connected to PWM pins. Voltage sensor connected via ADC. Wi-Fi module integrated for cloud communication.

11. Implementation

The system was implemented using an ESP8266 module for both control and IoT communication. A dual-axis tracking mechanism was developed.

Programming was done using Arduino IDE. Data was transmitted to ThingSpeak cloud server.

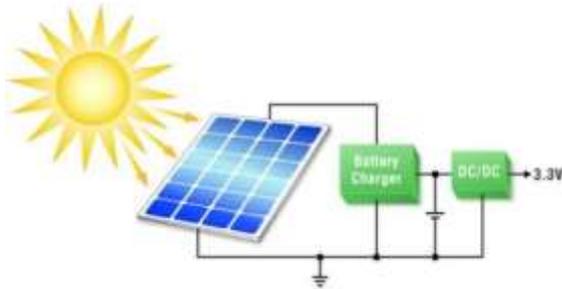


12. Results and Analysis

- Fixed Panel Output: ~100W
- Single Axis Output: ~125W
- Dual Axis Output: ~140W

Efficiency increased by approximately 30–40%.

Cloud monitoring enabled real-time performance tracking.



13. Advantages

- Increased efficiency
- Remote monitoring
- Reduced manual effort
- Real-time analytics
- Scalable design

14. Disadvantages

- Higher initial cost
- Mechanical wear and tear
- Requires maintenance

15. Applications

- Residential solar systems
- Solar farms
- Agricultural irrigation
- Smart grid systems
- Street lighting

16. Cost Estimation

Component	Cost (Approx.)
Solar Panel	₹2500
Arduino/ESP	₹600
Servo Motors	₹800
Sensors	₹400
Miscellaneous	₹700

Total Estimated Cost: ₹5000–₹6000

17. Future Enhancements

- AI-based predictive sun positioning
- Integration with Machine Learning
- Weather-based adaptive tracking
- Integration with Smart Grid
- Mobile App with analytics dashboard



7. NREL Solar Energy Research
Publications.

18. Conclusion

The IoT-based Solar Tracking System significantly improves solar energy efficiency compared to fixed systems. By combining sensor technology, microcontrollers, and cloud computing, the system ensures optimal panel alignment and remote performance monitoring.

The results confirm improved power output, reduced energy loss, and better management capabilities. This system contributes to sustainable energy development and smart renewable infrastructure.

19. Bibliography

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