iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: IV Month of publication: April 2025

DOI: https://doi.org/10.22214/ijraset.2025.69295

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

Solar Tracking System

Govind Tungariya[1], Nokia Ipili[2], Atharva Khamkar[3], Sagar Madri[4], Ashwini Khade[5]
VES Polytechnic

Abstract: solar energy has become an increasingly important and popular renewable energy source. By using a solar tracking system, we can produce an abundance of energy and improve the efficiency of solar panels. The solar panel's efficiency lies in its perpendicular proportionality with the sun's rays. Although cheaper options are also available, its installation charge is high. A prototype solar panel is discussed in this paper based on the sun's rays as the reason for its design and construction. Arduino is used as the main control circuit. As a result of the programming of this device, the LDR sensor, when it detects sun rays, will provide direction to the Servo Motor in order to move the solar panel. Consequently, the solar panel is positioned so that it can receive the maximum amount of sunlight.

***Index Terms*: Solar Energy, Photovoltaic, Renewable Energy, Green Technology**

I. INTRODUCTION

A solar tracking system is an advanced technology designed to optimize the performance of solar energy systems by automatically adjusting the position of solar panels to follow the sun's movement across the sky. Unlike traditional fixed solar panels, which are positioned at a fixed angle, solar trackers enable the panels to maintain the optimal angle of incidence throughout the day, maximizing sunlight exposure and increasing energy production. Solar tracking systems are classified into single-axis and dual-axis types, with the latter offering more precise tracking for higher efficiency. These systems are particularly valuable in regions with high solar potential, where they can increase energy output by up to 45%. By enhancing the efficiency of solar power generation, solar tracking systems contribute to reducing reliance on nonrenewable energy sources, lowering carbon emissions, and promoting sustainability. Their growing adoption in both residential and commercial applications highlights their importance in the global transition to renewable energy.

II. LITERATURE REVIEW

[1] Singh, A., Kumar, R., & Sharma, V. (2024). "Solar Tracking Systems: Advancements, Challenges, and Future Directions – A Review." Energy Reports, 12, 4658–4671.[2] Ahmed, M. M., Hasan, M. K., & Shafiq, M. (2019). "Development of Automatic Solar Tracking System for Small Solar Energy System." International Journal of Scientific and Research Publications (IJSRP), 9(4), 150–154.[3] Mohanapriya, V., Manimegalai, V., Praveenkumar, V., & Sakthivel, P. (2021). "Implementation of Dual Axis Solar Tracking System." IOP Conference Series: Materials Science and Engineering, 1084(1), 012073.[4] Nguyen, B. T., & Ho, H.-X. T. (2020). "Design, Implementation, and Performance Analysis of a Dual Axis Solar Tracking System." Advances in Science, Technology and Engineering Systems Journal (ASTESJ), 5(3), 43–47.[5] Das, P. K., Habib, M. A., & Mynuddin, M. (2018). "Microcontroller Based Automatic Solar Tracking System with Mirror Booster." International Journal of Engineering and Technology, 7(3.34), 158–162.

III. DEFINITION AND COMPONENTS

A. Solar Panel

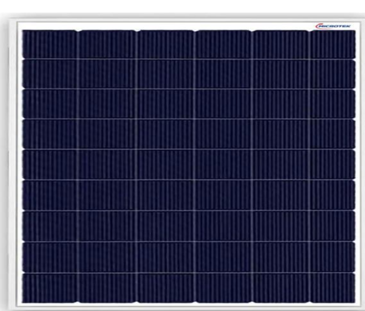


Figure 1: Solar Panel

The solar panel is the central component responsible for converting sunlight into electrical energy through the photovoltaic (PV) effect. It is typically made up of multiple solar cells, usually composed of semiconductor materials like silicon, which generate direct current (DC) electricity when exposed to sunlight. The efficiency of a solar panel is directly influenced by its orientation relative to the sun. Unlike fixed panels that receive varying sunlight throughout the day, solar panels in a tracking system are mounted on a movable structure that adjusts their position to follow the sun's path. This dynamic positioning, controlled by sensors and a microcontroller, ensures that the panel maintains an optimal angle with the sun, thereby significantly increasing its energy output. As a result, the integration of a tracking system with solar panels enhances overall performance and maximizes power generation, especially in applications where consistent energy supply is crucial.

B. Servo Motor

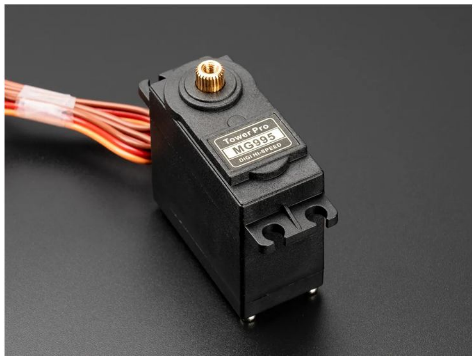


Figure 2: Servo Motor

The servo motor plays a crucial role in precisely controlling the movement of the solar panel to align it with the sun's position. A servo motor is a type of motor that allows for accurate control of angular position, speed, and direction, making it ideal for applications requiring fine adjustments. In solar trackers, the servo motor receives signals from the microcontroller based on input from sensors like Light Dependent Resistors (LDRs), which detect the sun's position. The motor then adjusts the orientation of the solar panel accordingly, either along a single axis or both axes in the case of dual-axis systems. Servo motors are preferred for their compact size, energy efficiency, and ability to hold their position firmly when not moving. This contributes to the overall reliability and effectiveness of the tracking mechanism, ensuring that the solar panel remains optimally aligned throughout the day to maximize energy capture.

C. LDR Sensor

Figure 3: LDR Sensor

The Light Dependent Resistor (LDR) sensor plays a vital role in detecting the sun's position. An LDR is a type of resistor whose resistance decreases as the intensity of light falling on it increases, making it highly sensitive to light changes. In solar tracking, multiple LDRs are typically placed around the solar panel to detect sunlight from different directions. These sensors provide real-time data to the system's microcontroller, which processes the input to determine the optimal position of the panel. By comparing the light intensity values from different sensors, the system can accurately identify the direction of the sun and adjust the panel's position accordingly to maintain the best angle for sunlight absorption. LDR sensors are preferred for their simplicity, low cost, and efficiency in continuously guiding the tracking mechanism, ensuring maximum energy production throughout the day.

D. Arduino

Figure 4: Arduino

The Arduino microcontroller serves as the central processing unit that controls the movement of the solar panel based on input from light sensors and other components. Arduino is a popular open-source platform that is widely used in DIY projects and automation systems due to its ease of use, flexibility, and cost-effectiveness. In the context of solar tracking, the Arduino is programmed to read data from Light Dependent Resistors (LDRs) or other sensors that detect the position of the sun. Based on this input, the Arduino sends control signals to the motors (such as servo or stepper motors) to adjust the panel's orientation. The simplicity of programming in Arduino, coupled with a wide range of available sensors and motor control libraries, makes it an ideal choice for small-scale or experimental solar tracking systems

E. Block Diagram

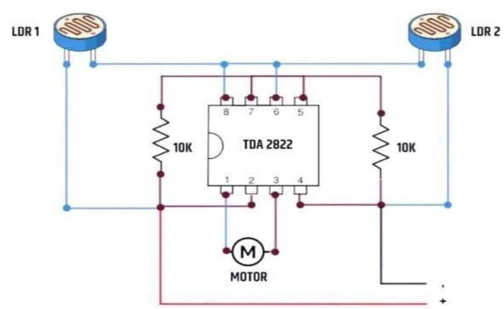


Figure 5: Block Diagram of Solar Tracking System

The block diagram illustrates a basic solar tracking system that uses two Light Dependent Resistors (LDR1 and LDR2) to sense the intensity of sunlight from different directions. These LDRs are part of voltage divider circuits, each paired with a 10kΩ resistor, which generate variable voltage signals depending on the amount of light falling on them. These voltage signals are fed into the TDA2822 integrated circuit, which acts as a comparator. The TDA2822 compares the voltage levels from the two LDRs and controls the direction of a DC motor accordingly. When the sunlight is more intense on one side, the motor rotates the solar panel toward that direction to maximize sunlight absorption. This automatic adjustment ensures that the solar panel always faces the direction of maximum sunlight, enhancing the efficiency of solar energy collection. The system is simple, cost-effective, and ideal for small-scale solar tracking applications.

IV. BENEFITS OF SOLAR TRACKING SYSTEM

1) Increased energy efficiency: Solar tracking systems can increase energy production by up to 30% or more compared to fixed solar panels by ensuring the panels are always aligned with the sun.
2) Maximized sunlight exposure: The tracking mechanism ensures that the solar panels are perpendicular to the sun's rays throughout the day, capturing more sunlight, especially during early morning and late afternoon hours.
3) Improved performance in low-light conditions: Solar tracking systems maintain optimal angles even when sunlight is less direct, ensuring more consistent energy generation.
4) Reduced land usage: By increasing energy capture in a smaller area, tracking systems can reduce the land area needed for solar installations, making them ideal for limited space.

V. TRACKING SYSTEM

A. *Definition and Characteristics*

A tracking system is a setup that helps adjust the position of something to follow a specific movement or path. In a **Solar** Tracking System, it automatically moves solar panels to follow the sun as it moves across the sky. This helps keep the panels at the best angle to get the most sunlight, which makes the system more efficient and generates more energy. The tracking system uses sensors, like Light Dependent Resistors (LDRs), to detect the sun's position and motors to move the panels. The panels can move in one direction (east to west) or in two directions (both up and down, as well as side to side) to capture sunlight all day long.

- Automatic Adjustment: Solar tracking systems automatically adjust the position of the solar panels to follow the sun's movement throughout the day.
- Single-Axis or Dual-Axis Tracking: They can operate on a single-axis (moving east to west) or dual-axis (moving both up/down and side to side) to optimize solar panel orientation.
- Increased Energy Efficiency: By keeping the solar panels aligned with the sun, they can capture more sunlight, increasing energy output by up to 30% compared to fixed systems.
- Real-Time Sun Positioning: The system continuously monitors the sun's position using sensors, ensuring optimal panel alignment for maximum energy capture.

B. *Benefits of Theft Detection*

- Automation: Once installed, the tracking system operates automatically with minimal human intervention, making it convenient and user-friendly.
- Adaptability to various locations: Solar tracking systems can be designed for different geographical regions and sunlight conditions, optimizing energy generation in each area.
- Increased longevity of solar panels: By reducing the stress and wear on solar panels from poor alignment, tracking systems can help extend the life of the panels.
- Environmental benefits: By maximizing the capture of solar energy, tracking systems reduce reliance on fossil fuels and contribute to a reduction in greenhouse gas emissions.

VI. CASE STUDIES

1) *IUSA – NEXTracker, California NEXTracker installed single-axis tracking systems in a 200 MW solar farm. Key Features:*

- Increased energy output by approximately 25% compared to fixed systems
- Automatically adjusted panel angles to follow the sun throughout the day

2) *India – Kamuthi Solar Power Plant Part of one of the world's largest solar farms, this project used both fixed and tracking systems. Key Features:*

- Improved energy generation during early morning and late afternoon
- Helped meet peak electricity demand more effectively

3) *Germany – University Campus Tracker A dual-axis solar tracker was installed for energy and educational use. Key Features:*

- Achieved 35% more power output compared to fixed panels
- Served as a practical learning tool for engineering students

4) *Australia – Agricultural Solar Tracking Solar trackers were used to power irrigation systems on rural farms. Key Features:*

- Provided steady power supply throughout the day
- Boosted efficiency and supported off-grid farming operations

VII. QUANTITATIVE DATA

1) Single-axis trackers improve efficiency by 15% to 25% compared to fixed systems.
2) Dual-axis trackers increase output by 25% to 35%, especially in high sunlight areas.
3) Tracking systems reduce required land by up to 20%, as fewer panels are needed for the same output.

VIII. TECHNICAL SPECIFICATIONS

A. Tracking Type

- Single-axis tracking: Moves panels along one axis (usually east to west).
- Dual-axis tracking: Moves panels on both horizontal and vertical axes for maximum sun exposure.

B. Control System

- Microcontroller-based (e.g., Arduino, PIC, or STM32)
- Uses input from sensors (like LDRs) to determine sun position
- Can include manual override or automated programming

C. Sensors Used

- Light Dependent Resistors (LDRs) for detecting sunlight intensity
- Optional: temperature sensors, IR sensors, or GPS for advanced tracking

D. Actuators/Motors

- Servo motors or DC gear motors for small systems
- Stepper motors or linear actuators for large/industrial systems
- Power rating: typically ranges from 5W to 50W per motor, depending on panel size

IX. SOCIAL IMPLICATIONS

A. Energy Access in Remote Areas

Improves energy generation efficiency in off-grid or remote locations, helping communities access reliable electricity.

B. Enhanced Quality of Life

With better and more consistent solar power, communities can benefit from improved lighting, communication, healthcare, and water systems.

X. FUTURE TREND

1) Integration with Artificial Intelligence (AI): AI will optimize tracking angles in real-time for maximum energy output using weather data and predictive algorithms.
2) IoT-Enabled Smart Tracking: Internet of Things (IoT) devices will allow remote monitoring, diagnostics, and maintenance of tracking systems.
3) Hybrid Tracking Systems: New systems may combine single and dual-axis tracking for better performance and cost-efficiency.
4) Increased Use in Residential Projects: As technology becomes more affordable, small-scale solar tracking will expand into homes and small businesses.

XI. POLICY IMPLICATIONS

A. Incentives for Solar Tracking Adoption

Governments may introduce financial incentives, rebates, or tax credits to encourage the installation of solar tracking systems, making them more accessible to developers and homeowners.

B. Support for Research and Development

Policies can promote funding for R&D in solar tracking technologies to reduce costs, improve efficiency, and make the systems more affordable and widespread.

C. Grid Integration and Smart Grids

As solar tracking systems increase power generation, policies must focus on integrating them effectively into existing grids, ensuring stability and efficiency, especially with renewable energy sources.

D. Local Manufacturing and Job Creation

Policy frameworks can encourage local manufacturing of solar trackers, boosting the domestic solar industry and creating job opportunities in the renewable energy sector.

XII. RESULT AND EVALUATION

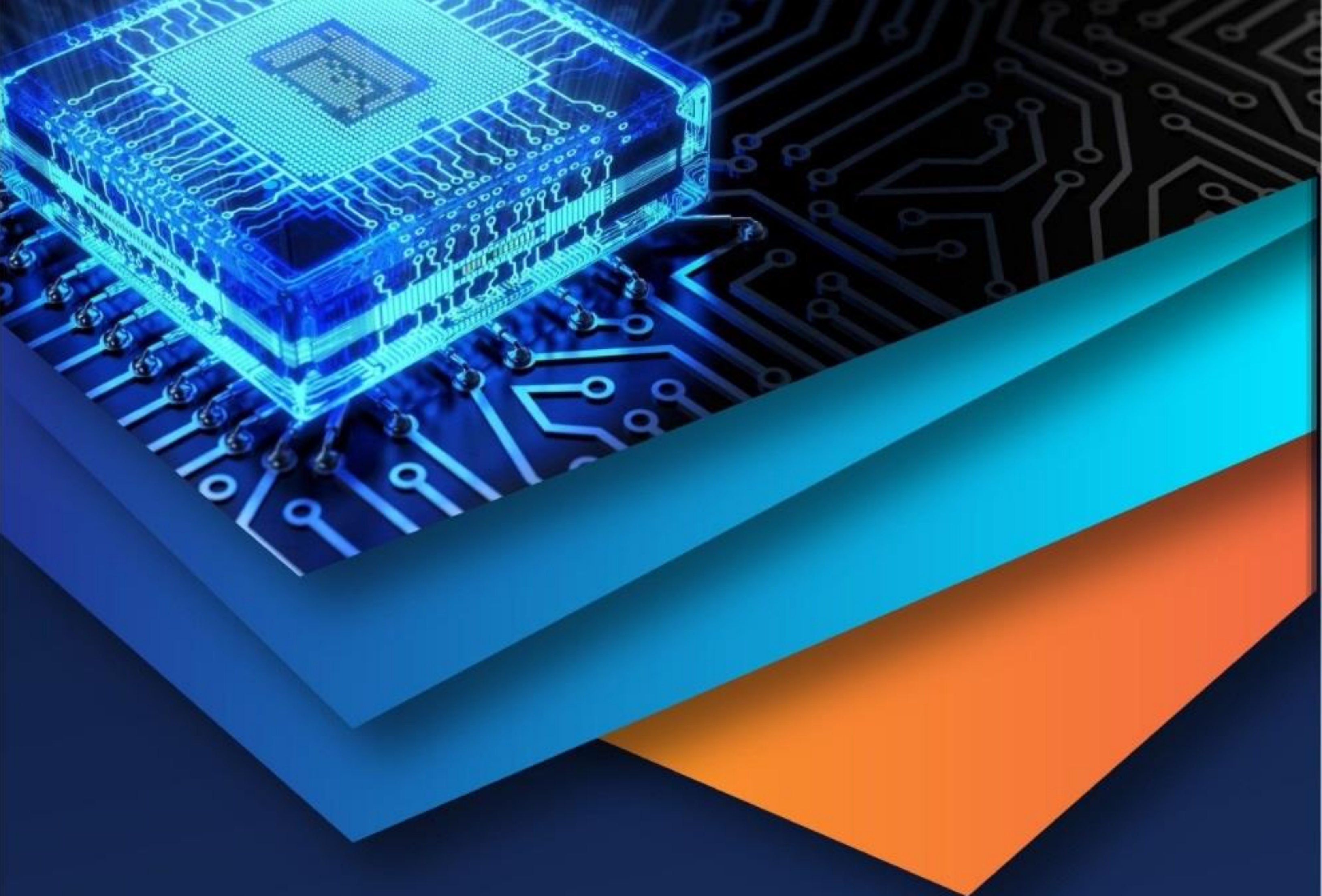
Solar tracking systems significantly increase energy output by 15% to 35% compared to fixed systems by adjusting panels to follow the sun. While they are more expensive to install, they offer a shorter payback period and lower long-term operational costs due to higher energy yield. Their performance depends on local weather and terrain conditions, with better results in sunny areas. These systems are especially beneficial for large-scale solar farms, contributing to more efficient energy production and supporting the shift toward renewable energy.

XIII. CONCLUSION

Solar tracking systems offer a significant advancement in solar energy technology by maximizing the efficiency of solar panels. By adjusting the position of the panels throughout the day to follow the sun, these systems can increase energy output by 15% to 35%. Despite higher initial costs, the long-term benefits, including shorter payback periods, improved energy yield, and lower operational costs, make them a valuable investment, particularly for large-scale solar projects. While performance is influenced by local weather conditions, solar tracking systems contribute to a more sustainable and reliable energy solution, helping to meet global renewable energy goals and support the transition away from fossil fuels. With ongoing advancements in technology and cost reductions, solar tracking systems are poised to play a vital role in the future of clean energy production.

REFERENCES

[1] Singh, A., Kumar, R., & Sharma, V. (2024). “Solar Tracking Systems: Advancements, Challenges, and Future Directions – A Review.” Energy Reports, 12, 4658–4671.
[2] Ahmed, M. M., Hasan, M. K., & Shafiq, M. (2019). “Development of Automatic Solar Tracking System for Small Solar Energy System.” International Journal of Scientific and Research Publications (IJSRP), 9(4), 150–154.
[3] Mohanapriya, V., Manimegalai, V., Praveenkumar, V., & Sakthivel, P. (2021). “Implementation of Dual Axis Solar Tracking System.” IOP Conference Series: Materials Science and Engineering, 1084(1), 012073.
[4] Nguyen, B. T., & Ho, H.-X. T. (2020). “Design, Implementation, and Performance Analysis of a Dual Axis Solar Tracking System.” Advances in Science, Technology and Engineering Systems Journal (ASTESJ), 5(3), 43–47.
[5] Das, P. K., Habib, M. A., & Mynuddin, M. (2018). “Microcontroller Based Automatic Solar Tracking System with Mirror Booster.” International Journal of Engineering and Technology, 7(3.34), 158–162.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY