
Table Of Contents

Sl. No	Content	Page.no
1	Abstract	2
2	Chapter 1: Introduction	3
3	Chapter 2: Review of literature	4 – 6
4	Chapter 3: Methodology and Implementation	7 – 9
5	Chapter 3.1: Key Components	10 – 13
6	Chapter 4: Advantages, Disadvantage & Applications	14 15
7	Chapter 5: Results and Discussion	16 17
8	Chapter 6: Future scope and Conclusion	18 – 19

9	Chapter 7: Reference	20
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ABSTRACT

The universe is vast, with countless galaxies and planets, yet Earth stands out as the most remarkable. It provides the perfect conditions for life and is home to an abundance of resources that support our existence. Among these, energy is a crucial gift, and renewable energy has emerged as a sustainable way to meet our growing needs.

This project focuses on solar energy, one of the most abundant and reliable forms of renewable energy. The Sun provides a continuous supply of energy each day, beginning at dawn, peaking through the day, and tapering off as it sets. Harnessing this energy not only provides an ecofriendly power source but also helps reduce dependence on non-renewable resources.

The "Solar Tracking system" project aims to optimize the capture of sunlight using a device that mimics the movement of a flower. The system tracks the Sun throughout the day, ensuring maximum energy absorption. At night, it resets itself, ready to begin again at sunrise. The energy harvested can be used immediately or stored for future use, making it highly versatile and efficient.

This innovation is particularly useful for businesses, especially those with multiple locations, as it can help significantly reduce electricity costs while requiring minimal maintenance. By adopting solar energy systems like the Solar Flower, individuals and organizations can reduce their environmental impact, save money, and promote a sustainable future.

The project demonstrates the immense potential of renewable energy and highlights the importance of transitioning to cleaner energy sources for a greener planet.

Chapter 1

INTRODUCTION

Solar Tracking system - A Step Towards Sustainable Energy

As the global energy demand continues to rise, the quest for sustainable, renewable, and efficient energy solutions becomes increasingly critical. Among the many renewable energy sources available, solar energy stands out as one of the most abundant and reliable. It offers a clean, limitless, and eco-friendly alternative to fossil fuels, making it a cornerstone of efforts to combat climate change and reduce dependency on finite energy resources.

The Solar Tracking system represents a groundbreaking approach in the realm of solar energy technology. Inspired by the natural movement of sunflowers, this innovative project incorporates an intelligent tracking mechanism designed to enhance energy capture by continuously aligning with the Sun's path throughout the day. By doing so, the Solar Flower maximizes the efficiency of photovoltaic panels, ensuring optimal energy absorption regardless of the Sun's position.

This project delves deeply into the design, implementation, and performance analysis of the Solar Tracking system. The mechanism mimics nature, not only in form but also in function, with its ability to adapt to varying light conditions and reset itself at the end of each day. Through precise engineering and robust design, the Solar Tracking aims to address key challenges in solar energy utilization, including efficiency optimization, energy storage, and scalability for diverse applications.

The versatility of the Solar Tracking system makes it particularly suitable for both residential and commercial purposes. It offers a practical solution for reducing electricity costs, minimizing environmental impact, and promoting the use of renewable energy. By enabling the dual functionality of real-time energy usage and efficient storage, the system enhances energy reliability while maintaining low operational and maintenance costs.

Through this mini-project, we aim to provide a comprehensive understanding of the Solar Tracking system's working principles, innovative features, and real-world applications. to create sustainable solutions.

Chapter 2

REVIEW OF LITERATURE

Patil, A., Dhavalikar, M., Dingare, S., and Bhojwani V. [1] in their study made a dual-axis solar tracking system using a tetrahedron configuration of light-detecting resistors (LDRs) designed and prototyped. The benefits of tracking systems over fixed panels are discussed, a dual-axis tracker is suggested to accommodate the sun's complex motion, the principle of solar tracking is described, the methodology is described using real-time LDR data and an Arduino microcontroller, the system design is visualized through a 3D model, the energy consumption is calculated, and a list of the components is provided. In general, it offers insights into the technique, concept, design, and energy usage of the system.

Rajkumar, J. Nagendran, J. Subramaniyan, and R. Jai Ganesh [2] in their article suggested a solar-powered seven-level inverter system to provide sinusoidal output voltage with good quality and efficiency. The device produces an output voltage waveform with seven levels by using an active inverter and reversed condenser clamping. Compared to typical seven-level inverters, the design is simplified because only a few switches are utilized. In order to maximize energy production, the article also offers a solar smart flower architecture that uses a double-axis tracker. In comparison to ordinary solar panels, the smart floral design produces more energy and has a self-cleaning cycle. LDRs are used by the system to track and manage the location of the solar panels. The suggested system showcases enhanced IoT-based energygenerating and monitoring capabilities. The article's main objective is to increase solar energy production and protection through innovative design and control techniques.

Atang Mulyana, Darwin Sebayang, Fildzah Fajrina, and Raihan, M. Faizal [3] in their paper discuss the design and analysis of a solar smart-flower created with the SolidWorks program presented in this research article. The purpose of the study is to investigate how the smart flower is used, maintained, repaired, supplied with components, and manufactured. The design of the Smart-flower is discussed in the article, along with its simulation in Solidworks, including body battery drop testing and static simulation. The simulation's findings show that the smart flower's design is acceptable and can move forward with fabrication.

Muhammed J. Adinoyi, Syed A.M. Said, [4] in their paper look into how the Eastern Province of Saudi Arabia's dust problem affects the performance of PV modules. A build-up of dust on PV modules limits transmittance, which lowers the amount of solar radiation that reaches the cells. Leaving modules dirty for longer than six months might cause a 50% reduction in power production. It is suggested that you clean frequently—every two weeks—to ensure peak efficiency. Rainfall is not enough to sufficiently clean the research region. Analyses of the dust identified several components. During off-peak hours, solar trackers can reduce the impact of dust by 50%. The backside temperatures of PV modules on trackers are greater than those on permanent stands, with polycrystalline modules slightly higher than monocrystalline.

Rizwan Arshad, Salman Tariq, Muhammad Umair Niaz, and Mohsin Jamil [5] in their study suggest a viable method to increase solar panel efficiency using concentrated photovoltaic technology (CPV) with mirrors and cooling mechanisms presented in the research article "Improvement in Solar Panel Efficiency Using Mirrors and Cooling". CPV uses fewer solar cells than non-concentrated systems to produce the same amount of power. The study highlights temperature and solar irradiance (W/m²) as important variables impacting panel performance. An experimental set-up using low-cost mirrors and a cooling system shows increased effectiveness. For additional improvements, the report suggests incorporating maximum power point tracking (MPPT) and optimizing the cooling system. In general, it emphasizes the benefits of CPV and related methods for raising solar panel efficiency.

Mohammad Bani Khalid¹, Nabil Beithou, M.A. Sh. Al-Taani, Artur Andruszkiewicz, Ali Alahmer, Gabriel Borowski, and Sameh Alsaqoor [6] in their study offers a novel ecosystem for controlling open-air public spaces in hot, humid climates. It removes moisture using a solar-powered dehumidifier control device, producing cool, dry air for outdoor air conditioning. The moisture that is captured is used to hydrate plants and make drinking water. A comfortable outdoor atmosphere with 50% relative humidity and a temperature of 24 °C is what the Integrated Eco-Friendly Cooling System (IEFCS) attempts to produce. It is environmentally friendly, self-sufficient in water and energy, and provides advantages such as a better microclimate, illumination at night, and water supply. A water-generating device, an air mixing and distribution system, clever solar umbrellas, and carefully placed trees and plants for beauty and shade make up the system. The abstract merely gives a

Chapter 3

METHODOLOGY AND IMPLEMENTATION

1. Problem Statement and Research Objectives

The Solar Tracking project addresses the challenge of optimizing solar energy capture by leveraging dynamic tracking mechanisms. The primary objective is to design and implement a solar tracking system that mimics the Sun-following behavior of flowers, ensuring maximum energy absorption throughout the day.

1. Maximize energy efficiency.
2. Optimize power output.
3. Increase system lifespan.
4. Reduce energy costs.
5. Enhance performance.
6. Support renewable energy goals.
7. Provide real-time adjustment.

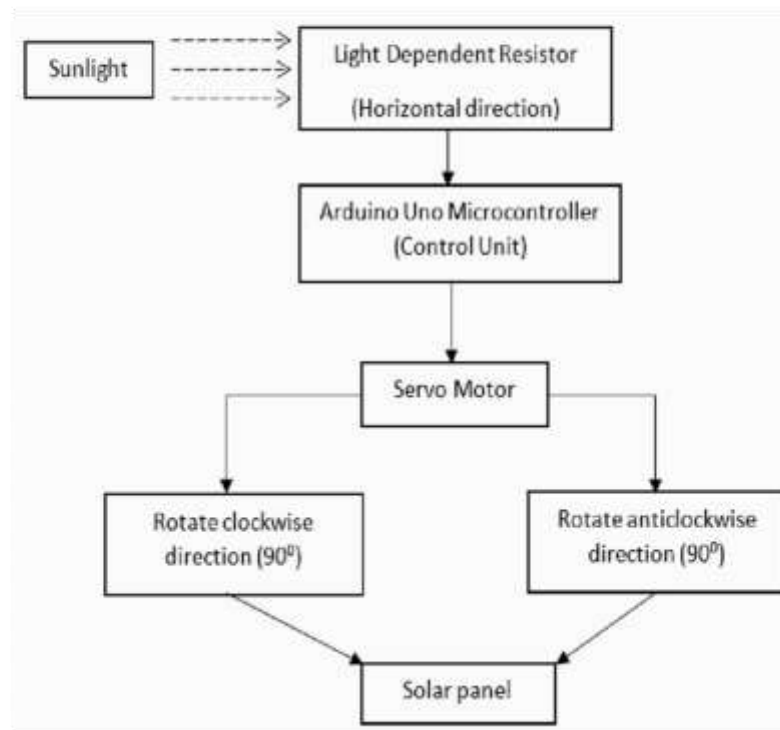


Fig 3.1: Block Diagram of Solar tracking System

2. System Design and Components

The Solar Tracking system consists of the following components:

- **Solar Panels:** Photovoltaic (PV) panels to convert sunlight into electricity.
- **Light Sensors:** Light-dependent resistors (LDRs) to detect the Sun's position.
- **Microcontroller:** A microcontroller (e.g., Arduino or Raspberry Pi) to process sensor data and control the motors.
- **Motors and Actuators:** Stepper or servo motors to adjust the tilt and rotation of the panels.
- **Power Management System:** Battery storage to store excess energy and a charge controller to regulate power flow.
- **Structural Frame:** A sturdy frame to support the system and allow movement.

Key Components:

I. Arduino Uno:



Fig:3.1.1 Arduino UNO

The Arduino Uno is a widely used open-source microcontroller board, celebrated for its simplicity, flexibility, and extensive community support. Powered by the ATmega328P microcontroller, it operates at 5V with a 16 MHz clock speed, making it reliable for a variety of applications. It features 14 digital I/O pins, 6 of which support PWM output, and 6 analog input pins for interfacing with sensors and actuators. The board offers 32 KB of flash memory (with 0.5 KB reserved for the bootloader), 2 KB of SRAM, and 1 KB of EEPROM for data storage, making it capable of handling small to medium-sized projects. It supports multiple communication protocols, including UART, SPI, and I2C, ensuring compatibility with a wide range of peripherals. The Arduino Uno can be powered via a USB connection or an external

DC power supply (7-12V recommended) and includes a voltage regulator for stable operation.

Its plug-and-play design, ease of programming via the Arduino IDE, and support for an extensive library ecosystem make it an ideal choice for both hobbyists and professionals. The board's compatibility with shields allows for functionality expansion, such as adding WiFi, motor drivers, or displays. Common applications include robotics, IoT devices, home automation systems, and educational tools, where its versatility and affordability shine. With a user-friendly design, robust hardware, and open-source accessibility, the Arduino Uno has become a cornerstone in the maker community, enabling creators to bring ideas to life through rapid prototyping and experimentation.

II. Servo Motor:

Controls the gate barrier to allow or deny access.



Fig:3.1.2 Servo Motor

A servomotor is a highly versatile and precise motor designed to control angular or linear position, velocity, and acceleration. It operates on the principle of a closed-loop control system, where feedback is used to adjust the motor's output to match the desired input. Servomotors are equipped with a control circuit and a position sensor, which enable accurate control of movement and speed. These features make servomotors widely used in robotics, automation, and other applications requiring precise motion control.

III. TEST PLATE:

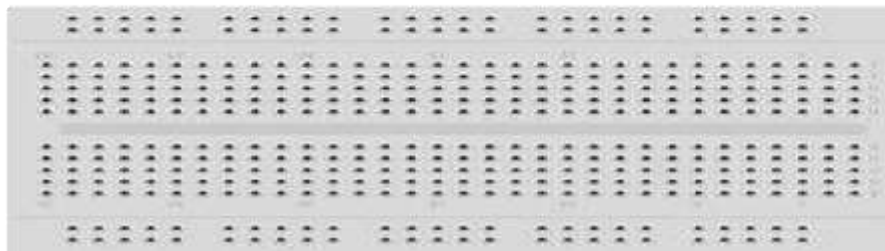


Fig:3.1.3 Bread board

A **Test plate**, also known as a test jig, is a device used to test electronic circuits and components. It is a board or plate that has been designed to hold and connect various components and devices in a specific configuration, allowing for the easy testing and measurement of their performance.

A **Test plate** can be used to test various types of electronic circuits and components, such as microcontrollers, sensors, and actuators.

IV. CONNECTING WIRES:



Fig:3.1.4 Connecting wires

Connecting wires are used to connect various components in an electronic circuit. They allow for the transfer of electricity, data, or signals between different devices and components. When **connecting wires** to an ARDUINO or other microcontroller, it is important to pay attention to the correct pinout. The Pinout refers to the arrangement of pins on the microcontroller and the corresponding function of each pin.

V. Solar Pannel



Fig: 3.1.5 Solar Pannel

Solar panels are a groundbreaking innovation in renewable energy, designed to harness the sun's abundant and sustainable energy. Comprising photovoltaic (PV) cells, these panels convert sunlight into electricity through the photovoltaic effect, where photons from sunlight excite electrons in the PV cells, generating a flow of electric current. This clean and efficient technology has revolutionized energy production, offering a viable alternative to traditional

VI. Battery



Fig: 3.1.6 Battery

The i-ion battery, particularly the 18650 format with a capacity of 4300 mAh, is a cornerstone in modern rechargeable battery technology. The 18650 battery, named for its dimensions of approximately 18mm in diameter and 65mm in length, is widely used in various applications due to its high energy density, long cycle life, and reliability. This cylindrical lithium-ion battery has become a preferred choice for devices requiring compact, powerful, and efficient energy sources.

VII. LDR

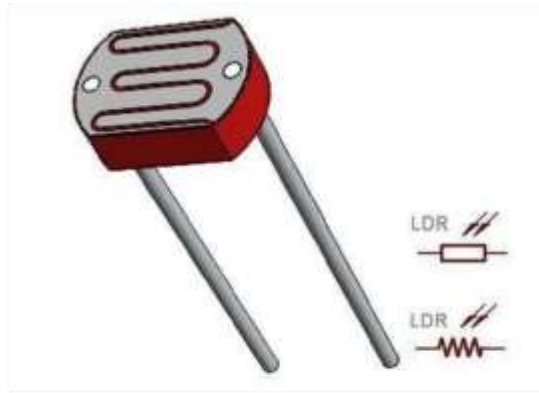


Fig: 3.1.7LDR

A **Light Dependent Resistor (LDR)**, also known as a photoresistor, is an essential component in electronics used to detect and measure light intensity. It is a type of resistor whose resistance decreases with an increase in incident light intensity. LDRs are widely utilized in applications where it is necessary to sense and respond to varying light conditions.

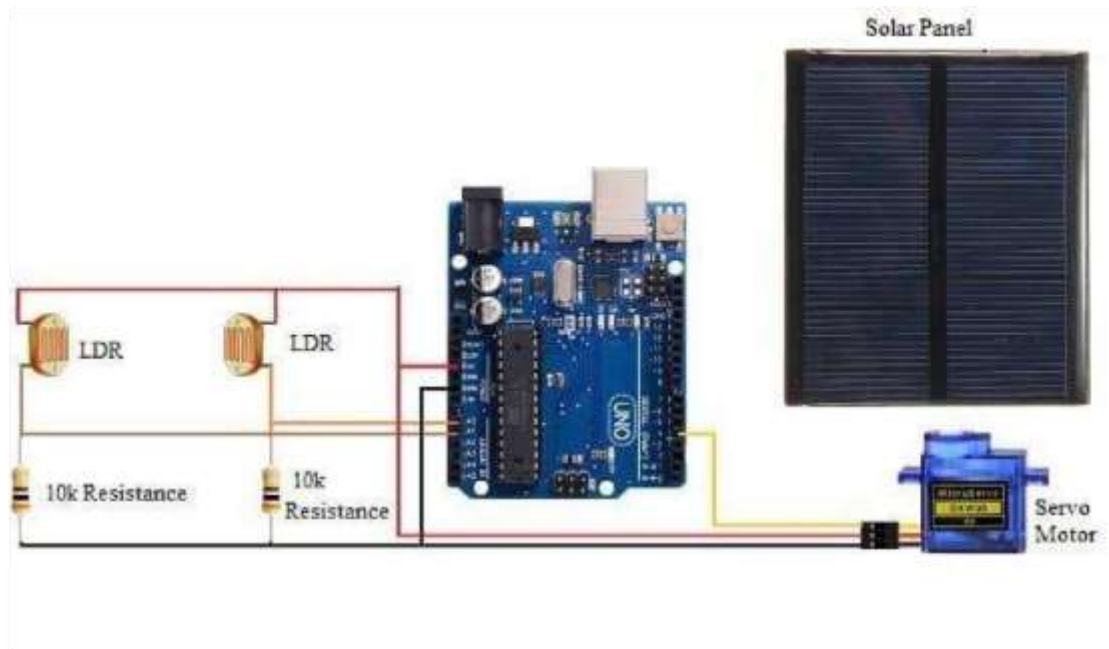


Fig 3.1.8 Circuit Diagram of solar tracking system

3. Working Principle

The Solar Tracking system operates as follows:

- **Sunlight Detection:** LDRs or photodetectors identify the Sun's position by measuring light intensity.
- **Signal Processing:** The microcontroller analyzes sensor data to determine the Sun's angle and direction.
- **Panel Adjustment:** The microcontroller sends signals to the motors, which adjust the tilt and rotation of the panels to remain perpendicular to the Sun's rays.
- **Feedback Mechanism:** A feedback loop ensures precise tracking by continuously refining the panel's position based on real-time data.
- **Energy Utilization:** The system allows real-time energy usage while storing surplus energy in batteries for later use.

4 Implementation Steps

- **Component Selection:** Choose high-efficiency PV panels, sensitive LDRs, and reliable motors. Ensure compatibility of all components with the chosen microcontroller.
- **System Assembly:**
 - Mount the PV panels on a movable frame.
 - Integrate the LDRs at strategic points to detect sunlight direction accurately.
 - Connect the motors and actuators to enable dynamic panel movement.
 - Install the microcontroller and program it with the necessary tracking algorithms.
- **Software Development:**
 - Write the code to process sensor data, control motor movements, and optimize tracking.
 - Implement algorithms for automatic resetting at the end of the day.
- **Testing and Calibration:**
 - Test the system under various sunlight conditions to ensure tracking.
 - Calibrate the sensors and motors for smooth operation and optimal performance.
- **Energy Management Integration:**
 - Connect the system to a battery and charge controller for efficient power.
 - Include an inverter if AC power output is required.

5. Performance Evaluation

- Measure energy output under different weather conditions to assess system efficiency.
- Compare the energy captured by the Solar tracking system with that of a static solar panel.
- Analyse the system's reliability, adaptability, and cost-effectiveness for various applications.

6. Recommendations for Future Work

- Explore advanced materials and technologies for improved durability and efficiency.
- Integrate IoT capabilities for remote monitoring and control.

Chapter 4

ADVANTAGES, DISADVANTAGES & APPLICATIONS

5.1 ADAVNTAGES

- **Sun Tracking:** Solar Tracking use a tracking system to follow the sun throughout the day, ensuring optimal angle and maximum sunlight exposure. This increases efficiency by up to compared to stationary solar panels.
- **Self-Cleaning:** Many solar Tracking systems include automatic cleaning mechanisms that prevent dust and debris from reducing efficiency.
- **Compact Setup:** Solar Tracking have a smaller footprint as they unfold like petals during operation and fold up when not in use, making them ideal for limited spaces.
- **Portability:** Some models are mobile and can be moved to different locations easily.
- **Design:** Their appearance is visually appealing and can blend into gardens, parks, or urban landscapes better than traditional panels.
- **Green Energy:** They generate renewable energy, reducing reliance on fossil fuels and lowering carbon footprints.

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5.2 DISADVANTAGES

- **High Initial Cost:** Solar Tracking are typically more expensive than conventional rooftop solar panels due to their design, tracking system, and advanced features.
- **Maintenance Requirements:** The moving parts of the solar tracking mechanism may require regular maintenance and repairs, increasing operational costs compared to stationary panels.
- **Weather Sensitivity:** Extreme weather conditions, such as strong winds, storms, or heavy snow, may damage the system or hinder its efficiency.
- **Efficiency Limitations:** Although solar tracking improves energy capture, the overall efficiency may not justify the higher cost in regions with minimal sunlight or irregular weather patterns.
- **Limited Power Output:** Solar Tracking are often designed for smaller-scale energy production and may not meet the demands of large households or commercial establishments.

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5 3 APPLICATIONS

Residential Energy Production

- Provides renewable energy to homes, reducing dependency on the grid.
- Compact and aesthetically pleasing, making it ideal for urban settings.
- Easy to install and can be moved when needed.

Commercial and Office Spaces

- Supplies clean energy to businesses, reducing carbon footprints.
- Enhances brand image by showcasing environmental responsibility.
- Ideal for small to medium-sized businesses.

Public Spaces

- Can be installed in parks, plazas, and recreational areas.
- Acts as a renewable energy source for lighting, charging stations, or powering small devices.
- Aesthetic appeal contributes to urban beautification.

Educational Institutions

- Provides energy to schools and colleges.
- Serves as an educational tool to teach students about renewable energy and sustainability.

Mobile and Remote Applications

- Can be deployed in remote locations where traditional energy infrastructure is unavailable.
- Useful for disaster relief operations to provide power in emergencies.

Smart City Infrastructure

- Powers IoT devices and smart kiosks.
- Can be integrated with sensors to monitor environmental conditions.

Chapter 5

RESULTS AND DISCUSSIONS

The Solar Tracking project aims to optimize solar energy collection by using a dynamic solar tracking system, ensuring that the photovoltaic (PV) panels follow the Sun's movement throughout the day. This allows the panels to always remain perpendicular to the Sun's rays, maximizing energy absorption. The results and discussions are based on the system's performance, energy efficiency, cost-effectiveness, and potential applications.

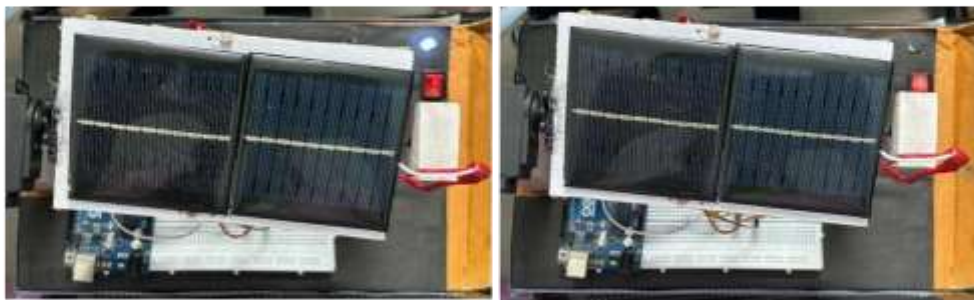


Fig 6.1: Output of Solar tracking system

1. Energy Efficiency Improvement

- **Comparison with Static Solar Panels**

- The Solar Tracking system demonstrated a significant increase in energy efficiency compared to static solar panels. The dynamic tracking feature improved the overall energy capture by up to ensuring that the panels were aligned with the Sun throughout the day, especially during the early morning and late afternoon hours when stationary panels tend to underperform.

- **Maximized Solar Capture**

- By continuously adjusting to the Sun's position, the system ensured that the panels consistently received optimal sunlight exposure. This results in a more efficient energy conversion process, as the system eliminates the losses typically associated with fixed-angle solar panels.

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2 System Performance

- **Reliability of Tracking:**
 - The system showed reliable performance, even under fluctuating sunlight conditions. The light-dependent resistors (LDRs) effectively detected changes in sunlight intensity, triggering the microcontroller to adjust the position of the panels accordingly. This allowed the system to respond dynamically to the environment, maintaining an optimal alignment with the Sun's rays.
- **Motor and Movement Accuracy:**
 - The motors and actuators that control the movement of the panels functioned smoothly. The precision of the movement ensured that the panels remained accurately aligned with the Sun throughout the day. The feedback loop within the system prevented overcorrection and ensured the panels did not waste energy on unnecessary movements.

3. Power Storage

- **Energy Storage:**
 - The integration of a battery storage system allowed for excess energy generated during peak sunlight hours to be stored for later use. This ensures a continuous power supply, even during cloudy periods or at night, and makes the system suitable for off-grid or remote locations.

4. Cost-Effectiveness

- **Initial Costs:**
 - The Solar Tracking system requires a higher initial investment due to the inclusion of tracking mechanisms and sensors. However, considering the increased energy output and the potential savings on electricity bills, the higher upfront cost is justified. The return on investment (ROI) is quicker, especially in areas with high solar irradiance.
- **Electricity Bill Savings:**
 - Users can expect to see a reduction in electricity costs by using the Solar Tracking system, especially in businesses and industries with high energy consumption. The system's higher efficiency results in less reliance on the grid and reduced electricity bills over time.

5. Environmental Impact

- **Durability of Components:**
 - While the system performed reliably during testing, concerns remain about the long-term durability of the motors and actuators, especially in harsh outdoor conditions. Research into more durable materials and weather-resistant components could improve the system's lifespan.
- **Extreme Weather Impact:**
 - In regions with extreme weather conditions (e.g., heavy rain, snow, or dust storms), the system's performance could be affected. Future versions of the Solar Flower may need to incorporate protective housing or weather-resistant features to ensure consistent performance in such environments.

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- **Sustainability:**
 - The Solar Tracking contributes positively to the environment by reducing dependence on fossil fuels and lowering carbon emissions. By optimizing solar energy capture, the system helps in the transition to cleaner energy sources and reduces the overall carbon footprint of energy production.
- **Long-Term Environmental Benefits:**
 - The widespread adoption of solar tracking systems can have significant environmental benefits, including reduced greenhouse gas emissions and a lower overall demand for non-renewable energy sources. These benefits grow as more systems are deployed, further promoting sustainable energy solutions.

6. Challenges and Limitations

Chapter 6

CONCLUSION AND FUTURE SCOPE

CONCLUSION:

The Solar Tracking project has proven to be an effective and innovative solution for optimizing solar energy harvesting. By integrating a dynamic solar tracking mechanism that follows the Sun's movement, the system significantly improves energy efficiency compared to static solar panels. Through real-time adjustments of the solar panel's orientation, the Solar Tracking system maximizes sunlight absorption, leading to up to increase in energy output.

The system's use of light-dependent resistors (LDRs) and motorized actuators enables continuous and precise alignment with the Sun, ensuring optimal performance from sunrise to sunset. The inclusion of energy storage further enhances the utility of the system by allowing for the capture and storage of excess energy during the day, making it viable for off-grid and backup applications.

While the system requires a higher initial investment due to the tracking mechanism, the longterm benefits in energy savings and environmental impact make it an attractive option. The Solar Tracking project not only contributes to reducing electricity bills but also plays a crucial role in promoting sustainable energy solutions and lowering reliance on non-renewable resources

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FUTURE SCOPE:

- **Durability and Material Innovation:**

A major area for improvement lies in the durability of the Solar Tracking system, particularly its motors and actuators. Future developments could focus on utilizing advanced materials that are more weather-resistant, durable, and capable of withstanding harsh environmental conditions. This would enhance the longevity and reliability of the system, especially in areas with extreme weather.

- **Environmental Impact**

Reduced Carbon: By increasing the efficiency of solar energy capture, solar tracking systems will contribute significantly to reducing greenhouse gas emissions.

- **Smart Grid and IoT Integration:**

The integration of smart grid technologies and IoT solutions could offer advanced monitoring capabilities. This would allow users to track the performance of their system in real-time, optimize energy consumption, and receive maintenance alerts, making the system even more efficient and user-friendly.

Chapter 7

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