DAYANANDA SAGAR COLLEGE OF ENGINEERING

Shavigemalleshwara Hills, Kumaraswamy Layout, Bengaluru-560111, Karnataka
(An Autonomous College affiliated to VTU Belgaum, accredited by NBA & NAAC)

Department of Electronics & Communication Engineering

II SEM BE MINI-PROJECT (22IDT28) REPORT
on

Title of the Mini-Project

Submitted in partial fulfillment of the requirement for the degree of

Bachelor of Engineering
in
Electronics & Communications Engineering - ECE
by

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Under the guidance
of
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VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnanasangama, Macche, Santibastwada Road
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2023-24

Certificate

Certified that the mini-project work **(Course Code: 22BEE23)** entitled "**Solar Panel with Sun Position Tracking**" carried out by **NATHAN KALLEM** (1DS23EC133), **VISHRUTH R** (1DS23EC248), **VISMAY VINOD GADEKAR** (1DS23EC249), **YADAMAKANTI SAI MOHITH REDDY** (1DS23EC252) are bonafide students of the Department of ECE of Dayananda Sagar College of Engineering, Bangalore, Karnataka, India in partial fulfillment for the award of Bachelor of Engineering in Electronics & Communication Engineering of the Visvesvaraya Technological University, Belagavi, Karnataka for the **II Semester course** during the academic year 2023-24. It is certified that all corrections / suggestions indicated for the mini-project work have been incorporated in the mini-report. This **2nd semester mini-project report** has been approved as it satisfies the academic requirement in respect of mini-project work prescribed for the said degree.

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Dr. B.G. Prasad : ______________________________

Principal, DSCE

<u>External Mini-Project Viva-Voce (SEE)</u>

Name of the mini-project examiners (int & ext) with date :

1 : Signature : ____________________

2 : Signature : ____________________

Declaration

Certified that the mini-project work entitled, "**Solar Panel with Sun Position Tracking**" with the course code **22IDT28** (2 Credits, 100 Marks, CIE & SEE 50 marks each) is a bonafide work that was carried out by ourselves in partial fulfillment for the award of degree of Bachelor of Engineering in Electronics & Communication Engg. of the Visvesvaraya Technological University, Belagavi, Karnataka during the academic year 2023-24 for the II Semester Autonomous Course. We, the students of the 2nd sem mini-project group/batch no. **P-2** do hereby declare that the entire mini-project has been done on our own. The results embedded in this mini-project report has not been submitted elsewhere for the award of any type of degree.

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Date : 06 /08/2024 Place : Bengaluru

Acknowledgement

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I also thank the teaching and non- teaching staff members of Department of Electronics and Communication Engineering and also, my family and friends for the help and support provided by them in successful completion of the mini- project. Our accomplishments would be incomplete without my beloved parents, for without their support and encouragement we would not have reached up to this level. We express our gratitude to the Almighty for guiding us throughout this journey.

Abstract

In this section, a brief abstract about the mini-project work that is going to be undertaken should be presented in a **single page only** with the important key words.

Summarize the main points of the mini-project work in a separate page in the form of abstract or the work that you are going to undertake in the mini-project work of your UG-BE course and what you have done. People getting interested in the mini project report after reading the title should be able to judge from the abstract / synopsis / introduction whether the work is really interesting for them, it should be able to give a clear cut picture about the whole undertaken mini-project work. It must contain the context / relevance of the problem at hand, a description of what is going to be done and a gist of the significant predicted observations / results. This page should precede the content page. It should be as exhaustive as possible but related to your mini-project work.

Keywords : *solar panel, light-dependent resistors, Arduino Uno, Servo moto, Light Detection resistor (LDR), Resistors*

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Nomenclature and Acronyms

Abbreviations (Alphabetical Order) :

IEEE	Institute of Electrical & Electronics Engineers
DSCE	Dayananda Sagar College of Engineering
ECE	Electronics & Communication Engineering

Chapter-1

Introduction

In the realm of renewable energy, solar power stands as a cornerstone technology for harnessing the sun's abundant energy potential. Solar photovoltaic (PV) systems convert sunlight directly into electricity, offering a clean and sustainable alternative to conventional fossil fuel-based power generation. However, the efficiency of solar panels in converting sunlight into electricity is closely tied to their orientation relative to the sun.

Traditional fixed solar panels are typically set at a fixed angle optimized for the average daily position of the sun. While this configuration works reasonably well under ideal conditions, it fails to account for the dynamic movement of the sun across the sky. Throughout the day, the sun's position changes due to factors such as the Earth's rotation, seasonal variations, and the latitude of the installation site. As a result, fixed solar panels may not consistently receive sunlight at the optimal angle, leading to reduced energy generation potential.

To overcome these limitations and enhance the efficiency of solar energy capture, solar panels with sun position tracking mechanisms have been developed. These advanced systems incorporate sophisticated technology to continuously monitor and adjust the orientation of solar panels in real-time to follow the sun's path across the sky. By dynamically tracking the sun's position, these systems ensure that the solar panels are always aligned perpendicularly to the incoming sunlight, thereby maximizing the amount of solar energy absorbed.

The implementation of sun position tracking involves several key components and processes. Firstly, sensors and algorithms accurately determine the precise position of the sun based on factors such as time, date, and geographic location. These data are then processed by advanced tracking algorithms that calculate the sun's trajectory throughout the day. Based on these calculations, actuators or motors adjust the orientation of the solar panels along one or two axes (single-axis or dual-axis tracking) to maintain optimal alignment with the sun.

Chapter-2

Literature Survey

In the past, research was made to solve the issue of loss of energy by solar panels. This paper suggests that the efficiency of solar power systems can be increased by incorporating a tracking system. Various types of tracking systems are possible. This paper is an overview of designing a single-axis sun tracker using a microcontroller. The study evinces that such tracking systems increase the yield of energy by a huge amount. Using microcontrollers manipulates the execution of the system with more efficiency. This paper addresses the factors that affect the efficiency of solar cells such as temperature, maximum power point tracking, and energy conversion efficiency. Solar cells are more efficient in various applications if all these factors are optimized. Thus, to utilize these factors a tracking system based on the function of a DC motor controlled by light sensors is fabricated.

The tracking system is designed using a microcontroller as well as a servo motor. The system can be programmed to rotate at different angles and also the sensitivity of the system can be encouraged by the use of Light Depending Resistors that is LDR sensors. This gives greater flexibility over existing systems. The paper explores how the single-axis algorithm could be extended to the dual-axis as well.

This paper proposes a financial assessment of the economic benefits of tracking systems over traditional systems. The financial survey was undertaken based on Texas's energy market rate and sun trackers' average price and operative expenses. The overall improvement in the final outcome was about 82%. Thus, the trackers proved to be economically more beneficial.

The paper relates to the architecture of a simple dual-axis tracking system using Arduino and a stepper motor. It gives the algorithm of the relation between the working of a motor based on the signals received from LDR which are responsible for the moment of the solar panel.

This paper approaches a photovoltaic panel system using an Arduino-based application as monitoring media. The Android application monitors the temperature changes and conveys the necessary angle inputs. The node MCU is the communication bridge for the microcontroller. The system is commanded by open loop control system. Servo motors are attached to bike wheels which move solar panels to follow the sun's positions. Thus, the output from the mobile application which serves as input for the servo motor and the position of the panel is adjusted. The tracking systems designed using microcontrollers are efficient as they provide systematic working of the system. The LDR sensors used with appropriate arrangement provide the signals to the servo motor and thus the panel rotates with the desired angle according to the position perpendicular to the sun rays. The paper performs a techno-economic-environmental analysis of maximum power generation by the solar tracking system. The panels were installed in the residential areas.

The results reflected that, by using tracking systems the number of plants needed was reduced. The single-axis tracking system resulted in greater cost-efficiency with 0.243 $/kWh cost of energy with an average of 25% increase in the output power. Although the dual-axis tracker increased power generation by 33%, it was less cost-effective.

The paper directs to the design of a dual-axis solar tracker. The panel adjusts its orientation by moving simultaneously in two directions. It is a closed-loop system using the Wheatstone bridge circuit that works with light-dependent resistors (LDRs).

Chapter-3

Objective

The primary objective of single-axis solar trackers is to optimize the efficiency of solar energy systems by dynamically adjusting the orientation of solar panels to follow the sun's path throughout the day. This adjustment ensures that the panels receive maximum sunlight exposure, thereby increasing energy capture and production efficiency. By maximizing solar energy utilization, these trackers contribute to reducing dependence on fossil fuels and promoting sustainable energy practices.

They enhance the economic viability of solar installations by boosting energy output, potentially shortening payback periods and increasing returns on investment. Moreover, single-axis trackers help minimize the environmental impact of energy generation by reducing greenhouse gas emissions associated with conventional power sources. Their versatility allows for deployment across various environments, including residential, commercial, industrial, and remote settings, meeting diverse energy needs effectively. Continued integration of advanced tracking algorithms and materials science advancements further enhances the reliability, durability, and operational efficiency of these systems.

Ultimately, single-axis solar trackers play a crucial role in supporting grid stability, facilitating energy storage integration, and driving ongoing innovation in renewable energy technologies worldwide.

Problem Statement

The increasing demand for sustainable energy solutions has made solar power a vital component in the global energy landscape. However, conventional fixed-position solar panels often fail to harness maximum solar energy due to the changing position of the sun throughout the day. This inefficiency results in suboptimal energy output, limiting the potential benefits of solar energy systems.

The primary problem is to design and implement an efficient solar panel system that continuously tracks the sun's position to maximize energy absorption. This involves creating a robust mechanical structure, developing an effective tracking algorithm, integrating a reliable control system, and ensuring overall system efficiency. The goal is to significantly increase the energy output compared to traditional fixed-position panels, making solar energy a more viable and efficient option for various applications.

Chapter 4

Methodology

The methodology for developing a solar panel system with sun position tracking consists of several key phases: research, design, implementation, and testing. Here is a detailed step-by-step approach:

1. Research and Planning

- Literature Review:

- Study existing sun tracking systems, their designs, and performance metrics.

- Understand the principles of solar energy conversion and tracking algorithms.

- Review related technologies, including sensors, microcontrollers, and mechanical components.

- Objective Definition:

- Clearly outline the objectives, expected outcomes, and success criteria for the project.

- Identify potential challenges and constraints.

2. Design Phase

- Mechanical Design

- Structure Design:

- Design a single-axis mechanical structure that allows the solar panel to tilt vertically

- Component Selection:

- Select appropriate materials for the structure to ensure stability and durability.

- Choose motor (servo motors)

- Electrical Design:

- Sensor Selection:

- Choose light-dependent resistors (LDRs) to detect the intensity and direction of sunlight.

- Microcontroller:

- Select a microcontroller (Arduino) to process sensor data and control the motor.

- Control System Design:

- Algorithm Development:

- Implement sensor-based feedback for real-time adjustments.

- Programming:

- Write code for the microcontroller to read sensor inputs and control motor outputs.

- Implement safety features to prevent mechanical overrun or damage.

3. Implementation Phase

- Prototyping:

- Mechanical Assembly:

- Assemble the mechanical structure according to the design specifications.

- Install motor and ensure proper alignment and range of motion.

- Electrical Assembly:

- Connect sensors, microcontroller, and motors.

- Ensure secure and stable electrical connections.

- Software Integration:

- Upload the control algorithm to the microcontroller.

- Test and debug the software to ensure correct sensor readings and motor control.

4. Testing and Evaluation

- Initial Testing:

- Test the system indoors to verify that sensors, motors, and the microcontroller work together as expected.

- Adjust mechanical and electrical components as needed.

- Field Testing:

- Place the system outdoors to track the sun's movement throughout the day.

- Collect data on solar panel orientation and energy output.

- Compare the performance with a fixed solar panel system under the same conditions.

- Data Analysis:

- Analyze the collected data to evaluate the efficiency improvements due to sun tracking.

- Identify any discrepancies and refine the system accordingly.

5. Documentation and Presentation

- Documentation:

- Document the entire process, including design, implementation, testing, and analysis.

- Include detailed diagrams, code listings, and data charts.

- Presentation:

- Prepare a presentation to showcase the project, its objectives, methodology, results, and conclusions.

- Highlight the efficiency improvements and potential applications of the tracking system.

6. Final Adjustments and Recommendations

- System Optimization:

- Make any necessary adjustments to optimize the system's performance.

By following this methodology, the project aims to successfully develop a functional prototype of a solar panel system with sun position tracking.

Block diagram

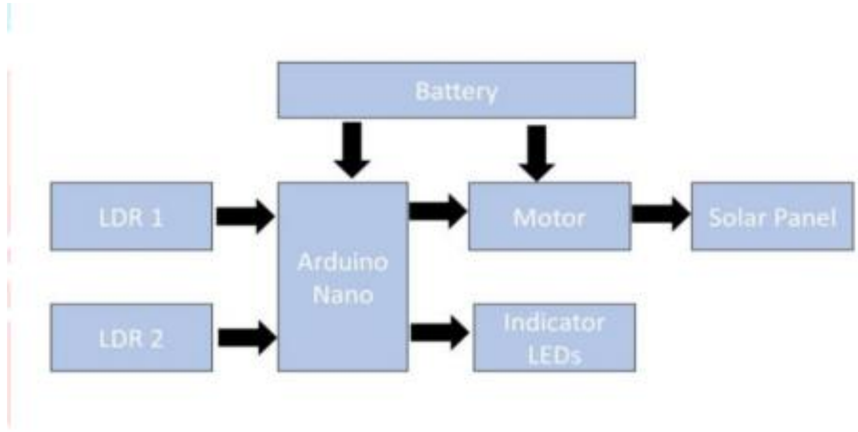

Fig. 4.1: Block-diagram of the proposed methodology

Circuit Diagram

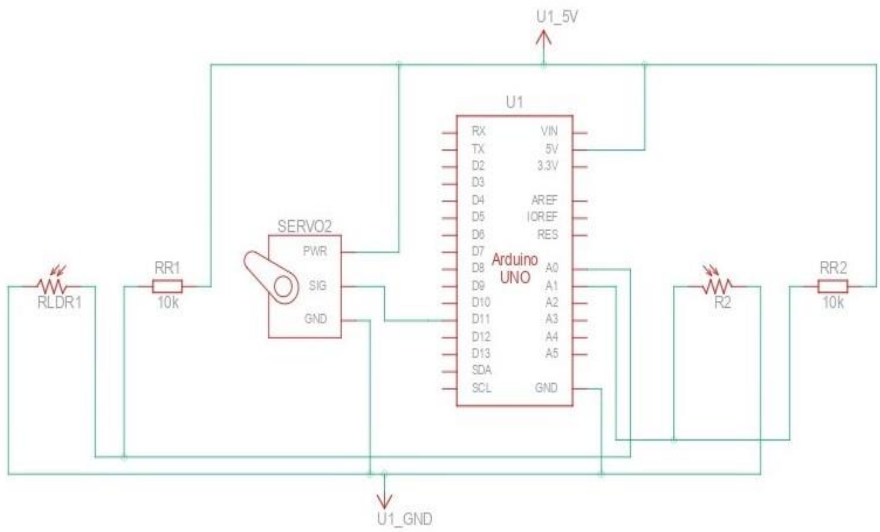

Fig. 4.2: Circuit Diagram

Chapter 5

Hardware / Software tools Used

In this chapter, the hardware & the software descriptions related to the mini-project work is presented in brief here.

Hardware:

-Arduino Uno

-Servo moto

-Light Detection resistor (LDR)

-Resistors

Software:

C program language is used in this mini project as it is easy to program and also easy to understand

Working Principle

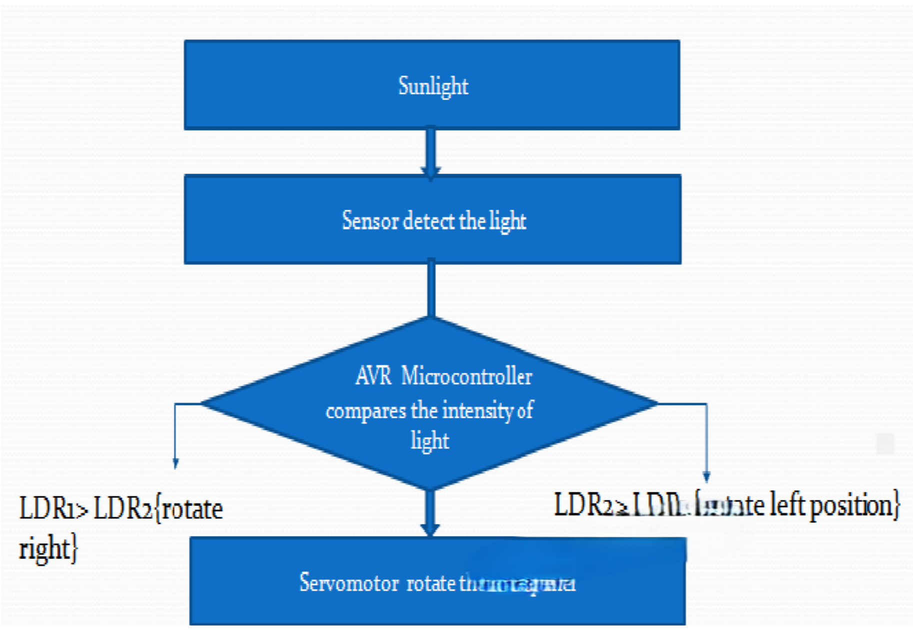

Fig. 5.1: Flow-chart of the methodology used

The solar panel system with sun position tracking operates based on the principle of maximizing solar energy absorption by continuously aligning the solar panel with the sun's position throughout the day. This involves using sensors to detect the sun's position, a microcontroller to process the sensor data, and motors to adjust the panel's orientation. Here’s a detailed explanation of the working principle:

1. Sunlight Detection

Sensors:

- Light-dependent resistors (LDRs) are used to detect the intensity and direction of sunlight.

- These sensors are strategically placed at different positions on the solar panel to measure the light intensity from various directions.

Sensor Readings:

- Each sensor provides an analog signal corresponding to the amount of sunlight it receives.

- The differences in the signals from these sensors indicate the direction in which the sunlight is strongest.

2. Data Processing

Microcontroller:

- An Arduino is used as the central processing unit for the system.

- The microcontroller continuously reads the analog signals from the sensors.

Sun Tracking Algorithm:

- The microcontroller runs an algorithm that processes the sensor data to determine the sun’s position.

- The algorithm calculates the difference in light intensity detected by the sensors on different sides of the panel.

- Based on these differences, the algorithm decides the direction in which the panel needs to move to maximize sunlight exposure.

3. Panel Adjustment

Motor Control:

- The system uses servo motors to adjust the solar panel’s orientation.

- The microcontroller sends control signals to the motors based on the calculations from the tracking algorithm.

3. Feedback Loop

Real-Time Adjustment:

- The sensors continuously monitor the sunlight intensity.

- The microcontroller updates the panel's position in real-time to ensure it remains aligned with the sun.

- This creates a feedback loop where the panel constantly adjusts its position based on the latest sensor data.

Chapter 6

Results and Discussions

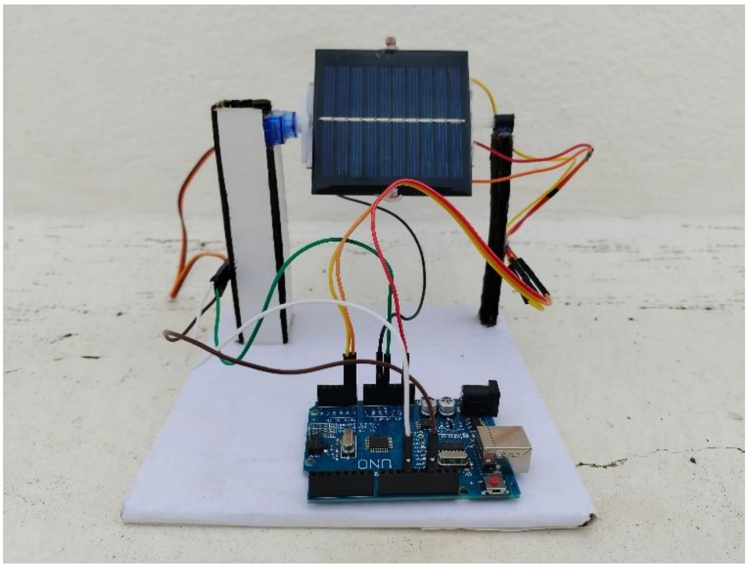

Fig.6.1: Front view of the model

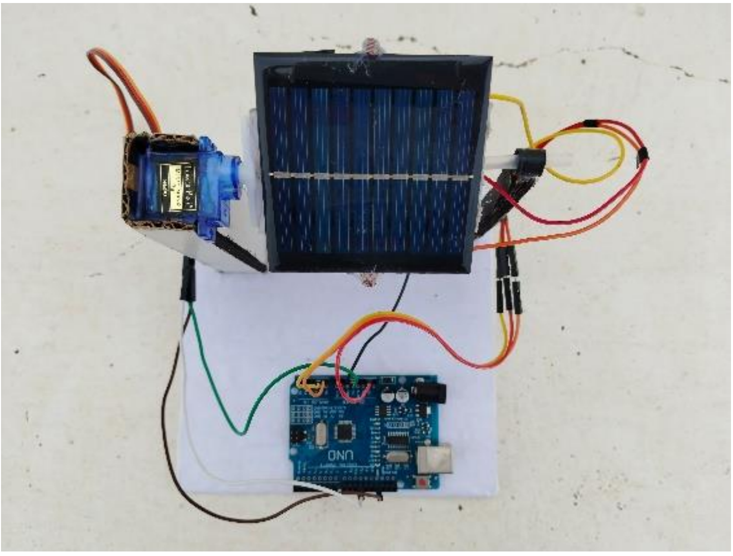

Fig.6.2: Top view of the model

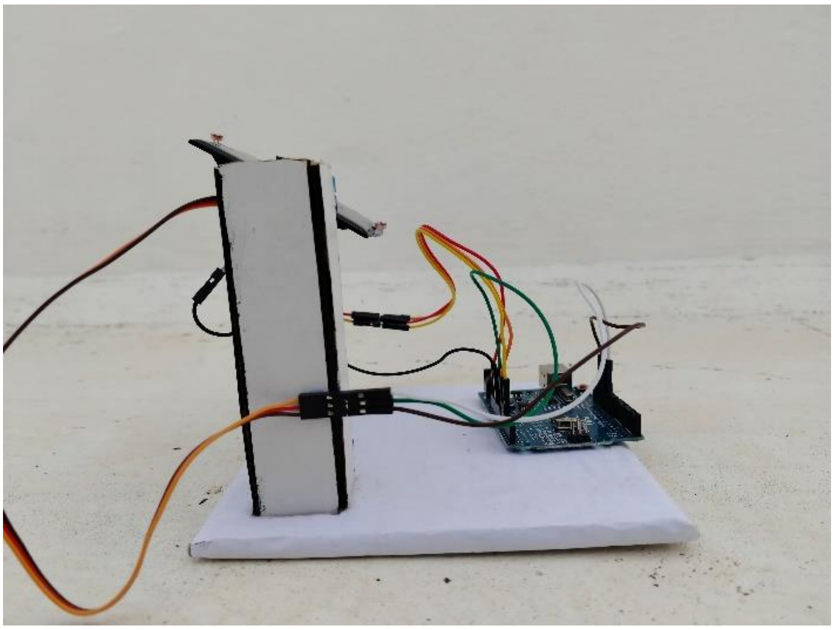

Fig.6.3: Side view of the model

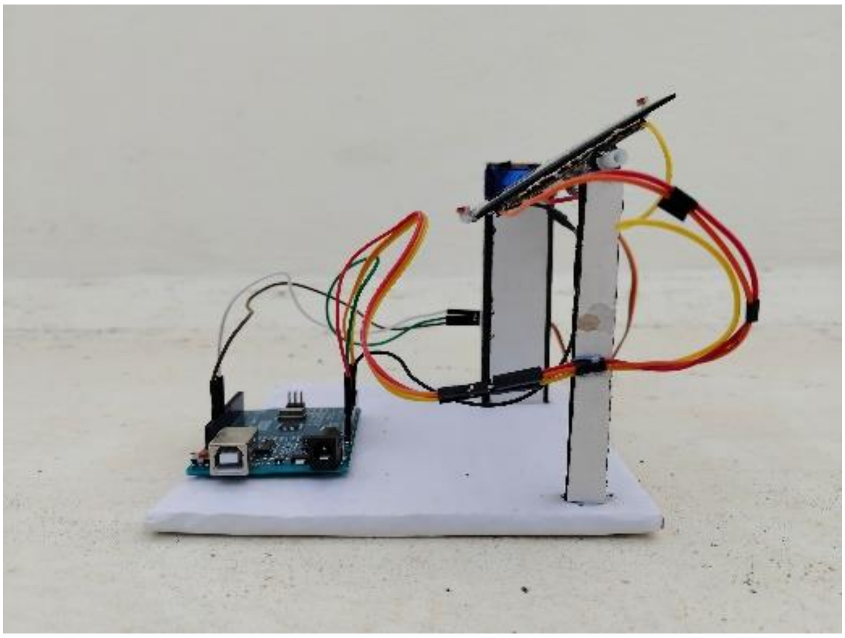

Fig.6.4: Side view of the model

- **Increased Energy Production**: Studies commonly show that single-axis solar trackers can increase energy production by approximately 20-30% compared to fixed solar panels. This improvement is due to the trackers' ability to orient panels optimally towards the sun throughout the day, maximizing solar irradiance capture.
- **Consistent Power Output**: Trackers maintain more stable and consistent power output profiles throughout the day compared to fixed panels, which experience fluctuations due to varying solar angles.
- **Improved Efficiency**: By aligning with the sun's position, trackers enhance the efficiency of solar panels, resulting in higher overall energy conversion rates.
- **Economic Benefits**: Despite higher initial costs for installation and maintenance, trackers can offer improved economic viability over time by generating more electricity and potentially reducing payback periods on initial investments.
- **Environmental Impact**: Increased energy production from trackers contributes to a reduction in greenhouse gas emissions and supports sustainable energy practices.
- **Versatility and Adaptability**: Trackers are suitable for various applications, including residential, commercial, industrial, and remote settings, where they can effectively meet diverse energy demands.

Chapter 7

Applications

- **Enhanced Energy Production**: Homeowners can install single-axis solar trackers to maximize the efficiency of their rooftop solar panels, ensuring higher energy output throughout the day.
- **Cost Savings**: The increased energy production can lead to significant cost savings on electricity bills over time.
- **Large-Scale Energy Generation**: Businesses and industries with large open spaces can utilize single-axis solar trackers to significantly increase their solar energy production, reducing their reliance on grid electricity.
- **Sustainability Goals**: Companies focused on sustainability can achieve their renewable energy targets more efficiently with the help of solar trackers.
- **Irrigation Systems**: Solar trackers can be used to power irrigation systems in farms, ensuring a reliable and efficient water supply for crops.
- **Remote Farming Operations**: In remote areas without access to grid electricity, solar trackers can provide a consistent energy source for various farming operations.
- **Remote Locations**: In remote areas where grid electricity is unavailable or unreliable, single-axis solar trackers can provide a dependable source of power for homes, schools, and clinics.
- **Emergency Backup**: Solar trackers can serve as an efficient backup power source in case of emergencies or natural disasters.
- **Street Lighting**: Solar trackers can power street lights and traffic signals, particularly in rural or remote areas, enhancing public safety and reducing electricity costs.
- **Educational Projects**: Solar tracker projects can be used as practical teaching tools in engineering and renewable energy courses.

Advantages

- **Optimal Sunlight Exposure**: Single-axis solar trackers follow the sun's path from east to west, maintaining an optimal angle of incidence. This maximizes the amount of solar radiation the panels receive throughout the day.
- **Higher Output**: By keeping the panels oriented towards the sun, single-axis trackers can increase energy production by 20-30% compared to fixed systems.
- **Consistent Performance**: Solar trackers reduce the impact of shading and low sun angles, ensuring more consistent energy output throughout the day.
- **Better Utilization of Space**: Trackers make better use of the available space by maximizing the energy harvested from each square meter of solar panels.
- **Higher ROI**: The increased energy production leads to higher returns on investment over the system's lifetime, offsetting the initial higher cost of the tracking system.
- **Versatile Applications**: Single-axis trackers are suitable for a wide range of applications, from residential and commercial to agricultural and remote installations.
- **Scalability**: These systems can be easily scaled up or down, making them ideal for both small-scale and large-scale solar projects.
- **Job Creation**: The installation, maintenance, and operation of solar tracking systems create jobs in the renewable energy sector.

Limitations

- **Installation Costs**: Single-axis trackers are more expensive to install than fixed solar panels due to the additional components such as motors and control systems.
- **Infrastructure Requirements**: The installation may require more complex infrastructure and foundations, adding to the initial investment.
- **Mechanical Components**: The moving parts of the tracking system, such as motors and gears, require regular maintenance to ensure proper functioning and longevity.
- **Potential for Failure**: Mechanical and electronic components can fail, leading to downtime and potentially costly repairs.

- **Land Use**: Single-axis trackers typically require more land area per panel compared to fixed systems due to the need for unobstructed movement and spacing between panels to avoid shading.
- **Exposure to Elements**: The mechanical components are exposed to environmental elements such as dust, rain, snow, and wind, which can cause wear and reduce the lifespan of the system.
- **Wind Load**: Trackers can be more susceptible to damage from high winds compared to fixed systems, requiring robust design and sometimes additional bracing.
- **Storage Systems**: To fully utilize the increased energy production, effective energy storage solutions are often needed, which can add to the overall system cost and complexity.

Chapter 8

Conclusions

Single-axis solar trackers are effective solutions for maximizing solar panel efficiency by adjusting their orientation to follow the sun throughout the day. This technology reliably increases energy production by 20-30% compared to fixed panels, ensuring consistent power output and optimizing energy capture during peak sunlight hours.

Their versatility makes them suitable for various applications, from residential rooftops to large-scale utility installations. However, the initial investment cost, maintenance requirements for mechanical components, and site-specific considerations such as terrain and shading can pose challenges. Despite these factors, the environmental benefits, including reduced reliance on fossil fuels and lower greenhouse gas emissions, highlight their role in sustainable energy solutions.

As technology evolves and costs decrease, single-axis solar trackers continue to emerge as practical options for enhancing the efficiency and sustainability of solar energy systems worldwide.

Chapter 9

Future Work

- **Advanced Algorithms**: Develop AI-driven tracking algorithms for precise solar panel orientation based on real-time data.
- **Energy Storage Integration**: Explore integrating with storage systems to optimize energy usage and grid interaction.
- **Durability and Cost Efficiency**: Improve materials and design to enhance durability and reduce manufacturing costs.
- **Urban Adaptation**: Design compact trackers suitable for urban environments without compromising efficiency.
- **Hybrid Systems**: Investigate combining single-axis tracking with other technologies for enhanced performance in diverse conditions.
- **IoT Integration**: Implement IoT for remote monitoring and control to maximize operational efficiency.
- **Environmental Impact**: Conduct assessments to minimize ecological footprint and environmental impact.
- **Grid Compatibility**: Develop solutions for seamless integration with smart grid systems for enhanced grid stability.
- **Education and Awareness**: Promote understanding and adoption of solar trackers through educational initiatives.
- **Technological Advancements**: Focus on continuous research to improve efficiency and functionality of solar tracking systems.

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