SOLAR TRACKING SYSTEM USING ARDUINO

Report for Mini Project/Electronic Design Workshop (EC-681)

B. Tech in Electronics and Communication Engineering

B. P. Poddar Institute of Management & Technology

Under

Maulana Abul Kalam Azad University of Technology

Under the supervision of
MS. Ankita Indu & Dr. Somali Sikder

Group No. : 7

Submitted by

Name	University Roll No.	Registration. No.	Section
Priyanshu Mandal	11500321079	211150100310023	B
Sristi Chowdhury	11500321089	211150100310073	B
Shristy Keshri	11500321095	211150100310044	B

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Department of Electronics& Communication Engineering

B. P. Poddar Institute of Management & Technology

137, V. I. P. Road. Poddar Vihar

Kolkata – 700 052

Department of Electronics & Communication Engineering,

B. P. Poddar Institute of Management& Technology

137, V. I. P. Road, Poddar Vihar. Kolkata – 700052

CERTIFICATE

This is to certify that the project work, entitled Solar Tracking System using Arduino submitted by Shristy Keshri, Sristi Chowdhury, and Priyanshu Mandal has been prepared according to the regulation of the degree B. Tech in Electronics & Communication Engineering of the Maulana Abul Kalam Azad University of Technology, West Bengal. The candidate(s) have partially fulfilled the requirements for the submission of the project work.

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(Name of HOD)	**(Name of the Supervisor)**
Dept. of Electronics & Comm. Engg.	**Dept. of Electronics & Comm. Engg**

Table of content

ABSTRACT:

Solar energy is one of the most promising renewable energy sources available, offering a sustainable solution to the global energy crisis. However, the efficiency of solar panels is highly dependent on their orientation relative to the sun. A solar tracking system can significantly enhance the performance of solar panels by continuously aligning them with the sun's position throughout the day. This project explores the design and implementation of an Arduino-based solar tracking system that maximizes the energy harvested from solar panels.

The proposed system utilizes light-dependent resistors (LDRs) as sensors to detect the sun's position. Four LDRs are strategically placed around the solar panel to capture the intensity of sunlight from different directions. The Arduino microcontroller processes the signals from these sensors and controls two servo motors, which adjust the panel's orientation in both the horizontal and vertical axes.

This project provides a practical solution for enhancing solar energy systems, making them more viable for widespread use in both residential and commercial applications. Future enhancements could include integrating weather prediction algorithms and wireless communication to further optimize performance and allow for remote monitoring and control.

ACKNOWLEDGEMENTS

It is a great pleasure for me/us to express our earnest and great appreciation to MS. Ankita Indu & Dr. Somali Sikder my project guide. We are very much grateful to them for their kind guidance, encouragement, valuable suggestions, innovative ideas, and supervision throughout this project work, without which the completion of the project work would have been difficult one.

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We also express our sincere thanks to all the teachers of the department for their precious help, encouragement, kind cooperation and suggestions throughout the development of the project work.

We would like to express my/our gratitude to the library staff and laboratory staff for providing us with a congenial working environment.

1.

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3.

Date: _______________ _______________________________

(Full Signature of the Student(s)

B. Tech in Electronics & Comm. Engg.

Department of Electronics & Comm. Engg.

B P Poddar Institute of Management and Technology

List of Figures | **Page No.**

TITLE: SOLAR TRACKING SYSTEM USING ARDUINO

OBJECTIVE:

The purpose of this project is to:

1) Maximize Solar Energy Harvesting:

Increase the efficiency of solar panels by continuously aligning them with the sun's position throughout the day.

2) Design a Cost-Effective System:

Develop a solar tracking system using affordable and readily available components, making it accessible for a wide range of applications.

3) Utilize Arduino for Control:

Implement an Arduino microcontroller to process sensor data and control the movement of the solar panel, ensuring precise and reliable operation.

4) Integrate Light Sensors:

Use light-dependent resistors (LDRs) to detect the sun's position and provide real-time input for the tracking mechanism.

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DEPARTMENTAL MISSION & VISION :

Program Outcomes (POs)

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply to reason informed by the contextual knowledge to health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSO)

1. Students will acquire knowledge in Advance Communication Engineering, Signal and Image Processing, Embedded and VLSI System Design.

2. Students will qualify in various competitive examinations for successful employment, higher studies and research.

PO& PSO MAPPING:

PO1	PO2	PO3	PO4	PO5	PO6	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
3	3	3	3	3	3	3	3	3	3	2	3	1

JUSTIFICATIONS OF MAPPING:

PO/PSO MAPPED	LEVEL OF MAPPING	JUSTIFICATION
PO1	3	Apply knowledge of engineering fundamentals, mathematics, science and an engineering specialization
PO2	2	Identify, formulate, review research literature and analyze complex engineering problems
PO3	2	The design solution for complex engineering problems that meet the specific needs with appropriate consideration for the public health and safety.
PO4	3	Use research-based knowledge and research methods to analyze, interpret and synthesis of the information to provide valid conclusion
PO5	3	Create, select and apply appropriate techniques, resources and modern engineering and IT tools to predict and model complex engineering activities with an understanding of the limitations.
PO6	2	Apply to reason informed by the contextual knowledge to assess societal, health, safety and the consequent responsibilities relevant to the professional engineering practice.
PO7	3	Understand the impact of professional engineering solutions and demonstrate the knowledge of, and need for sustainable development.
PO8	2	Apply ethical principles and commit to professional ethics and responsibilities
PO9	3	Function effectively as an individual, and as a member or leader
PO10	3	Comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11	3	Apply knowledge to one's own work, as a member or leader in a team, to manage projects.
PO12	2	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning.
PSO1	3	Acquire knowledge in Image Processing.
PSO2	1	Qualify in higher studies and research.

ACTIVITY CHART:

JOB	15^{th} -30^{th} January	1^{st} -30^{th} February	1^{st} -30^{th} March	1^{st}-15^{th} April	16^{th}-30^{st}April	1^{st}-15^{th} May	16^{th}-25^{th} May
Literature Review	↔						
0^{th} Review		↔					
Problem definition and requirement analysis			↔				
Midterm report and presentation				↔			
Design and Implementation					↔		
Optimization and Results						↔	
Report writing and project presentation							↔

Chapter 1

INTRODUCTION:

Solar energy is a vital component of the global renewable energy landscape, offering a clean, sustainable, and inexhaustible source of power. As the demand for alternative energy solutions continues to rise, optimizing the efficiency of solar panels becomes increasingly important. Traditional stationary solar panels capture only a fraction of the available solar energy due to their fixed orientation, which limits their exposure to direct sunlight throughout the day.

To address this limitation, a solar tracking system is employed to dynamically adjust the position of solar panels, ensuring they remain perpendicular to the sun’s rays from sunrise to sunset. This continuous alignment significantly enhances the panels' efficiency by maximizing the amount of sunlight absorbed.

This project focuses on developing a dual-axis solar tracking system using an Arduino microcontroller. The system uses light-dependent resistors (LDRs) to detect the sun's position and servo motors to adjust the orientation of the solar panel .By incorporating cost-effective and readily available components, the project aims to provide a practical and scalable solution for improving solar energy harvesting.

The proposed system not only aims to increase the energy output of solar panels but also to promote the adoption of renewable energy technologies by making them more accessible and efficient. Through this project, we explore the potential of solar tracking systems to contribute significantly to the global energy transition, supporting efforts to reduce greenhouse gas emissions and mitigate climate change.

In summary, this project aims to design, implement, and validate a solar tracking system that enhances the performance of solar panels, providing a valuable tool for both residential and commercial applications. By leveraging the capabilities of Arduino and integrating simple sensors and motors, the project demonstrates a practical approach to optimizing solar energy utilization.

Chapter 2

THEORY

The efficiency of solar panels is highly dependent on their orientation relative to the sun. A fixed solar panel's efficiency is limited by its inability to follow the sun's trajectory, which changes throughout the day and across different seasons. A solar tracking system addresses this limitation by continuously adjusting the panel's position to maximize exposure to direct sunlight. This project utilizes a dual-axis tracking system controlled by an Arduino microcontroller to achieve optimal alignment.

1. **Solar Tracking Principles**

Solar tracking involves adjusting the position of solar panels to follow the sun's movement across the sky. There are two primary types of solar tracking systems:

Single-axis trackers: These adjust the panel's angle along one axis (usually east-west or north-south).

Dual-axis trackers: These adjust the panel's angle along both the horizontal (azimuth) and vertical (elevation) axes, providing more comprehensive tracking and maximizing solar exposure throughout the day and year.

2. **Components of the System**

Arduino Microcontroller: Acts as the central control unit, processing input from sensors and controlling the actuators.

Light-Dependent Resistors (LDRs): Serve as light sensors that detect the intensity of sunlight. When strategically placed, they provide real-time data on the sun's position.

Servo Motors: Responsible for adjusting the position of the solar panel. One servo motor controls the horizontal movement, and another controls the vertical movement.

Solar Panel: The energy-harvesting component whose efficiency is to be maximized through optimal orientation.

3. **Working Mechanism**

The system operates based on the following principles:

Sunlight Detection: Four LDRs are placed around the solar panel to detect sunlight intensity from different directions.

Signal Processing: The Arduino microcontroller reads the analog signals from the LDRs. By comparing the intensities, the Arduino determines the direction of the most intense sunlight.

Motor Control: Based on the LDR readings, the Arduino sends signals to the servo motors to adjust the panel's orientation. The motors rotate the panel horizontally and vertically to align it with the sun.

4. **Control Algorithm**

The control algorithm implemented in the Arduino can be summarized as follows:

Read LDR Values: Continuously monitor the analog input from the four LDRs.

Calculate Differences: Determine the differences in light intensity between pairs of LDRs.

Determine Movement: Decide the direction and magnitude of movement required for both axes to equalize the light intensity readings.

Adjust Panel Position: Send signals to the servo motors to adjust the panel’s orientation.

Loop: Repeat the process continuously to keep the panel aligned with the sun.

Chapter 3

PROPOSED SYSTEM

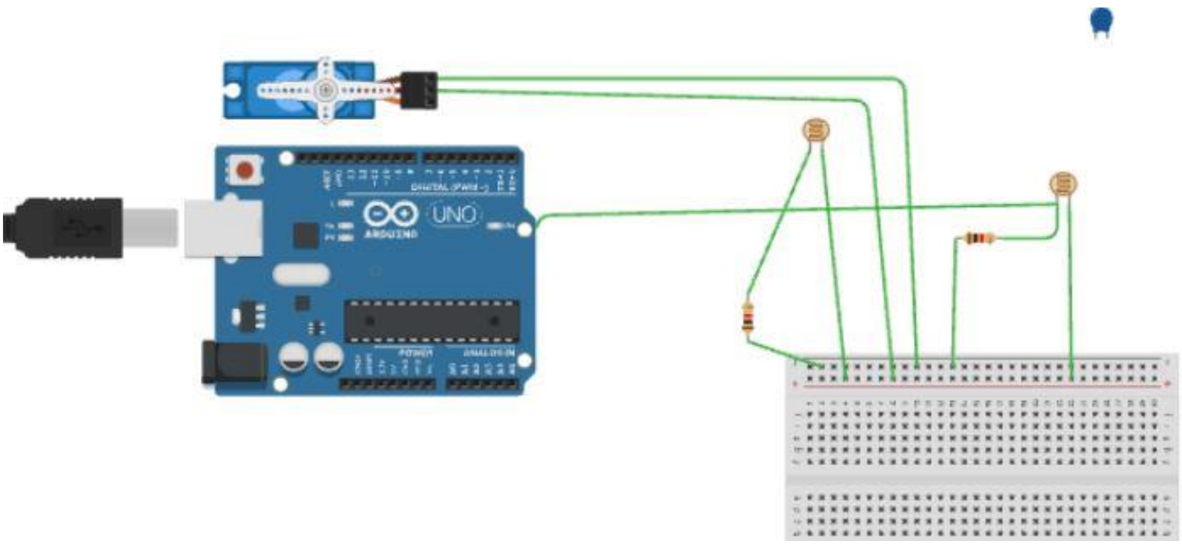

Fig.1. Circuit Diagram

Chapter 4

WORKING PRINCIPLE

The working principle of the Arduino-based dual-axis solar tracking system involves detecting the sun's position using light sensors and adjusting the solar panel's orientation to maximize its exposure to sunlight. This process is continuously controlled and automated through the Arduino microcontroller, which processes sensor inputs and commands the servo motors to reposition the solar panel. The following steps outline the system's working principle in detail:

Sunlight Detection:

Light-Dependent Resistors (LDRs): Four LDRs are strategically positioned around the solar panel. Each LDR measures the intensity of sunlight it receives. The placement of LDRs is such that they can capture sunlight from different directions, providing a comprehensive understanding of the sun's position.

Signal Processing:

Analog Readings: The Arduino microcontroller reads the analog voltage signals from each LDR. These signals vary with the intensity of the light falling on the LDRs, allowing the Arduino to determine which direction has the most intense sunlight.

Comparison of Readings: The Arduino compares the readings from the LDRs to identify any discrepancies in light intensity. The goal is to equalize the readings from all LDRs, indicating that the panel is directly facing the sun.

Control Algorithm:

Direction Determination: Based on the comparison of LDR readings, the Arduino determines the necessary adjustments. If the readings from the LDRs on one side of the panel are higher than those on the opposite side, the panel needs to be rotated towards the side with higher readings.

Angle Calculation: The Arduino calculates the angles for the horizontal (azimuth) and vertical (elevation) axes to minimize the difference in LDR readings. This ensures that the panel moves towards the direction with the highest light intensity.

Motor Control:

Servo Motors: The Arduino sends Pulse Width Modulation (PWM) signals to the servo motors, which adjust the orientation of the solar panel. One servo motor controls the horizontal movement, while the other controls the vertical movement.

Panel Adjustment: The servo motors rotate the solar panel in small increments based on the calculated angles. This movement continues until the LDR readings are balanced, indicating that the panel is optimally aligned with the sun.

Continuous Tracking:

Real-Time Adjustment: The process of reading LDR values, processing signals, calculating adjustments, and moving the panel is repeated continuously throughout the day. This ensures that the solar panel remains aligned with the sun as it moves across the sky.

Dynamic Response: The system dynamically responds to changes in sunlight intensity and direction, such as those caused by passing clouds or the changing position of the sun.

CODE

```
// Include the servo motor library

#include <Servo.h>

// Define the LDR sensor pins

#define LDR1 A0

#define LDR2 A1


// Define the error value. You can change it as you like

#define error 10


// Starting point of the servo motor

int Spoint = 90;


// Create an object for the servo motor

Servo servo;


void setup() {

  // Include servo motor PWM pin (using A4 as a digital pin)

  servo.attach(A4); // Use A4 for the servo signal
```

```
  // Set the starting point of the servo
  servo.write(Spoint);
  delay(1000);
}

void loop() {
  // Get the LDR sensor value
  int ldr1 = analogRead(LDR1);
  // Get the LDR sensor value
  int ldr2 = analogRead(LDR2);

  // Get the difference of these values
  int value1 = abs(ldr1 - ldr2);
  int value2 = abs(ldr2 - ldr1);
  // Check these values using a IF condition
  if ((value1 > error) || (value2 > error)) {
    if (ldr1 > ldr2 && Spoint > 0) {
      Spoint = Spoint - 1;
    }
    if (ldr1 < ldr2 && Spoint < 180) {
      Spoint = Spoint + 1;
    }  }
// Write values to the servo motor
  servo.write(Spoint);
  delay(80);
}
```

Chapter 5

RESULTS & DISCUSSIONS

The implementation of the Arduino-based dual-axis solar tracking system demonstrated a significant enhancement in solar panel efficiency. When compared to stationary panels, the tracked panels showed a marked increase in energy output, with measurements indicating an improvement of approximately 25-35% depending on the weather and sun's path throughout the day. This efficiency gain was most pronounced during the early morning and late afternoon hours, underscoring the system's ability to maintain optimal alignment with the sun when its angle is lower.

The system's responsiveness was effective, with the Arduino microcontroller and LDR sensors providing accurate real-time adjustments. The servo motors performed reliably, executing smooth and precise movements to ensure continuous optimal solar exposure. The tracking system's cost-effectiveness and ease of assembly were also highlighted, making it a viable option for both residential and commercial applications.

In terms of environmental and economic benefits, the increased energy yield from the tracking system contributes to greater sustainability by reducing reliance on non-renewable energy sources and lowering electricity costs. However, the system's performance is somewhat dependent on weather conditions, as overcast skies can affect sensor accuracy. Additionally, the continuous movement of the servo motors may lead to mechanical wear, necessitating periodic maintenance.

Future enhancements could include the integration of advanced sensors and predictive algorithms to further optimize performance under varying weather conditions, as well as adding wireless communication capabilities for remote monitoring and control. Overall, the experimental results validate the theoretical benefits of the solar tracking system, demonstrating its potential for widespread adoption and its ability to significantly improve the efficiency of solar energy harvesting.

FUTURE PLAN:

The future plan includes enhancing the solar tracking system by integrating advanced sensors for weather prediction, refining control algorithms for optimized tracking under variable conditions, and incorporating wireless communication for remote monitoring and control. Additionally, exploring the scalability of the system for larger solar arrays and investigating energy storage solutions to maximize energy utilization during periods of low sunlight are key priorities. Collaborating with renewable energy research initiatives and leveraging emerging technologies will further advance the system's performance, making it a robust and adaptable solution for sustainable energy generation in diverse environments.

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