DUAL AXIS SOLAR TRACKING SYSTEM

A PROJECT REPORT

submitted by

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BONAFIDE CERTIFICATE

Certified that this project report titled "**DUAL AXIS SOLAR TRACKING SYSTEM"** is the bonafide work of "**YASHVANTH NG (210701319), VISHAL D (210701313), VIMAL K B (210701309)"** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

A dual axis solar tracking system utilizing Arduino technology provides an efficient and cost-effective means of maximizing solar energy absorption for photovoltaic panels or solar thermal collectors. The system employs two motors, one for horizontal (azimuth) movement and the other for vertical (elevation) adjustment, allowing the solar panel to follow the sun's trajectory across the sky for optimal energy capture. It is a low-cost system that provides better efficiency. Here the analog signals are analyzed and controlled by Arduino Uno. This automatic system is completely programmed. The energy obtained from the sun is collected using a solar panel by arranging four LDRs. The amount of energy obtained and positions at two LDRs on the same axis are compared and analyzed to decide the movement of the servo motors which moves the panel to the direction where more energy is available. The Arduino microcontroller serves as the brain of the system, processing data from light sensors to adjust the panel's orientation throughout the day. By maintaining the panel perpendicular to the sun's rays, the system enhances energy output, improves efficiency, and can reduce overall energy costs. The implementation of such a system demonstrates the potential for smarter, more sustainable solar energy solutions.

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CHAPTER 1

INTRODUCTION

Nowadays the depletion of conventional energy resources forced many researchers to search for various renewable energy sources. Among the non-conventional resources available, solar energy has the greatest potential to be converted into electrical energy. Converting solar energy into electrical energy signifies one of the favorable technologies, providing dirt-free, dependable with negligible environmental impact. Solar energy is well known as an unrestricted, endless source, and involves no pollution filtrates or greenhouse gas emissions.. The solar photovoltaic industry has been improving very well recently. Most of the currently installed PV systems are of the fixed-tilt mounting design, of which the PV 2 modules are tilted at an optimal angle. For this type, these PV modules are reduced to severe cosine losses during harnessing of solar energy, especially early in the morning, and in the late evening. This project employs a sun-tracking solar panel to track the maximum rays using LDRs. This is more acceptable when compared to the light-sensing method which may not be accurate. The main aim of this work is to design a system that could track the sun with solar panels in a more efficient way compared to the existing system. This is obtained by coupling the LDR sensors with a servo sg motor to the solar panel such that the panel maintains its face always perpendicular to the sun to generate maximum energy. This is achieved by employing a programmed ARDUINO IC.

1.1 Motivation

- **Maximized Energy Harvesting:** A dual-axis solar tracking system allows solar panels to follow the sun's path more precisely throughout the day, leading to increased energy production compared to a fixed or single-axis system.

- **Increased Efficiency:** By keeping solar panels oriented toward the sun at all times, the system can produce more power and maximize the return on investment for solar energy installations.

- **Cost-Effective:** Arduino is an affordable and accessible platform for building the control system, making it feasible for hobbyists and professionals alike.

- **Environmental Benefits:** Increased solar energy production contributes to a reduction in reliance on fossil fuels, promoting a cleaner and more sustainable energy source.

1.2 Objectives

- **Maximize Energy Production:** The main goal of the system is to increase the solar panel's exposure to sunlight, thereby maximizing the energy output from the solar panels.

- **Precision Tracking:** The system should accurately track the sun’s movement across the sky, adjusting the solar panel's position in both the horizontal (azimuth) and vertical (elevation) axes.

- **Automated Control:** Utilize Arduino to automatically control the system’s movement based on sensors that detect the sun’s position or pre-programmed algorithms.

CHAPTER 2

LITERATURE REVIEW

1. The US Patent no. 0215199 A1 [2007] by Robert H. Dold describes a two axis solar tracker capable of withstanding extreme weather conditions. The solar tracker includes a solar array, a frame, a base, a pivot frame, and a first and second actuator. The solar array is mounted to the frame and captures sunlight.

2. The US patent No. 0308091 [2008] by Ronald P Corioclaimsas an object of the his invention to mechanically link multiple solar trackers in a large array configuration so that they may operate in unison, driven by a single motor and tracker controller, whereby the mechanical linkage system is designed such that it must only be capable of withstanding the relatively low forces.

3. Qiang Xiei's US Patent No.0051017 A1 [2010] refers to a solar collector which may receive and direct solar radiation onto a photovoltaic (or, solar) cell. A concentrating solar collector may also convert the received solar radiation into a concentrated radiation beam prior to directing the radiation onto the solar cell.

4. A US patent No. 0293861 by William F Taylor [2009] describes a conventional solar tracker employing controllable moveable solar panels to expose them continuously to the path of the sun both throughout the day and throughout the year.

2.1 Existing System

The Single-axis Solar Tracking System is considered as an existing system. It consists of a microcontroller, sensors, voltage regulator, driver circuit, dc geared motor, and solar panel frame axis. Here the sensors are arranged in such a way that the solar panel rotates in only one degree of freedom. When the sun travels from east to west, the sun's highest position also changes. Hence this system is only helpful in tracking either of the axes. Due to this ideal energy is not provided to the solar panel. As a result, the output energy is also not ideal.

2.1.1 Advantages of the existing system

- **Simpler Design:** Single-axis systems have fewer moving parts and motors compared to dual-axis systems, making them simpler in design and easier to maintain.

- **Lower Cost**: Due to their simpler design and construction, single-axis tracking systems are generally less expensive than dual-axis systems.

2.1.2 Drawbacks of the existing system

- Lower energy output during sunny conditions, when compared to dual-axis trackers and during cloudy days the efficiency of the single-axis tracker, is almost close to the fixed panel.
- It involves less technological advancement.
- It also requires an additional focus on company stability and bankability in large-scale implementation. When it involves getting projects financed, these systems are more complex and thus are seen as a better risk from a financier's viewpoint.
- Even with the evolution in reliability, there is more maintenance required than a traditional fixed rack, though the quality of the solar tracker can play a role in how much how frequently often this maintenance is required.

2.1 Proposed System

The Dual-axis solar tracking system that tracks the maximum sun rays using LDR sensors. This block diagram is designed according to track solar rays in both axes all day. The system includes a power supply, Arduino, two servo motors, four LDR sensors, battery, charge controller, and solar panel. This total system is designed in a form so that it tracks the sun efficiently and obtains maximum solar energy from the sun and increases the output efficiency and provides better performance even in cloudy conditions. The power supply is given to Arduino. The LCD is also powered by the Arduino. The analog information is transferred from LDRs to Arduino. According to the Arduino program, instructions are given to the servo motors and these motors eventually provide movement to the solar panel.

2.2.1Advantages of the proposed system

- **Automated Adjustments**: The automated nature of dual-axis tracking reduces the need for manual interventions and minimizes operational oversight.
- **Maximized Energy Production:** Dual-axis tracking aligns the solar panels perpendicular to the sun at all times, maximizing energy absorption throughout the day and year.
- **Increased Efficiency:** By keeping the panels directly facing the sun, dual-axis tracking systems can increase the efficiency of the solar panels by up to 40% compared to fixed systems.

CHAPTER 3

SYSTEM DESIGN

3.1Development Environment

3.1.1 Hardware Requirements

Arduino UNO

Bread Board

LDR sensor

Solar panel

Resistor

Servo sg motor

Jumper wires

Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online.

Arduino UNO

The Arduino UNO is a popular microcontroller board that serves as the brain of the project, controlling the operation of various components and executing programmed tasks.

Breadboard

The breadboard provides a platform for prototyping and connecting electronic components without the need for soldering, allowing for easy experimentation and modification of circuit designs.

LDR sensor

An LDR (light-dependent resistor) sensor, also known as a photoresistor, is an electronic component that changes its resistance in response to the intensity of light. This type of sensor is commonly used in various applications, including in dual-axis solar tracking systems, to measure ambient light levels and determine the sun's position.

Solar-panel

A solar panel, also known as a photovoltaic (PV) panel, is a device that converts sunlight directly into electrical energy using the photovoltaic effect. Solar panels are composed of a series of solar cells, which are typically made from semiconductor materials such as silicon. When sunlight strikes the cells, it excites electrons, creating an electric current.

Resistor

A resistor is a passive electronic component that limits the flow of electrical current in a circuit. It is one of the fundamental building blocks of electrical circuits and is used to control voltage, divide current, and protect other components in a circuit.

SG90-Servo-Motor

The SG90 servo motor is a popular and widely used micro servo motor known for its small size, lightweight, and affordability. It is a type of motor that provides precise control of angular position.

Jumper wires

Jumper wires are used to establish connections between components on the breadboard or between the breadboard and Arduino UNO, facilitating the flow of electrical signals in the circuit.

3.1.1Software Requirements

- Arduino IDE

CHAPTER 4

PROJECT DESCRIPTION

The project aims to develop an automated setup designed to optimize solar energy capture by adjusting the orientation of solar panels to follow the sun's movement across the sky. Utilizing an Arduino microcontroller, the system receives input from light-dependent resistors (LDRs) that measure sunlight intensity from different directions. Based on this data, the Arduino sends signals to two servo motors, which control the azimuth and elevation angles of the solar panels. This precise adjustment allows the panels to maintain a perpendicular position relative to the sun throughout the day, maximizing energy production. The system enhances efficiency, increases energy yield, and reduces the need for manual intervention, providing a cost-effective and sustainable solution for solar energy harvesting.

4.1 SYSTEM ARCHITECTURE

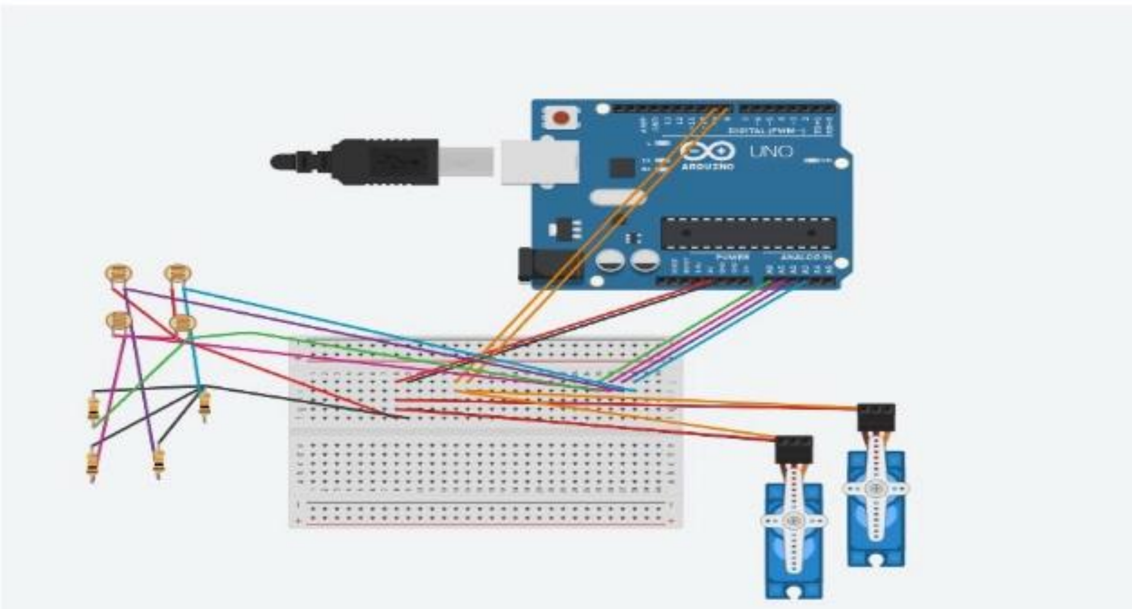

Fig 4.1 System Architecture

4.2 METHODOLOGY

- The methodology for a dual-axis solar tracking system involves using sensors and a microcontroller to continuously adjust the orientation of solar panels to face the sun directly throughout the day. Light-dependent resistors (LDRs) or other sensors are strategically positioned around the solar panel to measure sunlight intensity from different directions. The sensor data is sent to the microcontroller, which processes the readings and calculates the optimal position for the solar panels based on where the sunlight is strongest. The microcontroller then sends control signals to servo motors or other actuators, which adjust the azimuth and elevation of the solar panels accordingly. This real-time adjustment maximizes energy production by keeping the panels aligned with the sun, regardless of the time of day or season. This process is repeated continuously, ensuring efficient and optimal solar energy harvesting throughout the day.

CHAPTER 5

RESULTS AND DISCUSSION

In a dual-axis solar tracking system, the primary result is a significant increase in solar energy production compared to fixed solar panel systems. By dynamically adjusting the orientation of the solar panels to follow the sun's path across the sky throughout the day, the system ensures that the panels are always optimally positioned for maximum sunlight exposure. This leads to improved efficiency and higher energy output, potentially increasing overall solar panel performance. The tracking system's real-time adjustments allow for continuous optimization, even in changing weather conditions. Additionally, the system can adapt to seasonal variations in the sun's path, maintaining optimal performance year-round. Discussion on the system may include the system's successful performance in terms of energy output, reliability, and automation, as well as any challenges encountered such as calibration, maintenance requirements, or response to environmental conditions. Future improvements might focus on integrating advanced sensors or machine learning algorithms to further refine the tracking system's accuracy and efficiency.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Conclusion

Our dual-axis solar tracking system is a highly effective solution for maximizing solar energy harvesting by continuously adjusting the orientation of solar panels to follow the sun's path across the sky. This system offers increased energy production and efficiency by maintaining optimal angles for solar exposure throughout the day and across seasons. By using sensors like LDRs and components such as SG90 servo motors, dual-axis tracking systems enable precise, automated panel positioning, thereby enhancing the overall performance and return on investment of solar installations. This technology plays a crucial role in advancing sustainable energy solutions and can be applied to a range of solar projects, from residential rooftops to large-scale solar farms.

6.2 Future Work

- **Enhanced Sensor Technologies**: Developing more advanced sensors (e.g., solar position sensors, infrared sensors) for better sun tracking and increased accuracy.

- **Integration of AI and Machine Learning:** Utilizing AI and machine learning algorithms to optimize solar panel positioning based on historical data, weather forecasts, and current environmental conditions.

- **Advanced Materials**: Exploring the use of lightweight and durable materials for the construction of tracking systems to reduce wear and tear and enhance longevity.

APPENDIX

SOFTWARE INSTALLATION

Arduino IDE

To run and mount code on the Arduino NANO, we need to first install the Arduino IDE. After running the code successfully, mount it.

Sample code

```
#include <Servo.h>

Servo myservo1, myservo2;
int LDR1 = A0, LDR2 = A1, LDR3 = A2, LDR4 = A3;
int rRDL1 = 0, rRDL2 = 0, rRDL3 = 0, rRDL4 = 0;
int max1=0, max2=0, max3=0;
int ser1 = 80, ser2=0;

void setup() {
  myservo1.attach(9);
  myservo2.attach(8);

  Serial.begin(9600);
  myservo1.write(ser1);
  myservo2.write(100);
}

void loop() {

  rRDL1 = analogRead(LDR1) / 100;
  rRDL2 = analogRead(LDR2) / 100;
  rRDL3 = analogRead(LDR3) / 100;
  rRDL4 = analogRead(LDR4) / 100;

  max1 = max(rRDL1, rRDL2);
  max2 = max(rRDL3, rRDL4);
  max3 = max(max1, max2);

  //Serial.println(String(max3));
```

```
  //Serial.println(String(rRDL1) +", "+String(rRDL2) +", "+String(rRDL3) +",
"+String(rRDL4));


  if(rRDL1<max3 && rRDL2<max3)
  {
    if(ser1<140)
      ser1+=1;
    myservo1.write(ser1);
  }
  if(rRDL3<max3 && rRDL4<max3)
  {
    if(ser1>0)
      ser1-=1;
    myservo1.write(ser1);
  }

  if(rRDL2<max3 && rRDL3<max3)
  {
    Serial.println("servo2 +" + String(ser2));
    if(ser2<180)
      ser2+=1;
    myservo2.write(ser2);
  }
  if(rRDL1<max3 && rRDL4<max3)
  {
    Serial.println("servo2 -" + String(ser2));
    if(ser2>0)
      ser2-=1;
    myservo2.write(ser2);

  }
  delay(15);


}
```

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