# Dual Axis Solar Tracking System using Arduino

## Abstract

The Dual Axis Solar Tracking System using Arduino is an automatic solar panel alignment mechanism designed to maximize solar energy absorption. By employing four Light Dependent Resistors (LDRs) and two servo motors controlled by an Arduino Uno, the system continuously adjusts the solar panel’s orientation in both horizontal and vertical directions to face the sun directly. The project aims to improve energy efficiency and reduce manual adjustments, making it suitable for renewable energy applications and academic demonstration purposes.

## 1. Introduction

Solar energy is one of the most promising renewable energy sources, but its efficiency largely depends on the angle at which sunlight strikes the solar panels. Fixed solar panels cannot utilize the maximum available sunlight throughout the day. To overcome this limitation, a solar tracking system is used to automatically orient the panels toward the sun. In this project, a dual-axis solar tracker is implemented using an Arduino Uno, Light Dependent Resistors (LDRs), and servo motors.

## 2. Objectives

The main objectives of this project are:  
- To design and implement a dual-axis solar tracking system using Arduino.  
- To sense sunlight direction using LDR sensors.  
- To automatically adjust the solar panel orientation for maximum sunlight exposure.  
- To simulate and validate the system operation in Proteus before hardware implementation.

## 3. Literature Review

Previous solar tracking systems have utilized microcontrollers and LDRs to track sunlight direction. Single-axis trackers adjust the panel in one direction, while dual-axis trackers move both horizontally and vertically. This project builds on those designs by using the Arduino Uno microcontroller and servo motors for precise control, providing greater efficiency and flexibility in solar energy harvesting.

## 4. Components Used

* Arduino Uno – microcontroller for system control.
* LDR Sensors (4x) – to detect sunlight intensity from four directions.
* Resistors (100kΩ each) – to form voltage dividers with LDRs.
* Servo Motors (2x) – for horizontal and vertical panel movement.
* Connecting wires and breadboard – for circuit connections.
* Power supply (5V DC).

## 5. Circuit Explanation

The system consists of four LDR sensors connected in a voltage divider configuration with four 100kΩ resistors. Each LDR-resistor pair outputs a varying voltage depending on the intensity of light falling on it. The outputs from these dividers are fed to the analog input pins A0–A3 of the Arduino Uno. The Arduino compares the light intensity values and controls two servo motors connected to digital pins (e.g., 9 and 10) to adjust the solar panel’s position accordingly. The horizontal servo aligns the panel East-West, while the vertical servo controls North-South movement.

## 6. Working Principle

When sunlight falls unevenly on the four LDRs, their resistance values change, resulting in different voltage readings. The Arduino continuously reads these values and determines which direction the panel should move to balance the readings. If LDR1 and LDR2 receive more light than LDR3 and LDR4, the horizontal servo moves to align the panel toward LDR3 and LDR4 until balance is achieved. Similarly, vertical adjustments are made based on top and bottom LDR pairs. This ensures the solar panel remains perpendicular to sunlight throughout the day.

## 7. Arduino Code

// --- Dual Axis Solar Tracker (Stepwise Rotation) ---

// Author: Austin

// Components: 4 LDRs, 2 DC motors, Arduino Nano

// LDR1 & LDR2 -> control Motor1

// LDR3 & LDR4 -> control Motor2

// Each motor rotates briefly once depending on which LDR group sees more light.

const int LDR1 = A0;   // Left group

const int LDR2 = A1;

const int LDR3 = A2;   // Right group

const int LDR4 = A3;

const int motor1 = 10;   // Motor 1 control pin

const int motor2 = 9;  // Motor 2 control pin

int threshold = 100; // minimum difference to trigger movement

int motorRunTime = 2400; // duration of rotation (milliseconds)

void setup() {

  pinMode(LDR1, INPUT);

  pinMode(LDR2, INPUT);

  pinMode(LDR3, INPUT);

  pinMode(LDR4, INPUT);

  pinMode(motor1, OUTPUT);

  pinMode(motor2, OUTPUT);

  Serial.begin(9600);

}

void loop() {

  // Read all LDR values

  int ldr1 = analogRead(LDR1);

  int ldr2 = analogRead(LDR2);

  int ldr3 = analogRead(LDR3);

  int ldr4 = analogRead(LDR4);

  // Compute average light for each group

  int leftLight  = (ldr1 + ldr2) / 2;

  int rightLight = (ldr3 + ldr4) / 2;

  Serial.print("Left: "); Serial.print(leftLight);

  Serial.print("  Right: "); Serial.println(rightLight);

  // Compare brightness difference

  int diff = abs(leftLight - rightLight);

  if (diff > threshold) {

    if (leftLight > rightLight) {

      // Left LDRs are brighter → rotate Motor1 once

      digitalWrite(motor1, HIGH);

      digitalWrite(motor2, LOW);

      delay(motorRunTime);      // run motor briefly

      digitalWrite(motor1, LOW);

    }

    else {

      // Right LDRs are brighter → rotate Motor2 once

      digitalWrite(motor2, HIGH);

      digitalWrite(motor1, LOW);

      delay(motorRunTime);

      digitalWrite(motor2, LOW);

    }

  }

  else {

    // Light levels nearly equal → no movement

    digitalWrite(motor1, LOW);

    digitalWrite(motor2, LOW);

  }

  delay(300); // small delay before next check

}

## 8. Simulation Results

The simulation was performed in Proteus software. The system responded accurately to varying light intensities on the LDRs. The servo motors adjusted their angles to reorient the solar panel toward the brighter side. This behavior verified that the Arduino control logic and sensor interfacing were correctly implemented.

## 9. Advantages

* Improved energy efficiency compared to fixed panels.
* Automatic adjustment to sunlight direction.
* Simple and cost-effective design.
* Easily implementable using Arduino platform.

## 10. Applications

* Solar farms for maximizing power generation.
* Home solar systems for better energy harvesting.
* Educational and research projects in renewable energy.
* Automation and robotics projects involving light tracking.

## 11. Conclusion

The Dual Axis Solar Tracking System using Arduino successfully demonstrates how sunlight can be efficiently captured by dynamically adjusting the orientation of solar panels. Using LDRs as light sensors and servo motors for movement, the system maintains an optimal position relative to the sun, improving overall energy output. Simulation results confirm the system’s effectiveness and potential for real-world renewable energy applications.

## 12. Future Scope

The project can be enhanced by integrating solar power measurement sensors to quantify energy gains, implementing wireless data monitoring, or adding weather-based automation. Further developments could include machine learning algorithms for predictive sun-tracking and automatic cleaning mechanisms for solar panels.

## 13. References

* Arduino Official Documentation: https://www.arduino.cc
* The Engineering Projects – Proteus Simulation Tutorials
* Research papers on Solar Tracking Systems using Microcontrollers (IEEE, Elsevier)