DUAL SOLAR TRACKING SYSTEM

Abstract

The Dual Solar Tracking System is designed to automatically orient a solar panel toward the direction of maximum sunlight intensity throughout the day. This project enhances energy efficiency by ensuring that the solar panel receives the greatest possible solar radiation. The system employs an Arduino Nano microcontroller, four Light Dependent Resistors (LDRs) for light sensing, and two DC motors with inbuilt drivers for movement along both horizontal (azimuth) and vertical (elevation) axes. Powered by a rechargeable battery, this system demonstrates an intelligent and automated solution for maximizing solar power generation.

1. Introduction

Solar energy is one of the most abundant and renewable sources of energy. However, the efficiency of solar panels is significantly influenced by their orientation relative to the sun. Stationary solar panels cannot track the sun’s movement, resulting in reduced energy capture. A solar tracking system solves this problem by continuously adjusting the position of the panel to face the sun. The dual-axis tracker used in this project moves the panel in two directions — east–west and up–down — ensuring optimal solar alignment at all times. This project was implemented using an Arduino Nano, which serves as the brain of the system, interpreting light intensity data from LDR sensors and commanding the DC motors accordingly.

2. Objectives

1. To design and construct a dual-axis solar tracking system controlled by an Arduino Nano.
2. To increase the solar panel’s efficiency by maintaining perpendicular alignment with sunlight.
3. To demonstrate practical application of sensors and automation in renewable energy systems.
4. To provide a low-cost and energy-efficient alternative to fixed solar installations.

3. System Overview

The Dual Solar Tracking System consists of three main sections:
- Sensing Unit: Four LDRs are arranged in a cross formation on the solar panel surface to detect light intensity from different directions.
- Control Unit: The Arduino Nano processes signals from the LDRs and determines the direction in which the panel should move.
- Actuator Unit: Two DC motors (each with inbuilt motor drivers) physically rotate the panel along the horizontal and vertical axes.

The system is powered by a battery connected to the Arduino and the motors, allowing it to operate independently without external power.

4. Block Diagram and Description

Block Diagram Components:
1. LDR Sensors (x4): Detect sunlight intensity.
2. Arduino Nano: Processes sensor inputs and outputs motor control signals.

3. Motor Drivers (inbuilt): Amplify control signals to drive the DC motors.
4. DC Motors (x2): Rotate the panel horizontally and vertically.
5. Solar Panel: Captures solar energy.
6. Battery: Supplies power to the system.

Operation: The LDRs generate varying voltages depending on the light intensity they receive. The Arduino compares these signals and determines which motor to activate to align the panel toward the brightest light source.

5. Circuit Description

Each LDR forms a voltage divider with a resistor, producing an analog voltage signal proportional to light intensity. These signals are connected to the Arduino’s analog input pins (A0–A3). The Arduino analyzes the readings: if the light intensity on the right LDR is greater than the left, the horizontal motor rotates eastward. If the upper LDR detects more light than the lower one, the vertical motor tilts upward. When the light levels on all sensors are nearly equal, the panel remains stationary, indicating correct alignment.

6. Working Principle

The system continuously reads LDR values and compares them in pairs (East vs. West, Up vs. Down). The Arduino then outputs logic signals to the respective motor terminals to rotate the solar panel in the required direction until balance is achieved. As the sun moves, the balance shifts, causing the system to readjust automatically, ensuring maximum sunlight exposure throughout the day.

7. Arduino Code Summary

The Arduino program performs the following steps:
1. Reads analog signals from four LDRs.
2. Compares the readings between opposite pairs (East–West, North–South).
3. Determines which motor should rotate and in which direction.
4. Sends PWM control signals to motor driver inputs.
5. Continuously repeats the loop for real-time tracking.

Example logic:
```
if (LDR_East > LDR_West) rotateHorizontal(EAST);
else if (LDR_West > LDR_East) rotateHorizontal(WEST);
if (LDR_Top > LDR_Bottom) rotateVertical(UP);
else if (LDR_Bottom > LDR_Top) rotateVertical(DOWN);
```

8. Results and Testing

The system was tested under various light conditions. During morning hours, the panel aligned eastward and gradually rotated westward by evening. Under cloudy conditions, minimal movement occurred since the light intensity was nearly uniform. Observations showed that the system significantly improved solar exposure compared to a fixed panel. The dual-axis configuration allowed better adaptation to sunlight changes throughout the day and across seasons.

9. Conclusion

The Dual Solar Tracking System successfully demonstrated automatic adjustment of a solar panel toward maximum sunlight using Arduino Nano, LDRs, and DC motors. It improved the efficiency of solar energy capture and provided a practical example of renewable energy automation. The use of affordable components makes it suitable for both educational and real-world applications.

10. Recommendations

1. Future versions can include a real-time clock module to reset the panel to the east position at dawn.
2. Integration of solar charging circuitry for the battery can make the system fully autonomous.
3. Use of servo motors may improve precision and reduce power consumption.
4. Implementation of data logging for solar performance analysis.

11. References

1. Arduino Documentation – www.arduino.cc
2. Solar Tracker Research Papers – IEEE Explore
3. TutorialsPoint: Solar Tracking Systems
4. Electronics Hub: Dual Axis Solar Tracker Projects