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COMPARATIVE STUDY OF DUAL AXIS SUN TRACKERS FOR BETTER SOLAR PANEL EFFICIENCY

Jeet Naskar
Electronics&CommunicationsEngineering
University of Engineering & Management
Kolkata, India
naskarjeet29@gmail.com

Sayed Rahaman
Electronics&CommunicationsEngineering
University of Engineering & Management
Kolkata, India
sayedrahaman240@gmail.com

Rohit Dey
Electronics&CommunicationsEngineering
University of Engineering & Management
Kolkata, India
rohitdeyx1118@gmail.com

Shreya Nag
Electronics&CommunicationsEngineering
University of Engineering & Management
Kolkata, India
snshreya20@gmail.com

Maumita das
Electronics&CommunicationsEngineering
University of Engineering & Management
Kolkata, India
maumita.das@uem.edu.in

Abstract— **This study introduces an easy and automatic way to increase the energy efficiency of solar panels. In this project, a dual-axis detachable sun training system has been developed to track the sun continually. In our proposed model, four LDR sensors have been used to continuously detect the position of the sun by comparing light intensity on different sides of the LDR's. As per the LDR signal, two servomotors have been integrated to move the solar panel, and an AVR-based microcontroller, ATMega8A, has been used as a processing unit for the LDRs and also to drive the servos accordingly. A heavy-duty plastic frame has been developed to hold all the components together, including the solar panel.**

Keywords: — *Solar panels, Sun tracking, LDR, Servo, AVR.*

I. INTRODUCTION

Future fossil fuel shortages will inevitably result in a global interest in renewable energy sources among scientists, technologists, financiers, and policymakers. Hydroelectricity, bio-energy, solar, wind, and geothermal energy, tidal power, and wave power are some of the new energy sources that are gaining prominence. All of them are considered as advantageous fossil fuel substitutes because of their renewable nature. Solar photovoltaic (PV) energy is one of the most readily available forms of energy among those categories. The energy efficiency of a solar panel depends on the sun and its movement from its position in the sky. Because of that, the effectiveness will not be constant for the whole day, and the sun will change its position season-wise. A dual-axis solar panel is such a device that can be used to deal with such problem. It is adevice with a tracking mechanism that can adjust the position of its solar panel to follow and track the sun's movement in both the directions (horizontal and vertical). It has two axes, primary and secondary, and is made of components like sensors, motors, controllers, etc. It can be utilized to increase the absorption of solar energy and convert it to electricity. It has certain advantages over a single-axis tracker, such as greater solar energy generation, being more flexible and reliable, having more accurate tracking, and being able to adjust to different seasons and weather conditions

Over the years, the development of solar tracking technology has seen support from numerous people as well as organizations, and through this process, a solar tracking system with dual-axis was achieved. John Perlin, during the 1970s, developed one of the very first solar tracking devices, which was a single-axis tracking device that used to track the sun as it moved across the sky [1]. Despite the advancements, the design had its own limitations, as it could track the sun's movement only in one direction and was not optimized for obtaining the maximum solar energy. The researchers at the Sandia National Laboratories in the United States, after multiple studies, discovered a more capable and optimized tracking system during the 1980s that benefits from a mechanism using dual-axis. The tracking system was able to track the movement of the sun in both horizontal as well as vertical direction, which made it easier to put the solar panel in a position that was best suitable to absorb and gather the maximum solar energy all through the day. After that, there have been a lot of advancements and innovations in the technology of dual-axis solar tracker mechanisms, which include various design changes and implementations for such systems all over the world. Since then, dual-axis solar tracking systems have become widely recognized as one of the most effective and efficient technologies used to boost solar energy absorption and improve the overall efficiency of solar power systems found today [5] [6] [7].

A solar tracking system is a device that aligns a solar panel in a sun-facing position using a mechanism. Because the sun moves around with time and changes its position, it is used to track the sun's position. After performing several model tests, it was found that, in comparison to photovoltaic (PV) modules mounted on a fixed system; PV modules mounted on a tracking system received more solar radiation over a particular critical threshold. Additionally, utilizing a variable tracking system instead of a fixed system is estimated to boost solar panel energy absorption by as much as 60% [9]. This can also be used to boost the yearly power production by as much as 40% [10].

Despite all the advantages, it is still a challenge for solar PV energy to take its place as a conventional source of energy in the market. There are a lot of shortcomings that remain a problem while utilizing the production power of such systems in regions with limited solar radiation. Even though there are lots of advancements in the technologies from various manufacturers, there is still a lot of scope for optimizing the architecture and mechanism of such systems to obtain their maximum potential, which will take some time.

The project's objective is to construct a smaller-scale light tracking system prototype, but the concept may be used for any solar energy system in real life. A quantitative assessment of the tracking system's performance in comparison to a system with a fixed mounting mechanism is also anticipated from this study.

II. METHODOLOGY

A. Apparatus used

Its key components include solar panels (photovoltaic panels), a microcontroller, light-dependent resistors (LDRs), servo motor, and resistors. The solar panels convert sunlight into electricity, while the microcontroller calculates the optimal panel position based on sensor input. LDRs detect sunlight intensity, and the servo motor adjusts panel orientation. Resistors play a role in control circuitry, ensuring stability.

B. Working principle

The working principle of the model fully depends on the workings of LDR. As mentioned earlier LDR is a semiconductor based variable resistor which change its resistance depending on intensity of light emitted on to it.

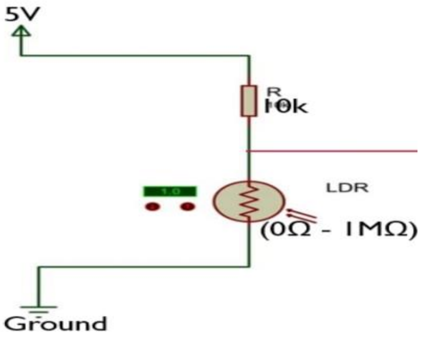

Figure.1: Voltage Divider (Intensity to voltage converter)

Usually, higher light intensity causes lower resistance. Utilizing this feature, a voltage divider has been formed using a LDR and a 10k resistor, where LDR relates to ground and 10k resistor relates to +Vcc (5v).

This Volta divider has used here as light intensity to voltage converter.

The voltage can be operated using this formula

$$V = v_{in} \times \frac{10k}{10k + R_L}$$

Where V_{in} = 5v, R_L = Resistance of LDR

From the above equation we can say that when light intensity increases R_L decrease and divider voltage also increases and when light increases decrease R_L increase and divider voltage decrease.

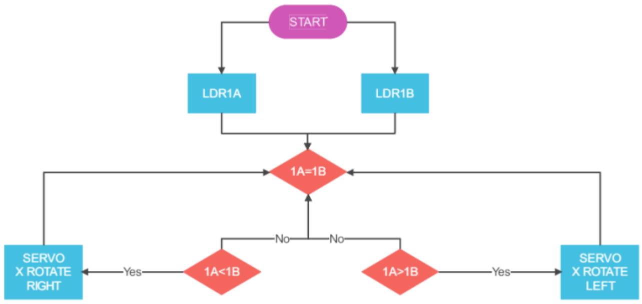

Figure.2: Flow Chart (Working)

Four of this LDR voltage divider have been incorporated with solar panel in four sides of the panel (Two in X axis and two in Y axis) to determine which side is facing more intense light. An AVR based ATMega8A microcontroller has been used for this divider voltage comparison. Using analogRead() function it can measure the divider voltage and after comparing voltages it can decide which side of solar panel is facing more intense light.

After that ATMega8A microcontroller generates a PWM signal to control servo motor accordingly. Servo changes its position depending on the width of the pulse. When it detects the position where light intensity is same in all sides the controller holds this position until sun changes its position.

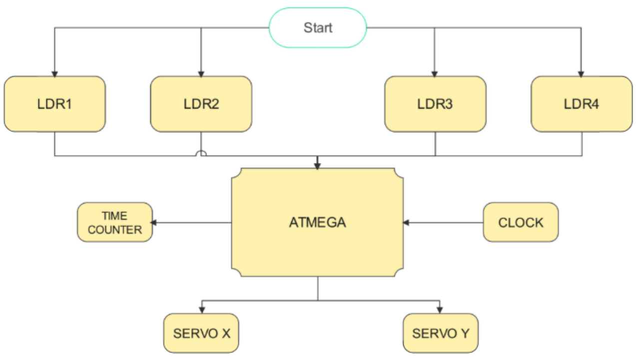

Figure.3: Setup Connection

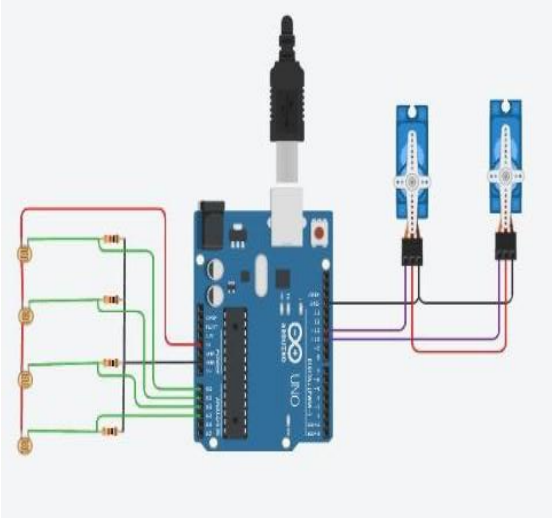

Figure.4: Circuit Diagram

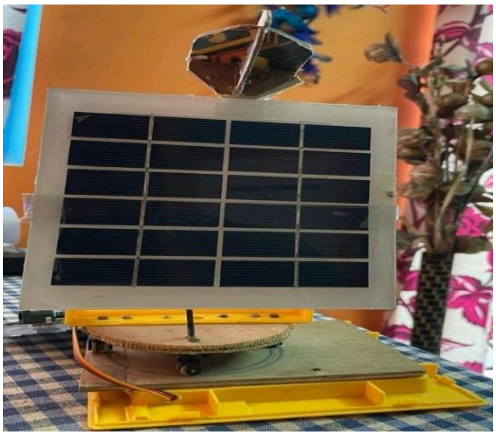

Figure.5: setup image

III. RESULTANDANALYSIS

The solar panel system underwent rigorous testing during a sunny day. Observations were made by tracking both the angle of sunlight and the solar panel's orientation relative to the ground. The measurements spanned from 0 degrees to 90 degrees, followed by the reverse from 90 degrees to 180 degrees (or -0 degrees).

Observation table: -

SL.NO	Time	ANGLE B/W SUNLIGHT & GROUND	ANGLE B/W SOLAR PANEL & GROUND
1	6 a.m.	5°	85°
2	8 a.m.	30°	60°
3	10 a.m.	60°	30°
4	12 a.m.	90°	0°
5	2 p.m.	60°	30°
6	4 p.m.	30°	60°
7	6 p.m.	15°	75°
8	7 p.m.	5°	85°

Also the efficiency of the system has been tested by taking voltage reading of the panel at day time. The test has been conducted from 6am (rise time) to 6pm (set time) in 1 hrs interval.

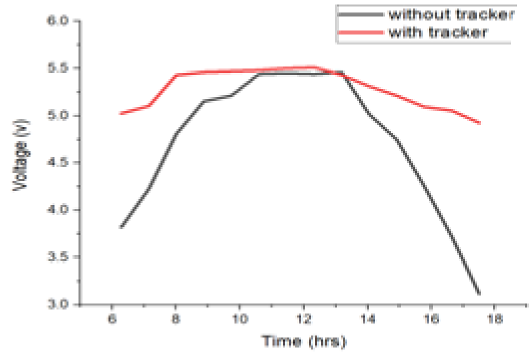

Figure.5: Efficiency comparison

From the above graph, it has been observed that the tracking system significantly increased efficiency by helping the solar panel harness stable voltage throughout the day.

IV. CONCLUSION

Dual-axis sun tracker solar panel maximizes solar energy collection by precisely tracking the sun's movement. It can result in more energy harnessing than fixed panels. These systems are suitable for both residential and commercial applications, offering quicker return on investment (ROI), reduced environmental impact, and long-term cost-effectiveness. Studies have shown that dual-axis tracking systems can generate up to 60 percent more energy compared to fixed-mounted systems and up to 30 percent more than single-axis solar trackers.

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