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Solar Tracking System

Puja A. Chavan (Cholke), Tushar M. Nasery, Janhavi H. Tiwari, Ankur D. Tripathi, Ashlesha S. Todkar, Shreya S. Tonape

Department of Engineering, Sciences and Humanities (DESH), Vishwakarma Institute of Technology, Pune, 411037, Maharashtra, India

Abstract — Most of us use solar panels in our life every day to obtain some form of energy. However, the solar panels we use are stationary. These solar panels do not align to the Sun as it goes across the sky. This results in loss of energy every day. A Solar Tracking System helps us utilise maximum daylight by aligning itself in orientation with the Sun's current position. Using sensor-based tracking, the system senses if the PV panel is directly exposed to sunlight or not. If not, it gives corrective outputs through servo motors. The angle by which the correction is to be made is calculated with the help of a set of formulae, taking inputs from the light dependant sensors. The analogue inputs of the LDRs are converted to digital signals by the Arduino. This results in the solar panel facing directly to the Sun. As a result, more area of the solar panel is exposed to direct sunlight, thus harnessing more solar energy during the day. The Solar Tracking System described in this paper uses dual-axis functionality which enables it to move on both horizontal and vertical axes. This facilitates adjustment for changing seasons as well, when the vertical angle of the PV panel has to be changed as well.

Keywords — Arduino Uno, dual-axis, higher efficiency, sensor-based, Solar tracking system

I. INTRODUCTION

Renewable energy has been accepted worldwide as the future sources of energy these days. Solar energy is one of the most sustainable and renewable energy sources. Stationary solar panels do not utilise most sunlight and hence, solar trackers are the most efficient source.

Solar trackers utilise different electronic parts to situate the panels to get the most immediate sunlight conceivable to maximise the sun powered irradiance on the board. Solar trackers produce more power when it is exactly perpendicular to the sun. This is due to increased direct exposure to the Sun. Solar trackers use various electrical components to orient the panels to receive sunlight as directly as possible in order to maximise the solar irradiance on the panel.

Solar Trackers can arrange the panels or reflectors so that there could be minimum angle between the sun and the panel, thereby receiving the most irradiation possible and increasing the performance and efficiency of the solar plant.

A solar tracking system has been implemented using various different methods in various climatic conditions. We have adopted some of the methods and taken help of the existing research done on the same, to improve this concept. There exist several types of solar tracking systems which have limiting features in them. Some use solar mapping instead of sensor-based tracking [1][4] which decreases the accuracy. A few also use single-axis systems [5][6] which restrict the movement to one axis. Others do not use an Arduino [3], are in different climatic conditions [2] or cover the theory of the concept. It has also been found that the accumulation of dust particles on stationary solar panels may result in loss of energy [8]. Another study shows us that the efficiency of a two-axis solar tracker is increased by around 33% in comparison to a fixed solar panel [9]. Despite the limitations, this research work provides us with immense knowledge about the circuitry, calculations, mechanical methods of design, structures, graphs and results.

II. Problem Statement

To utilise the energy lost due to the misalignment of the solar panels in orientation with the Sun. Stationary solar panels lose energy when the Sun is not perpendicular to their surface. A solar tracking system helps us solve this problem.

III. Objectives

The main objective of this project is to track the Sun and rotate the solar panel accordingly, in order to receive sunlight to the fullest extent always during the day. In this project, we will design an effective sensor array to track the movement of the sun and find the angle of exposure to sunlight for better collection of solar energy. This will help in achieving lower cost, will maximise power per unit area of a solar panel and generate more power output than stationary solar panels.

IV. Methodology

A. Hardware Requirements and Construction

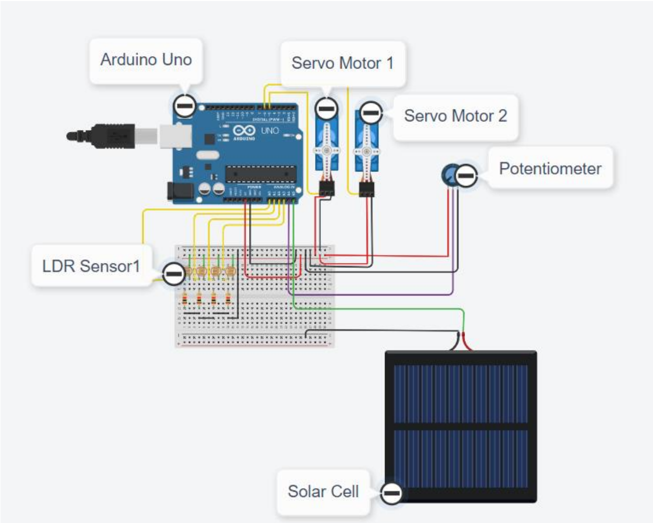

Fig.1. Hardware Requirements. Here, we can see all the components required to make the proposed solar tracking system.

The components used in the Solar tracking System are Micro-servo motors, Light Dependent Resistors (LDR), Resistors, Potentiometer, Arduino Uno, Arduino IDE, Solar cell. The servo motors help in the angular moment of the Solar cells so that it closely follows the Sun. An LDR is a resistor whose resistance decreases with increase in light. Therefore, it is used as a sensor to detect the solar cell's position with respect to the sun. Further, the potentiometer calibrates readings from the LDRs. The Arduino Uno board is used as a microcontroller.

B. System Architecture

A typical solar tracking system is composed of a solar panel, servo motors, four LDR sensors and an Arduino Uno which controls the dual axis solar tracker. A servo motor which is also referred to as servo is used to rotate the solar panel according to the positioning of the sun whose positive terminal is connected to the arduino and negative to the ground. The LDRs are placed in four corners of the solar panel which detect the intensity of light. They are connected to the arduino through analogue pins to send the information. The microcontroller is used to convert analogue values into digital and to control the servo motors using pulse width modulation (PWM) to track the Sun.

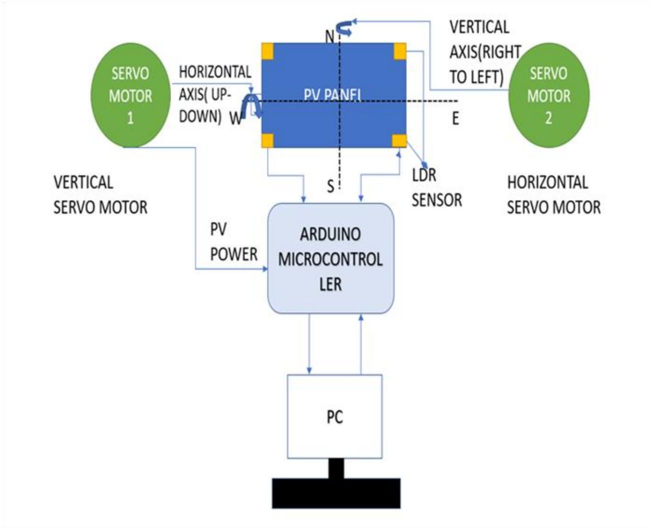

Fig. 2. System Architecture. The given figure shows us the basic outline of the functioning of the system. We can see the inputs, the processing unit and the outputs.

C. Algorithm

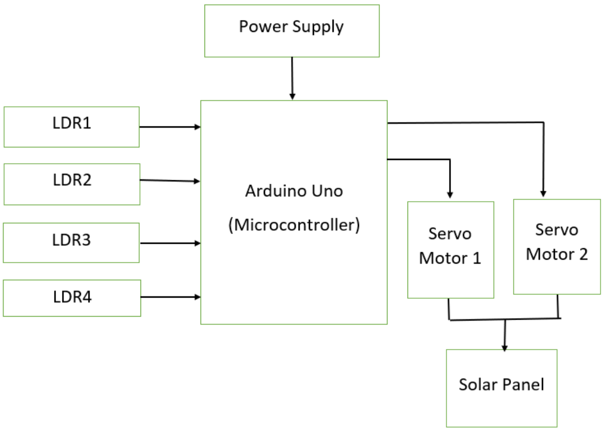

Fig. 3. Algorithm. In this figure, we can see the algorithm based on which the tracker works.

The Solar Tracking System consists of a solar panel, Arduino microcontroller and sensors. For this framework to work there should be emanation of light from the Sun. The LDRs fill in as the sensors to recognize the power of light entering the sunlight-based chargers. The LDR then, at that point, sends data to the Arduino microcontroller. The servo engine circuit is then built. There are 3 pins in the servo motor in which the positive one is linked with the Arduino Uno microcontroller. The servo motor has 3 pins; the positive, negative and signal. The positive pin is attached to the +5V of the arduino uno circuit board. The negative of the servo is associated with the ground. The element on the servo is associated with the simple point on the microcontroller. A potentiometer is associated to manage the speed of the servo engine. So as the LDRs sense more light, the servo motors move the Solar panels in the direction of more light.

D. Characterization

The code is designed in such a way that it takes the values from the sensors and performs calculations to send a signal to the servo motors in order to align the solar panel to the Sun. The input is taken from the LDRs placed at all four corners of the panel. If an LDR is not exposed to enough light, signals are sent to the servo motors to move in a direction which will expose it to more sunlight.

V. MATHS

The energy harnessed by a solar panel is dependent upon the cosine of the area exposed to the Sun directly. In stationary solar panels, the average value of cosine in between 0° to 180° can be calculated with the help of the following equation:

$$|< cos\ \theta >| = \left| \frac{\int_0^{\pi/2} cos\theta d\theta}{\int_0^{\pi/2} d\theta} \right| = \frac{2}{\pi} \qquad (1)$$

Here, θ is the angle between the normal of the solar panel and the Sun. From this equation, we find that the modulus of the mean value of cosine in between 0° to 180° is approximately 0.6366. However, with the help of our system, the mean value of cosine is 1, as θ is always 0°.

VI. RESULTS AND DISCUSSIONS

This paper discusses the advantages of dual-axis solar trackers over stationary solar panels. It tells us how the system works and how it helps in harnessing solar energy more efficiently than their stationary counterparts. The text also discusses other implementations of this system and tells us how this system has tried to overcome the limitations of those previous implementations.

VII. ADVANTAGES

1) The dual-axis solar trackers generate more electricity than the single-axis solar trackers and the fixed solar panels due to increased exposure to sunlight. This increase can vary from 10% - 25% depending upon the geographical location.
2) Long term maintenance concerns are reduced due to the advancement in technology and reliability in electronics and mechanics.
3) Some states offer time of use rate plans for solar trackers. These power generators are purchased by people only at the peak time of the day. The implemented system can help overcome this by harnessing energy from the Sun throughout the day.
4) There are many types of solar trackers such as single-axis and dual-axis trackers, all of which can be an appropriate fit for a unique site. The type of solar tracker which is best suited for a certain solar installation depends on some factors such as installation size, weather conditions, electrical requirements, etc.

VIII. LIMITATIONS

The dual-axis solar trackers have a shorter lifespan and lesser reliability. It is more expensive than their stationary counterparts and requires more maintenance.

IX. FUTURE SCOPE

Despite the fact that the solar tracking system is more efficient than the stationary solar panels, it will have to be maintained. To overcome these issues, it can be modified further in the future, such as by using battery management systems or by using a spring of proper stiffness. These changes can reduce the maintenance cost. There are a few issues like costly material that is utilised in planning these Solar trackers. This can be replaced with some inexpensive alternatives. The land that is used for stationary solar panels is not enough for solar trackers, since it keeps changing its position. Hence, it requires more space. Therefore, these trackers can be placed on the rooftops of offices and industries.

X. CONCLUSION

The installation of this system in place of traditional stationary solar panels will help us in utilising daylight more efficiently. This will especially be useful in areas where the day doesn't last for a long time. This is beneficial in achieving lower costs, continuous energy supply throughout the day and higher sustainability.

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