Investigation and analysis of a Solar Tracking Panel powered by an Arduino

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Abstract - The solar panels' efficiency can be improved by identifying various ways to follow the sun's position, a work comprised of the discovery of numerous methods of tracking the sun, as well as analysis. The challenge is to build a system that increases electricity generation by at least 35% and no more than 45%. The control circuit is done using the microcontroller. Once the control circuit has determined the orientation of the solar panel, it next places the motor in order to achieve this best position. The project was created to help combat the difficulty of finding affordable, accurate, and power-efficient microcontroller-based tracking systems that fit inside an allotted time and budget. It is expected to automatically track the sun's position in the sky during the day and to greatly reduce the amount of power that is used throughout the night. An algorithm has been implemented to solve the motor control and it has been programmed into C on Arduino IDE.

Keywords - Solar Panel, Arduino, LDR

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INTRODUCTION

People used to get their energy from sources like fossil fuels, but in the modern era, depletion of these resources prompted experts to investigate into renewable energy sources. For all of the good it can do, solar energy is remarkably hopeful. For generating heat, light, and electricity, solar technologies utilize the sun. The solar energy potential is tremendous. Even though there is an endless supply, harvesting it is difficult due to the limited array cell efficiency. We've been discussing climate change a lot in the past few years. A large number of scientists are working to develop alternatives to fossil fuels, more ecologically friendly fuels, and cleaner sources of energy due to the environmental impact of fossil fuels. Clean and abundant solar energy is available.

In addition to systems that use microprocessors and sensors, there are four more varieties of systems, all of which use either a sensor and time/date or a sensor and bifacial solar cell. **Kelly and Gibson (2009) as well as Lim et al. (2014)** report that Compared to an immovable panel, the current achievement is 47 percent better. Using a single-axis system, **Ponniran et al. (2011)** employed a similar strategy. There are several attempts at a solar tracker to increase the performance of PV systems, most recently by **Engin&Engin (2013)**. The system was made up of two distinct software and hardware components. A microcontroller, motor driving circuitry, control unit, pyranometer, GPS, and anemometer were all included with the hardware. A Microcontroller-based technique described by **Elagib et al. (2013)** predicts the position of the Sun using solar maps. Although this process is straightforward, the system in place must be continuously modified as the position of the solar map changes. A single-axis solar tracking system developed by **Abadi et al. (2014)** utilized a microprocessor. A single-axis sun tracking system using an RF transmitter is proposed by **Kabalc et al. (2015)**. But, it has a steep expense due to the need of a PC. A solar tracking system was created by **Kumar and Arjun (2016).** This solar tracking was a single-axis setup that had five sensor points and an LDR sensor to help control the motor's spin. In the study "Tracking Solar Positions Using Global

Positioning System (GPS). **Altayeb et al. (2018)** suggested a two-axis solar tracking system that uses GPS to detect the location of the tracker and the sun. The accuracy of this positioning approach can be disputed, although this system's complexity is attributed to the usage of GPS. The conceptualization of numerous options, followed by the design, development, and optimization of the selected concept, was the key in the creation of an intelligent single axis solar tracking device developed **by Munanga et al. (2020)**.

The significant reason for the current exertion is to plan a framework that could follow the sun for a sun based board. Light sensors (LDRs) that can recognize the measure of daylight that arrives at the sun oriented board are what permit this to be refined. The LDRs look at the qualities they acquire. It is likewise watching out for approaches to make sun powered boards more effective.The usage of solar tracking is prevalent. To orient the solar array for optimal power output, the tracking mechanism moves and positions the array. There are various strategies to minimize losses, including identifying sources of them and devising measures to offset them. MPPT, or optimizing the power output from the solar panel by keeping it at the P-V knee point, is the process of applying MPPT. By utilizing a solar tracking system, you may enhance the electricity production of your solar panels by 35% to 55%. In locations around the equator where the sun appears to move little, single-axis trackers are preferable. The efficiency of the tracking system will dictate how much the efficiency is increased.

AN EXAMINATION OF FIXED AND TRACKED COLLECTORS, UTILIZING THE CONCEPT OF NUMERICAL ANALYSIS

Solar collectors can use stationary or mobile collectors to capture the radiant energy. Fixed collectors are usually placed where there is the most sunshine, and when the sun is in a satisfactory position. Know the location of the sun's position during different seasons and at different times of the year when utilizing these collectors. The average daily energy per unit area is determined, disregarding atmospheric conditions.

$$dw = IS.\,dt\ kWh/m^2 \quad (1)$$

On the area that is perpendicular to the direction of radiation, S is the projection area.

$$S = S_0 \cos\theta \quad (2)$$

Where θ the quantity $-\frac{\pi}{2}$ to $\frac{\pi}{2}$ represents the interval in which the sun passes over the sky during the day and where the sun's angular velocity equals the variable ω

$$\omega = \frac{2\pi}{T} = 7.27 \times 10^{-5}\ rad/sec \quad (3)$$

The theoretical extracted energy of a collector that is perpendicular to the radiation is calculated assuming that the maximum radiation intensity is falling on the region. $I = 1100\ W/m^2$. Let's assume we ignore the effects of the atmosphere. We can calculate how much energy each square metre would absorb for a full day as follows: $W = IS_0t = 13.2\ kWh/m^2$ daily. It may be inferred that for the tracking collector, a greater amount of energy is gained from the second experiment. To be sure, in both of these circumstances, the sun's rays go through a thick layer of the atmosphere. Regardless, the tracking collector receives more energy from the sun over time.

OPTIMAL PERFORMANCE OF SOLAR PANELS

The most often used metric for comparing performance of one solar cell to another is the efficiency. The amount of energy generated by the solar panel is inversely proportional to the amount of energy absorbed from the sun. While observing the solar cell's performance will play a part, the other variable that affects the performance of the solar cell is the spectrum and intensity of the sunlight striking the cell, as well as the temperature of the cell. To determine which device is more efficient, we must carefully regulate the conditions. To calculate the efficiency of solar cells, divide the percent of solar radiation converted to electricity by the total power received. In short, it is defined as:

$$P_{max} = V_{OC} I_{SC}\ FF\ \eta - \frac{V_{OC} I_{SC}\ FF}{P_{in}} \quad (4)$$

Where

$V_{OC} = Open - circuit\ Voltage$

$I_{SC} = Short\ circuit\ current$

$FF = Fill\ Factor$

$\eta = Efficiency$

The input power for efficiency calculations is $1\ kW/m^2$ or $100\ mW/cm^2$Thus the input power for a $100 \times 100\ mm^2$ cell is $10\ W$.

PROCUREMENT OF DESIGN AND IMPLEMENTATION

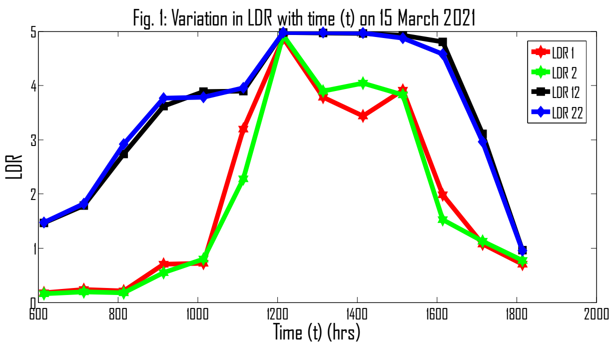
Using two LDRs to maintain the same light intensity is known as “stability position.” When the light source moves, like in the sun, the LDR's intensity changes and this is compensated for by employing voltage dividers, or voltage dividers in conjunction with the change in the light source's intensity. The microcontroller's built-in comparator is used to monitor the voltage fluctuations and the motor is used to rotate the solar panel so as to keep pace with the light source. A servo motor is frequently employed in a wide variety of applications. The typical shape and efficient energy use of these objects are what characterise them. This contains the servo circuitry inside the motor unit and has a movable shaft with a gear affixed to it. The motor is set using an electronic signal that tells the engine how much shaft movement it should generate. Most of the servo motor's components include: The servomotor has three major components: a tiny DC motor, a potentiometer, and a control circuit. The motor is attached to the control wheel using gears. In order to govern the quantity of movement and needed direction, the control circuit adjusts the resistance of the potentiometer, as the motor turns. To ensure the motor does not produce power, the shaft of the motor must be fully turned to the idle position. The motor should be turned in the correct direction if the shaft is incorrect. The position of the desired target is transferred electrically via the signal wire. The faster the motor moves, the greater the gap between the desired location and the actual location. The slower the motor turns, the closer it is to its intended location. Otherwise, it accelerates quickly. Proportional control is also referred to as simple control. A servo is started by transmitting a number of electrical pulses, known as PWM, through the control wire. This illustrates the concept of pulse, the maximal pulse, and the repetition rate. With the servos, it is normally possible to rotate the movement to only 90 degrees in either direction for a total of 180 degrees of movement. When you have the equal amount of rotation in both the clockwise and counter-clockwise directions, the motor is in neutral. The PWM signal to the motor controls the shaft's position, and how long the signal is sustained affects how far the rotor will turn. Once every 20 milliseconds, the servo motor expects to see a pulse that tells it how far to turn. One millisecond is 1/1,000th of a second. In the instance that the pulse was less than 1.5 milliseconds long, it would point directly toward the 0 degree mark; while if the pulse was longer, it would travel to the other side of the 0 degree mark. Servos are useful for applications that demand strong torque. The servos retain torque up to 90% of the rated torque. The overall efficiency of their business are between 80 to 90 percent. In most servos, the maximum rated torque may be applied for brief periods of time, which provides ample capacity to draw from when needed. Additional features include: they are quiet, are in C and DC, and are vibration-free. In the 1980s, microcomputers with tiny circuits built by VLSI manufacture became commonplace. When embedded in a device, microcontrollers are known as embedded controllers because they contain the circuitry that support them, as well as the microcontroller itself. Small-scale computers, sometimes known as microprocessors, are available in varying word lengths (4bit, 8bit,16bit,32bit,64bit and 128 bit microcontrollers are available today).

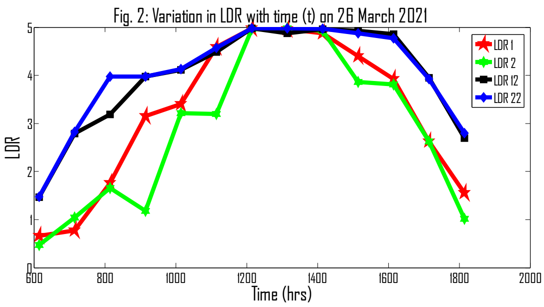
NUMERICAL RESULTS AND DISCUSSION

Data was collected for two days, after which it was written down. Light intensity influenced the outputs of the LDRs. There are also digital pins (0 (RX) and 1 (TX)) on the Arduino board, as well as a USB connection to the computer. Pins 0 and 1 can be utilized for digital input or output, if these functionalities are employed. The built-in serial monitor in the Arduino development environment can be used to communicate with the Arduino board. A programme was built that would enable the LDRs to collect data every hour. At the intervals specified, the LDR values should be read and recorded. In general, the LDRs do an adequate job of measuring the intensity of light, and this makes them a suitable gauge for the strength of the solar panel's output that reaches the surface. The consequence is that it will be feasible to differentiate between the tracking panel and the fixed panel through monitoring the light intensity at a specific time. The power output of the solar panel is related to the light intensity. Two LDRs (light-dependent resistors) were connected to an electronic circuit so that readings can be taken every hour. This could have been prevented if the EEPROM hadn't arrived early. When the board is turned off, the values held in the memory remain. The ATmega 328P has 1024 bytes of RAM and a small EEPROM storage section. The Arduino board was used to connect the microcontroller to the computer, so the values could be obtained at the end of the day. These two pins are connected to the RX and TX pins. To allow the microcontroller to retrieve the recorded values, the code for reading them is put into the microcontroller. To convert these numbers into volts, the various values are obtained and then transformed. The microprocessor gets its 5V power from the Vcc to the microprocessor and the LDRs. This microcontroller (ATmega 328P) has 1024 voltage steps, using 5 volts. When values are digitized, they will be between 0 and 1023. Using the relation below, the conversion is done.

$$LDR\ output = \frac{Digital\ equivalent\ output \times 5}{1023}\ volts \qquad (5)$$

The data from the graph analysis shows that LDR 12 and LDR 22 are both used in the tracking panel, but have more energy stored in them than LDR 1 and LDR 2. This additional energy is derived from the panel's exposure to sunlight over the course of the day, and the panel which is parallel to the sunlight. From graphs 1 and 2, it can be seen that the readings of the tracking panel and fixed panel were practically equal for the time between 1115 hours and 1315 hours. Additionally, LDR12's energy is 1.462 while LDR1's energy is 0.181.





CLOSING COMMENTS

The main goal of the project is to make solar panel more efficient utilizing a tracking system. Tracking mechanism managed by an algorithm implemented in the software on an Arduino-compatible microcontroller that solves the motor control and is afterwards put into C-language code on an Arduino IDE. Literature and present study show that tracking of solar energy is relevant to solar panel efficiency. This will lead to better overall solar panel efficiency.

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