DUAL AXIS SOLAR TRACKING SYSTEM WITH REALTIME MONITORING SYSTEM

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Abstract**—** The development of techniques for using renewable energy resources is at the forefront of public concern due to the twin dangers of energy depletion and global warming. Among the most promising renewable energy sources is solar energy. Sun trackers may significantly increase a photovoltaic (PV) system's ability to produce power. In order to guarantee stable system performance, this work presents a unique design for a dual-axis sun tracking photovoltaic system that makes use of basic electrical circuits, a four-quadrant light dependent resistor (LDR) sensor, and feedback control theory. To achieve solar tracking, the suggested system makes use of a special dual-axis AC motor and a standalone PV inverter. The control implementation is a straightforward and efficient technological innovation. Furthermore, a laboratory prototype with reduced size is built to confirm the scheme's viability. Experimental evidence supports the Sun tracker's efficacy. To sum up, the study's findings might be very helpful as references for next solar energy applications.

Keywords: stand-alone photovoltaic inverter, energy gain, light-dependent resistor, dual-axis sun tracker, and feedback control theory.

I. INTRODUCTION

The process known as the photovoltaic effect, which converts solar energy into direct current electricity in specific types of semiconductors, enables solar energy systems, or PV systems, to be as small and straightforward as pocket calculators or as complex and potent as space station power supplies.

Understanding many physics principles, including as photons and solar radiation, semiconductor structure, and the conversion of solar radiation into chemical and electrical energy, is necessary to fully comprehend the process. The idea of the phenomena has only been partially explored and discussed in the context of this project, which is creating a tracking module. This section of the article will concentrate on the topic's technical and practical aspects, including a PV system's mechanical setup, subsystems, and components, as well as other elements that affect the efficiency and performance of PV systems. In particular, the design of a solar tracking system will be discussed, along with basic background in physics for its functioning.

In terms of producing solar energy, Morocco is regarded as the global leader in this regard. Morocco uses solar energy to provide 20% of its total energy needs. The largest nation in the world with concentrated solar electricity is Morocco. With concentrated solar power, all of the sun's rays are focused to one spot in an attempt to generate thermal energy, which is then transformed into electrical energy. However, photovoltaic cells are used by conventional solar panels to convert solar energy into electrical energy.

The sun provides the world with around 1.8*1011 MW of power, which is sufficient to meet the planet's electrical needs. Earth has 10,000 times more solar energy than is needed for all of the world's electrical needs. According to estimates, the yearly global energy consumption may be satisfied by solar energy obtained from the sun for only 1.5 hours. Thus, solar energy provides a simple solution to the energy dilemma. Despite this, a lot of nations are not actively taking part in the revolution. Land is wasted as a result of solar energy's huge area acquisition.

We must make solar installations more efficient in order to address this issue. PV panels should always be kept in the best possible position to maximise their power production. in order for daytime solar radiation to be orthogonal to the panel (ss). Therefore, it is crucial to locate the sun and line up the solar panel such that it is perpendicular to the sun. There are two options for this tracing: single-axis and dual-axis.

II. LITERATURE SURVEY

A novel, low-cost, single-axis passive solar tracker with an actuator made of shape memory alloy is created. The tracker's primary benefits are its comparatively inexpensive cost (less than $150 US dollars per square metre), its 40% collecting energy surplus (in comparison to fixed tilt collectors), its very simple modular solid state construction, its automated morning orientation, its tracking angle of 140°, and its sealed casing [7]. It was discovered that polar-axis and elevation kinds of sun monitoring devices were the most effective and widely used [8]. New developments in solar cell technology have led to an increasing preference for solar tracking systems over more conventional fixed PV systems. An extensive overview of solar tracking systems and their potential for solar energy applications is provided in this study. The article provides a summary of the kinds, construction, design parameters, and driving system strategies for various applications of use [9].

III. SYSTEM ARCHITECTURE

The "Automatic Solar Tracking System" project is created by installing the various small parts, including a solar panel that can produce 12 volts of output, an Arduino microcontroller, a motor driver with an integrated circuit (IC) L293D, two LDR sensor modules, a 10 r.p.m. simple DC motor, a current sensor, and a 9 V battery. The project in question is being constructed using a wooden foundation that is set in the ground. It is fastened with iron rods on both sides that are arranged in a cross form. The iron rods are linked to a hollow cylindrical rod from both sides, and the DC motor is attached to one edge of the hollow rod. The solar tracking system's circuit is separated into three portions.

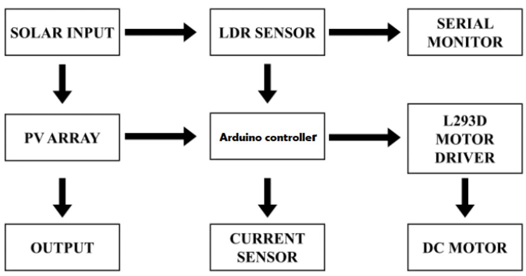

Figure: Block Diagram

The system's microcontroller is programmed using the Arduino ide software, two LDR modules are organised in the input stage to create a voltage divider circuit, and a DC motor in the drive circuit aids in the rotation of the solar panel. Three terminals are included with the motor driver: two are used for motor input and output, and the third is used for power input. Two of the Arduino UNO's fourteen digital input/output pins are linked to the motor input terminal, and the DC motor is connected to the motor output terminal after that. Using analogue Arduino inputs, the two LDR sensor modules are attached to the scaffolding. Then, on each side of the solar panel, the light-dependent resistors are attached along the length.

Three discrete phases are individually designed before being combined into a single system. This method has been used because it guarantees an exact, logical, simple, and understandable approach, much like progressive refinement in modular programming. Additionally, it guarantees that any flaws are taken into account and fixed separately.

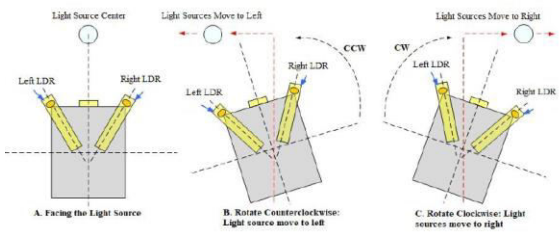

Figure: Concept of using Two LDR

The concept for installing light-dependent resistors (LDRs) is shown in the image. When the two LDR's light intensities match, a secure condition is reached. The Sun, the main source of light energy, travels westward. The difference in light intensity levels falling on the two LDRs is caused by this movement of the Sun. The solar panel rotates in accordance with the light source's trail as a result of the devised algorithm comparing variations in light intensity within the microcontroller and motor.

a) Research Design

The primary concept behind the construction of the aforementioned project is to optimise solar energy use. The process of storing solar energy at its highest level is the next step that becomes clear, and it leads to the creation of the

"AUTOMATIC SOLAR TRACKING SYSTEM" project. A number of components have been released in the process of making the aforementioned project caviar in its use; some of them are described thus

1. Solar Panel
2. DC Motor
3. L293D Motor driver module
4. Arduino Controller
5. LDR sensor module

The project in question, when all of the aforementioned elements are combined, should aim to maximise solar radiation absorption through the LDR sensor module, which is etched on the solar panel's edges according to its length and rotates to assist the DC motor by keeping pace with the sun's movement. As a result, the invention is rooted in the realisation that solar energy may be used profitably to produce a range of other goods that address pressing societal needs. Furthermore, it would be more honourable to mention that this initiative may prove to be a strong undertaking at a time when pollution is making the planet ill and demonised.

The sun constant refers to the relative constant of solar radiation output and the intensity of that radiation striking a unit area of the earth's crust. This solar constant's value may be stated as:

$$G_{SC} = \sigma . T^4 . \left(\frac{4\pi R}{4\pi D}\right)^2 = 1367\ W/m^2$$

On the surface of the planet, the absorption of solar radiation varies according to several characteristics. Among the required criteria are latitude and longitude. Depending on where one is on Earth and the sun's angles, one may view sunlight at varying angles. The following categories apply to the sun's angle:

The angle formed between the sun and the horizon is known as the elevation angle. At the equator, the elevation angle is zero degrees at dawn and ninety degrees at midday. At various times of day and at different latitudes, the elevation angle varies. The elevation angle may be calculated using the formula shown.

$$\alpha = 90 + \varphi - \delta$$

Elevation angle and zenith angle are similar. The measurement is made along the vertical, which is the sole difference. Thus, the elevation angle is equal to the zenith angle (90°) — the angle formed between the sun and the vertical.

$$\zeta = 90^\circ - \alpha$$

The compass direction from which the sun is coming is known as the azimuthal angle. The sun is straight north in the southern hemisphere and south in the northern hemisphere during solar noon. Throughout the day, the azimuth angle changes. Regardless of latitude, the sun rises exactly east and sets directly west during the equinoxes. Thus, at dawn and sunset, the azimuth angles are 90 degrees and 270 degrees, respectively.

Use these calculations to calculate the times of sunrise and sunset.

$$\text{Sunrise} = 12 - \frac{1}{15^\circ}\cos^{-1}(-\tan\varphi\tan\delta) - \frac{TC}{60}$$

$$\text{Sunset} = 12 + \frac{1}{15^\circ}\cos^{-1}(-\tan\varphi\tan\delta) - \frac{TC}{60}$$

where TC is the time correction, δ is the declination angle, and φ is the location's latitude.

Algorithm Used In Arduino

Step1: Start.
Step2: Define the initial position value to Servo Motors.
Step3: Assign analog LDR outputs & PWM servomotor inputs to the arduino.
Step4: Collecting analog values of each LDR i.e., topl, topr, botl, botr.
Step5: Now calculating the average i.e., avgtop (Average of top left and top right), avgbot (Average of bottomleft and bottom right), avg left (Average of top left and bottom left) & avgright (Average of top right and bottom right).
Step6: Align the solar panel.
Step7: If avgtop is greater than avgbot then increase the value of servomotor by 1 unit, with given delay.
Step8: Else If, avgbot is greater than avgtop then decrease the value of servomotor1 by 1 unit, with give delay.
Step9: (Simultaneous along with step7) If avgleft is less than avgright, then increase the value of horizontal servomotor by 1 unit, with give delay.

Step10: Else if, avgleft is more than avgright then decrease the value of servomotor2 by 1 unit, with give delay.
Step11: Goto back to step 6.
Step12: End.

IV. HARDWARE COMPONENTS

Any system's design is made up of software development and hardware needs. Software development is concentrated on the code that is put into the hardware, while hardware requirements are focused on the components that are required for project design.

a) Arduino Uno

An open-source platform called Arduino is used to construct electrical projects. The Arduino system is comprised of a programmable circuit board, often known as a microcontroller, and an IDE (Integrated Development Environment) software that is installed on your computer and is used to develop and upload computer code to the board.

The Atmega328 has two KB of SRAM and one KB of EEPROM, which may be read and written using an EEPROM library. It also has 32 KB of flash memory for code storage, of which 0.5 KB is needed for the bootloader.

Figure: Arduino Uno

Table: Arduino Specifications

FEATURE	SPECIFICATION
Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

b) Liquid Crystal Display

There are two lines on an LCD panel, each with 16 characters. A 5x7 dot matrix makes up each character. The power supply voltage and whether messages are shown in one or two lines determine the display's contrast. As a result, pin Vee receives a fluctuating voltage of 0-Vdd. Typically, a trimmer potentiometer is used for such function. There are display models with integrated backlights (blue or green LEDs). As with any LE diode, a resistor should be used to restrict current while the device is working.

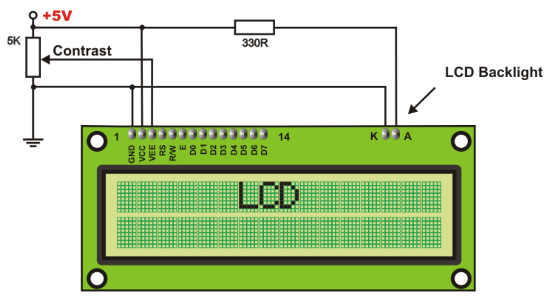

Figure: LCD Display

c) Dc Motor

A DC motor is intended to operate with DC electricity. Michael Faraday's homopolar motor, which is rare, and the ball bearin motor, which is a recent invention, are two instances of pure DC designs. The two most popular forms of DC motors are brushed and brushless, which are not strictly speaking DC machines since they require internal and external commutation, respectively, to produce an oscillating AC current from the DC source.

Figure: DC Motor

d) ULN Driver

High voltage, high current darlington arrays, each with seven open collector darlington pairs with common emitters, are internally used by the ULN2003. Each channel has a 500 mA rating and can handle 600 mA peak currents. To make the board layout simpler, the inputs are pinned opposite the outputs and suppression diodes are incorporated for inductive load driving. ULN2003A is a CMOS, 5V TTL device. These adaptable gadgets may be used to drive a variety of loads, such as thermal printheads, DC motors, solenoids, relays, LED displays, filament lights, and high power buffers. In order to minimise heat resistance, the ULN2003A are provided in 16-pin plastic DIP packages with a copper leadframe.

Figure: ULN Driver

e) Light Dependent Resistor

Light Dependent Resistors are very important, particularly in circuits using light or dim sensors. Generally speaking, an LDR has a high level of protection—it can sometimes reach 1,000,000 ohms—but when they are illuminated, that protection drastically decreases. Accordingly, LDR anticipates a fundamental role in this project including the trading of lights based on light power; that is, if light power is greater (during the day), the lights will be off. Additionally, in the nights, when light is less abundant, the lights will be switched on.

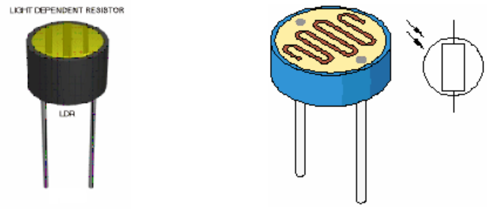

Figure: LDR Sensor

The ADC receives the yield from the LDR and converts it from a basic power incentive to a sophisticated piece of information, which it then offers to the microcontroller as a contribution.

V. RESULTS

Finally, we connect all the components correctly so that it can follow the sun in order to create an autonomous dual-axis movement solar tracker. The fact that the system could follow even the smallest movement of the sun made it a crucial design consideration. Figure depicts the whole circuit used to follow the sun. We tracked the sun on two axes by using two LDRs, as the circuit illustrates. Each pair of LDRs is in charge of monitoring the sun. The output from each of the two neighbouring LDRs is measured, and the microcontroller receives this data via four inputs.

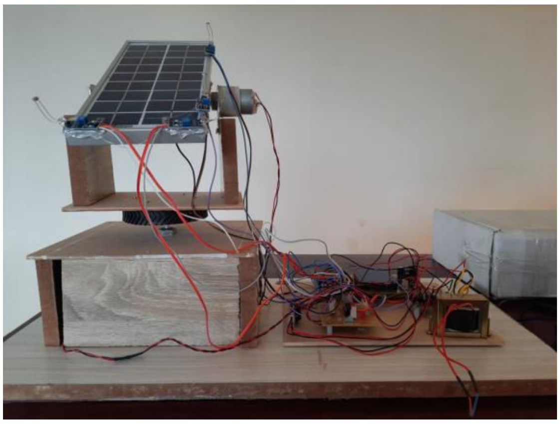

Figure: Hardware Prototype

CONCLUSION

The project's objective, as described in this article, was to develop and build a small-scale tip-tilt dual-axis solar tracker prototype with fundamental tracking capabilities. Process design and implementation have been finished in accordance with the project's work.

The end product was a fully working system that complied with all design specifications. Although the project was successful in producing a device with the essential functions, the device's performance still has a number of significant flaws and limits, as the project's implementation work has addressed. In further development, it is feasible to get around these restrictions and enhance the device's performance.

The project was a success in achieving my initial goal, which was to do research and keep up with emerging technology in the area of energy extraction. It is a helpful resource for anyone who must create systems that are comparable. The information and expertise gained from this research may potentially serve as a foundation for the creation of more apps in the future.

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