Design and Implementation of Low Cost Dual Axis Solar Tracking System using Microcontroller

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Abstract*—The phrase "the sun is the source of all energy" implies that solar energy is an essential element for the earth. Sun-powered vitality is fast becoming a substantial approach for renewable energy source assets. The sun is a plentiful source of vitality, and this sun-powered vitality may be effectively dealt with by employing sunlight-based photovoltaic cells and photovoltaic impact to convert sun-powered energy into electrical vitality. The solar tracking system maximizes the power generation of your solar system by following the sun through your panels throughout the day, optimizing the angle at which your panels receive solar radiation. Compared to stable solar panels, a solar tracking system using solar panel linear actuators or gear motors can increase the efficiency of solar panels by 25% to 40%. The transformation efficiency of any sun-based application increases when the modules are consistently adjusted to the optimal edge as the sun crosses the sky. A dual-axis tracker allows your panels to move on two axes, both north-south and east-west parallel. This paper presents the design and implementation of a dual-axis solar panel based on the Arduino microcontroller.*

Keywords*—Arduino UNO, Solar Panel, Servo Motor, LDR, Solar Tracker;*

I. INTRODUCTION

The exploitation of coal, oil, natural gas, and other mineral resources and the development of nuclear energy are all aimed at meeting energy needs. At the same time, the carbon dioxide produced by the use of mineral energy has caused a global greenhouse effect. The use of this energy source has many side effects. Solar energy, wind energy, tidal energy, and other new energy all use the innate energy of nature. The process of using them is basically collection, so these are clean energy. More and more countries and regions value its development and use and increase investment. Among these clean energy sources, solar energy is the most used, the most stable, and the most convenient [1].

The sun is a numerous source of vitality, and this sun-powered vitality may be effectively dealt with by using sun-oriented photovoltaic cells and photovoltaic impact to convert vitality into electrical vitality. However, the transformation capability of a standard PV cell is limited. The major reason for this is because the output of PV cells is dependent on the light intensity, and with the sun's location in the sky changing constantly, the efficiency of a solar panel would be much lower at a specific time of day and year. Solar PV cells are most productive when they are perpendicular to the sun and least productive when they are parallel to the sun. As a result, solar panels are necessary to increase energy output while also improving efficiency.

Through the programming-based arrangement, the sun-based tracker also provided a valuable solution for poor nations to easily coordinate it into their nearby planetary system. The analysis discovered that using a stepper motor allows for precise tracking of the sun and the LDR resistors needed to determine the solar-powered light force [2]. Experts predicted that incorporating a global positioning framework with a sun-oriented board will provide precise and appropriate responses to meet the demands of the force in a variety of operating scenarios.

A solar-powered global positioning framework designed with microcontrollers and LDRs to follow the sun and modify its location as needed to increase energy production. The LDR fused on the sun-oriented board aids in differentiating daylight and so advances the board in a similar manner [3]. The sunlight-based tracker demonstrated a more improved way to increasing the force consumption by the sun-powered board from the sun by simply spinning the sun-powered board in accordance with the location of the sun. Looking at the results, it was discovered that immediate light emission aids in the creation of vitality more than when the sun-oriented board is fixed. The proposed have shown that the efficacy of sun-powered boards may be increased in general if the sun-oriented boards continue to rotate toward the sun.

To track the sun, a microcontroller and a series of LDR sensors can be used [4]. Regardless, the framework was less effective due to the poor affectability and disturbing effects of light ward resistors.

Another mechanical construction for solar panels comprises of two stepper engines with the expectation of complementary rotation on X and Y hubs [5]. The turn is limited by a pre-modified 2K microcontroller device that offers a simple programming process in C language. The structured computation was based on the measurement of the power of sunlight-based radiation, which was captured by a bright sensitive device known as a pyranometer. The framework had been tested, and the results demonstrate an extraordinarily large influence on the mechanical structure, regulating computation, and the cost of the turn of events.

In recent years, the use of solar energy has yielded fruitful results and there is a certain scale. Solar automated tracking systems have different methods such as differential pressure type, photoelectric type, and day-dependent trajectory type and each has its advantages and disadvantages but lacks accurate tracking and intelligence. To improve the efficiency of the use of solar energy, the method of combining image processing with the trajectory of the sun is used to perceive the solar panel for tracking the sun with high accuracy.

The article is structured as follows: The introduction to this study is included in Section I, Section II includes a description of required components. A brief description of the proposed methodology given in Section III. The essential description of the design and implementation is given in section IV, Section V describes discussion about this work and finally, in Section VI, the conclusion of this research work has been drawn.

II. REQUIRED COMPONENETS

To accomplish the system, some components are needed. They are listed in Table I.

Table I: Required Componenets

Sl. No.	Components	Quantity
1	Arduino UNO R3	1
2	Servo Motor	2
3	LDR(250 kilo ohm)	4
4	Solar Panel	1
5	Resistors	7
6	Jumper Wire	Not Specific
7	Breadboard	1

A short definitions for components that using in system prototype is given below:

A. Arduino

Arduino type Uno R3 is a microcontroller that using in this work for motor position control. Arduino has 14 input/output digital ports that provide signals of PWM to servo motor by 6 of them and 6 input ports as analogue, also contains oscillator crystal of 16 MHz and cable USB for push through program. The Arduino advantages are independent platform, construction robust and low price. Table 1 shows the components description of the system prototype depending on their functions [6]. A typical image of Arduino UNO is shown in Figure 1.

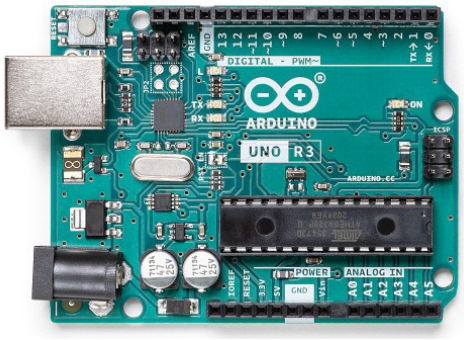

Fig. 1: Arduino UNO

B. Light Dependent Resistor (LDR) Sensors

LDRs are also named as photo conductors or photo resistors and the photoconductivity is the principal of their working. LDR resistance is increased with decrease light intensity and vice versa. Solar energies catch by purpose sensing which are done by using LDRs before providing the input analog to Arduino [7]. A typical image of LDR is shown in Figure 2.

Fig. 2. LDR

C. Servo Motor

Servo mechanism is the principle work of dc motor which has 3 wires and maximum angle of 180° can be rotated. There are two servo motors using for both horizontal and vertical directions because the system is working

in dual axis. Arduino provides output of PWM to these servo motors for operation [8]. A typical image of SG 90 Micro Servo Motor is shown in Figure 3.

Fig. 3. SG 90 Micro Servo Motor

D. Solar Panel

Solar energy is a group of photovoltaic cells that produce electrical energy from sun light energy and convert the received light energy from sun into electrical energy. Solar panel extracts high-energy emitted from the sun. They are widely applications of solar panel in industrial area, domestic and street lights [9]. A typical image of a solar panel is shown in Figure 4.

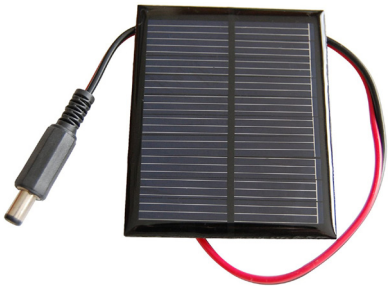

Fig. 4. Solar Panel

E. Resistors

A resistor is a generator that interrupts the flow of electricity in an electronics circuit. If we want to know about resistor, we must first know about another thing about resistor. Resistance is a special property of conductors. The nature of the conductor for which the flow of electricity through it is interrupted or obstructed is called resistance [10]. There are generally two types of registers.

1. ***Fixed resistor:*** A resistor that is set in a fixed or uniform manner is usually called a fixed resistor. The value of this resistor cannot be changed at any time.
2. ***Variable resister:*** A resistor whose value is not specified and whose value can be changed as required is called a variable register. It can be increased or decreased at any time.

The function of the resistor is to block the current flow and drop the voltage. This component is used to tie current and drop voltage in all circuits of electronics. Some typical images of fixed resistors is shown in Figure 5.

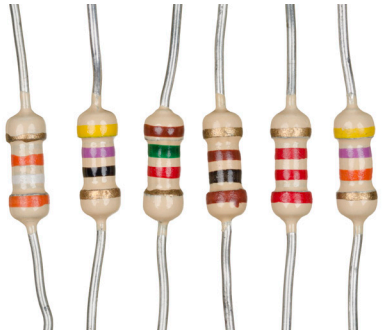

Fig. 5. Fixed Resistors

F. Breadboard

A breadboard is a rectangular and perforated board. It is also called trainer board or projector board. It has two rows of holes at the top and bottom. Separately the holes in each row are connected horizontally. Again the holes in the middle are divided into several vertical rows. The holes in a vertical row are connected vertically. One row of holes does not connect to the other row of holes. Again, there is no connection between the hole on one side of the empty space in the middle and the hole on the other side [11]. A typical image of a breadboard is shown in Figure 6.

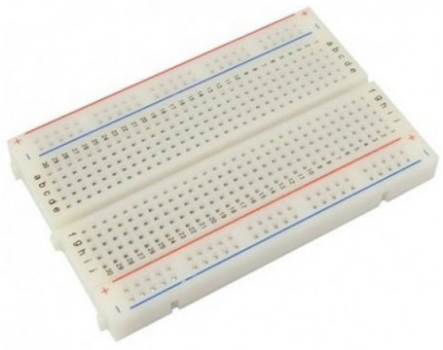

Fig. 6. Breadboard

III. METHODOLOGY

A single-board microcontroller is the heart of the Arduino UNO. It is reasonable and has an open-source physical registration stage as well as an enhanced circumstance for composing programs for the board. Light Dependent Resistors (LDRs), servo-engines, and sun-oriented boards are the other key segments. Light Dependent Resistor completes the solar-powered global positioning

architecture (LDR). Four LDR are connected to Arduino basic pins A2 to A5, which serve as the framework's contribution. Using the implicit Analog-to-Digital Converter, the basic estimation of LDR is converted into computerized (Pulse Width Modulation). The servos are moved using PWM beat estimations. The information capturing the lightest power by one of the LDRs will be picked, and the servo engine will move the sun-oriented board to the position of the LDR that was put up in the programming. Engine turns to serve two functions: 180 degrees and 45 degrees. LDR locations are divided into four categories: upper left, upper right, base left, and base right. The four places allow the greatest concentrated force of daylight to be recognized. The Light Dependent Resistor (LDR) provides a basic contribution to the microcontroller, which is subsequently converted into a computerized signal by an Analog-to-Digital converter. The yield delivered to the servo engine determines the growth of the sun-oriented board.

IV. DESIGN AND IMPLEMENTATION

The block diagram of the system is shown in Figure 7.

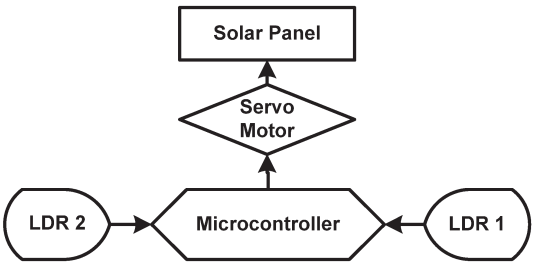

Fig. 7. Block Diagram

Figure 8 depicts the circuit diagram of the system.

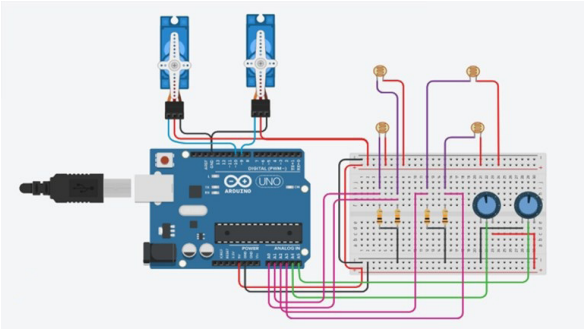

Fig. 8. Circuit Diagram

Some steps have been taken in order to control the servo motor. They are given below:

1. The voltages from the four LDRs are sent into the circuit.
2. The inputs are analog. They are translated to converting digital ranging from 0 to 1023.
3. The four digital values are top, bottom, right and left.
4. The average of top (both left and right) and bottom values are calculated.
5. The Servo motor moves with the greatest intensity in the direction of the LDR.

The software part comprises a programming language that is developed utilizing C++ programming. The codes are focused on Arduino UNO to be gathered and transferred. The equipment and programming are actualized and incorporated to structure and build up the total double hub Solar Panel.

Figure 9 illustrates the hardware layout and interconnections.

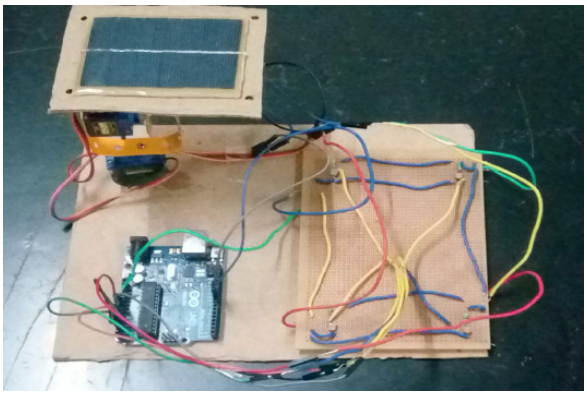

Fig.9. Final Module

V. DISCUSSIONS

This system is accomplished by the use of light sensors that detect the quantity of sunshine that hits the solar panel. The values produced by the LDRs are compared, and if there is a substantial discrepancy, the panel is actuated using a servo motor to virtually perpendicular to the sun's beams. This was accomplished through the use of a system comprised of distinct phases or subsystems. Each stage plays a distinct role. The stages were,

1. A control stage that was responsible for controlling actuation and decision making
2. A driver stage with the servo motor. It was responsible for the panel's actual movement.

Because their resistance fluctuates with light, LDRs were proven to be the best choice for this project. They are widely accessible and reasonably priced. Temperature sensors for instance would be expensive. A microprocessor in the control stage receives voltages from the LDRs and decides the action to be taken. The microcontroller

is configured to send a signal to the servo motor, which moves in response to the created error. The final step was the drive circuitry, which mostly comprised of the servo motor. The servo motor produced enough torque to power the panel. Servo motors are quiet and inexpensive, making them the perfect choice for this work.

Shading has a negative impact on the performance of solar panels. Because the cells are frequently linked in series, the shade of a single cell has an influence on the entire panel. As a result of the shading, the tracking system will be unable to boost efficiency as necessary. Because there is no sun radiation at night, we do not want it to function at night or during the rainy season.

VI. CONCLUSION

The goal of this paper is to create a simulated framework of a dual-axis solar panel that detects sunlight on the board and travels toward it to maximize solar output. The primary goals of this inquiry are as follows: When compared to previous solar panel frameworks utilized for the same application, the suggested simulated framework is simple and minimal. Because it is Arduino-based and requires no external components, programming this solar panel is exceedingly straightforward and quick to alter on the ground. The simulated architecture is simple to use and provides increased effectiveness. The system has the potential to be used on a much greater scale.

In the future, one may explore using more efficient sensors that are both cost-effective and require less electricity. This would increase efficiency while decreasing expenses. It would be really beneficial if there was a way to further reduce the cost of this system.

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