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IOT Integration in two-axis sun tracking system with LDR sensors in a Wheatstone bridge Circuit

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ABSTRACT

Nowadays, using photovoltaic (PV) cells is among the power generation methods that absorb solar energy and convert it into electrical energy. The sun moves from east to west during the day and its radiation angle changes relative to the Earth in different seasons. So, the output power of PV panels changes as well. The output power of PV panels increases by being located in a position perpendicular to the angle of the sun's rays. This study aims to design and implement a dual-axis solar tracker (DAST) to increase the output power of the PV panel. This simple system has high efficiency and adjusts the PV panel based on solar radiation by moving simultaneously on two axes. An analog controller is used for its control system. DAST control system is a closed-loop system that uses Wheatstone bridge circuit function along with light-dependent resistors (LDRs). A small DAST was designed and built to validate the proposed system, the performance of which was verified. Based on the experiments, I-V and P-V specifications were obtained. Finally, it was found that the output power of the PV panel using solar tracker was higher than that of the fixed panel. Further this paper discusses the implementation of IoT (Internet of Things) for maneuvering and remote monitoring the orientation of the solar panel from anywhere.

Keywords: Wheatstone bridge, LDR sensors, DAST system, PV panel, closed-loop system.

1 Introduction

Solar energy is emerged as a possible source of renewable energy over the past two to three decades. This solar energy is converted into electrical energy by using solar panel according to the principle of photovoltaic effect. Out of various renewable energy sources solar energy is widely used. Because it is simple and it is easy to use in household too. Solar Trackers is a device used for the rotation of solar panel according to the sun's rays. To utilize this renewable solar energy solar trackers are employed. For static solar panel, there is no movement in the panel. But the position of the sun changes during rising and setting (sun rises in the east and sets in the west. So we adopted dual axis solar tracker to utilize the solar energy effectively and efficiently by rotating the panel in both horizontal and vertical direction. Dual axis tracker is able to rotate on both horizontal and vertical movement. This dual axis solar tracker was implemented by using Arduino board. The integration of IoT technology facilitates remote



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monitoring, enabling users to optimize energy production and identify any potential issues promptly.

2 Research Methodology

Dual-axis solar tracking system, simultaneously adjusts the PV panel toward solar radiation in two x and y axes. The proposed tracking system is based on closed-loop control, in which LDRs are the system inputs. In the closed-loop DAST system, the intensity of the sunlight is considered as a reference input signal. The control of the proposed system is carried out by ICs circuits and transistors. The Wheatstone bridge was used to measure very low values of resistance.

2.1 Control Unit

An Arduino microcontroller is used for its control system. Control system is a closed-loop system that uses Wheatstone bridge circuit function along with LDRs. LDRs data are processed by a microcontroller and track the sun, independent of its geographical location. The control unit handles the controlling task and coordinates all parts of the DAST system and also the PV panel's movement in all directions. The DAST system function is automatically performed by the control unit and LDR sensors. The DAST system has two circuits for controlling the rotary motion of the PV panel in both horizontal and vertical axes and each axis operates in two directions. Each hardware circuit consists of three parts including a Wheatstone bridge with an LDR sensor, op-amps, and control circuits. To achieve maximum power for the PV panel, the astronomical tracking processes proceed simultaneously to make the PV panel perpendicular to sunlight. Then, the voltage generated at the output of the Wheatstone bridge is transmitted to the op-amps and amplified as well. The output voltage of the op-amps by the control circuits activates the relay. The relay rotates the engine of the tracking system in the desired direction, and the PV panel will rotate around its axis so that the ST system automatically places the PV panel perpendicular to the direction of the sun rays. Accordingly, the control system continuously monitors the solar radiation angle and PV panel by LDRs and sends a differential control signal to the relay of the tracker motor until the voltage difference in the bridge branches becomes less than a threshold value.

2.2 X-Y Rotation

The main axis of the horizontal rotation of the PV panel allows the rotation of the PV panel to track the angle of the solar radiation from the east to the west. The ball bearings facilitate the rotation of the PV panel on the structure. The vertical rotational axis of the PV panel allows the PV panel to rotate in order to track the angle of the solar radiation from the north to the south. The upper gearing mechanism (DC motor with gear mechanisms) is connected to the horizontal shaft to bear the axle load along with the gear mechanisms situated in a suitable box on the moving part. After that the Arduino process the information from the sensor to



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command the DC motor that hold the photovoltaic to move toward the sun. Next, the photovoltaic gather the energy from the sun and charges the battery and send the value to the Arduino.

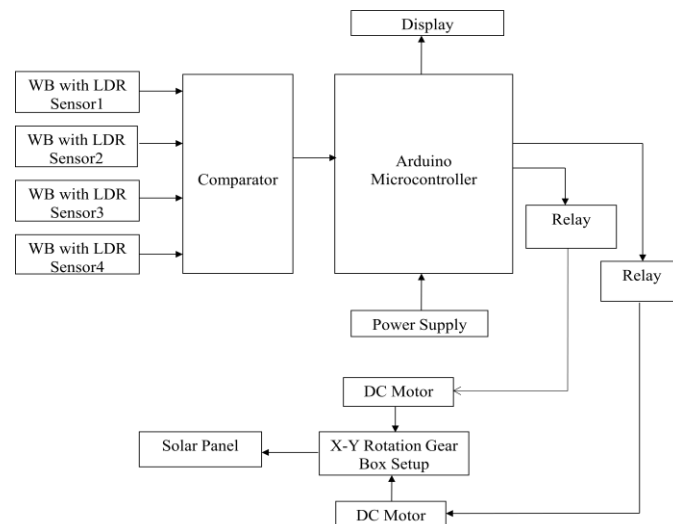


Figure 1: Block Diagram

Lastly, the Arduino will send the data that has been taking by photovoltaic to WIFI module and send to the IOT monitoring system for. The IOT monitoring system will be update the data every 3 second.

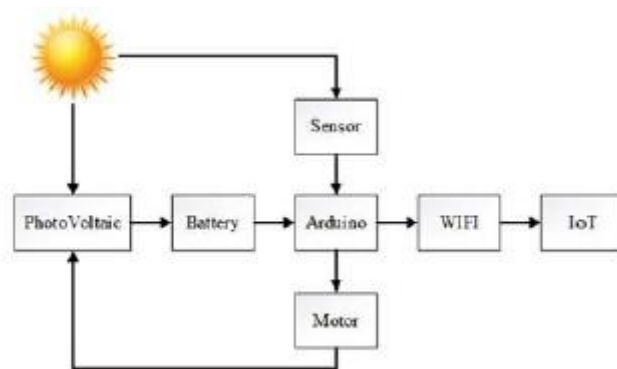


Figure 2: Process of Solar Tracking

3 Theory and Calculation

The LDR sensors are placed on the four sides of the PV panel at a distance of 1 cm from the panel surface. The angle of the sun changes, the LDR sensor remains in the shadow. DAST system is more sensitive and faster due to the use of the Wheatstone bridge circuit. Sensors LDR1 and LDR2 are used to calibrate the PV panel relative to the horizontal axis and sensors



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LDR3 and LDR4 are employed to calibrate the PV panel relative to the vertical axis. The Wheatstone bridge was first used to measure very low values of resistance. It is more precise compared to many other techniques and simply operates by dividing the voltage. One of the most important and well-known applications of the Wheatstone bridge circuit is measuring the variations of the sensor resistance. Figure 3(a) it is fully illustrated how to connect and use the resistance sensor in the quadratic Wheatstone bridge circuit. The half-bridge structure shown in Figure 3(b) is used to measure two elements with the same type to achieve higher sensitivity. This method is used to provide a signal in the output of resistance sensors such as light-dependent resistance sensors and LDRs.

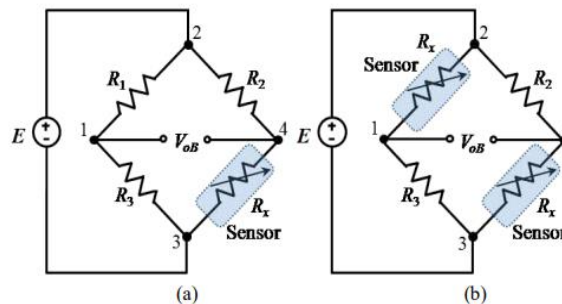


Figure 3: The structure of the Wheatstone bridge. (a) Full bridge; (b) half bridge

4 Results and Discussion

To maximize power, the PV panel should be placed perpendicular to the sun radiation angle. The PV panel is positioned at different angles depending on the angle of solar radiation. The sun moves from east to west during the day. By the movement of the sun, the DAST system simultaneously moves in all directions and locates the PV panel in the direction of solar radiation. The performance of the DAST system is examined in two modes as follows:

- 1) The motion of the panels to the west
- 2) The motion of the panels to the east
- 3) The motion of the panels to the east
- 4) The motion of the panels to the east

As the sun radiates on the surface of the light sensors, their ohmic resistance decreases. The higher the radiation intensity, the lower the sensor resistance. As the sun radiates on the surface of the sensors (LDRs) in different modes of the DAST system, their ohmic resistance changes.

4.1 Software development

On this part the movement and rotation of solar tracker will be testing to find out the system in the right order. Starting from four sensors that detecting the position of the sun. The data



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that has been received from the sensor will be converted from the analog data to digital data and the data will be read in Arduino UNO to make a comparison for position the solar panel directly towards the sun ray. The system will analyze the data in order to determine the direction of the sun and made horizontal and vertical servo motor move accordingly to the command that has been set in Arduino IDE. Table 1 shows the meaning of word that use in flow chart. When the power supply is supplied to the circuit, it will turn on the Arduino UNO and the motor. The Arduino used as the main processor unit and DC motor is used as the hardware component to rotate the solar tracker. This project, use DC motor for horizontal and vertical movements. The DC will be operated according to LDR sensor that has been detecting the sun ray. The sensor has five conditions to make the motor rotate. First, when sensor LT and RT detected sun radiation more than LD and RD the vertical motor will be turn from 0-degree to 120-degree angle. Secondly, when LT and RT less than LD and RD the vertical motor will rotates from 0-degree to 15-degree angle. Third, when sensor LT and LD more than sensor RT and RD the horizontal motor will be rotate to 65-degree angle. Forth, when sensor LT and LD less than sensor RT and RD the horizontal servo motor will be turn 180-degree angle and lastly when all the sensor in equal which mean all the sensor detected sun ray the motor will be stop. Thus the system will be loop to get the best position of sun.

Table 1: *Table of sensor*

Code Name	Function
LT	Left Top
LD	Left Down
RT	Right Top
RD	Right Down

4.1 I-V and P-V Characteristics

A solar power panel is made of photovoltaic cells arranged in a configuration that can contain 32, 36, 48, 60, 72 and 96 cells. The power output of the PV panel depends on the type of cells and the number of cells in the PV panel, the amount and angle of solar radiation, the temperature of the cell, and voltage loads (or battery). In this proposed system configuration we have selected the 9 number of cells that are connected in parallel. The maximum power by PV panel with respect to the Solar Irradiation at temperature of 32 °C is 1.28 Wp.



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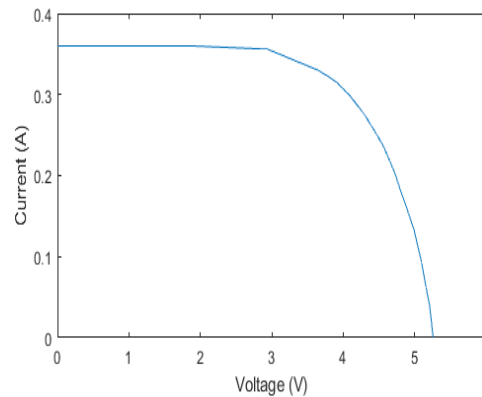


Figure 3: I-V Characteristics of PV panel

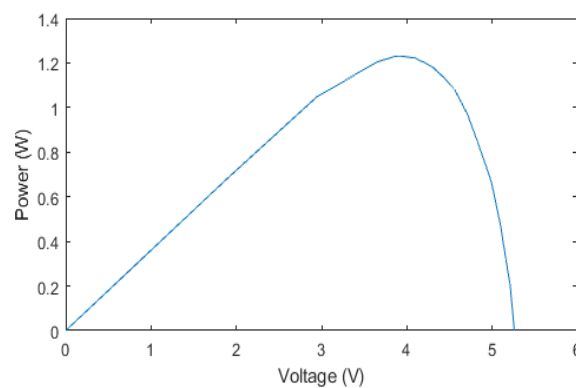


Figure 4: P-V Characteristics of PV panel

5 Conclusion

The solar tracking system detects the astronomical position of the sun during the day and increases the output power of the PV panel by placing it in a suitable position relative to the angle of the sun's rays. Many solar tracking systems have been developed so far that either has been not able to move on two axes or have been based on geometric and astronomical equations and artificial intelligence, which are expensive. This study presented a new DAST based on LDRs, which adjusts the PV panel relative to the angle of the sun's rays by moving simultaneously on two axes. DAST is a very simple and cost-effective control system that utilizes Wheatstone bridge circuit function and LDRs. If this controller is used, it is possible to control PV panels on the metal structure both individually and in an integrated manner. Therefore, the experimental findings of this solar tracking system can help develop solar energy applications. The monitoring system is equipped with WIFI module in order to transfer the data from solar panel to IOT monitoring system. The system can work in one condition which is the dual axis solar tracker must work within the WIFI coverage so that the user can attach the system with WIFI module and access the solar panel parameter via IOT



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monitoring System. IOT controlled Dual-axis solar trackers will helpful to accomplish the optimum solar energy level for implementing this technique. Efforts should be taken to implement this on a large scale for future purpose so as to meet increasing energy requirements.

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