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Solar Panel Sun-Rays Tracking and Cleaning System for Improvement in Power Efficiency

Journal of Electrical Systems

Abstract: - There is an increasing need to reduce greenhouse gas emissions and find more environmentally friendly ways to power the planet. An estimated 4 billion years will pass before the sun stops shining, making it a renewable natural power source. A sustainable method of generating electricity from the sun's energy is offered by solar power systems. In comparison with single axis solar tracker, a dual axis solar tracker tracks the sun at every instance hereby increasing the efficiency by 30-35%. In this system we have a solar panel which tracks the position of the sun and always try to remain perpendicular to sun rays. It will track the sun in all four directions i.e east-west and north-south. This paper focus more on Design of Dual tracking system, which includes installation of GPS and RTC system, stored energy usage for application , periodic cleaning in order to maintain efficiency of panel and comparative analysis of stored energy. Alternative, less expensive options have been suggested because the solar tracking equipment is expensive to manufacture.The goal of this effort is to create a solar dual tracking system model that includes solar panel cleaning as well.

Keywords: Solar panel Three systems in one: dual tracking, solar panel tracking, and solar panel cleaning.

I. INTRODUCTION

The Sun's position in reference to the solar panel is not fixed due to Earth's rotation. To make the best use of solar energy, the solar panels must absorb as much energy as possible. This is only possible if the panels are oriented toward the Sun on a regular basis. The solar panel should therefore always face and rotate in the direction of the sun. The solar panel rotation circuit is covered in this article.

The need to reduce greenhouse gas emissions and discover more environmentally friendly solutions to power the planet is growing. The sun is a natural power and converting its energy into electricity by using Solar power systems is a sustainable method to utilize the sun's radiations.

An average solar power system takes four years to pay for itself, which means that within that time, the energy produced has equaled the energy used in its construction. A system should last between 25 and 30 years. The sun has enormous energy potential and is one of the new energy sources that are supported in order to ensure that technology is distributed globally.

Vitality from sun rays is abundant and free of pollutants. Although solar heat energy is converted over an extended period of time, solar light energy conservation into electrical energy is developing. The world uses roughly 12 terawatts of power per day, whereas the earth receives 84 terawatts of power. We are attempting to use solar panels to harness more solar energy [1]. Solar cells have historically been attached to set elevating angles.

Their inability to track the sun results in low power generating efficiency [2].These are for use in industry and domestic settings, taking into account the ecological impacts of the rapid depletion of the main conventional energy sources, such as coal, oil, and gaseous gasoline, as well as the need to harness these resources.

The work's goal is to follow the sun's path such that its rays always align with the panel at a right angle. Alternative, less expensive options have been suggested because the solar tracking equipment is expensive to manufacture. The goal of this effort is to create a model of a solar tracking system. Control circuits are manufactured using the AT89S52 micro controller. To detect daylight, Light Dependent Resistors (LDR) are used, which drives the servo

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motor to rotate the solar panel. The solar panel is kept in an area that receives the maximum amount of daylight exposure.

When dust particles accumulate on the surface of solar panels, their capacity to absorb solar radiation is greatly diminished. As seen in Figure 2, this reduction varies according to the amount of dust deposited on the panel. Deposits may also block the light from solar cells, reducing the amount of electricity generated. Photovoltaic (PV) solar panels can be cleaned with water-based cleaning systems, which are specially designed equipment that use water as the main cleaning agent. The purpose of these systems is to maintain the cleanliness and absence of impurities on the surface of solar panels, which may lower their energy efficiency.

The Earth's rotation causes the Sun's location with regard to the solar panel to fluctuate. The solar panels must absorb as much energy as possible in order to use solar energy efficiently. This is only possible if the panels are positioned consistently in the direction of the sun. Solar panels should therefore always revolve in the direction of the sun. The circuit that rotates a solar panel is described in this article.

II. Literature Review

In the past, research was made to solve the issue of loss of energy by solar panels. The efficiency of solar power systems can be increased by incorporating a tracking system. Various types of tracking systems are possible; as such designing a single-axis sun tracker using a microcontroller. The study evinces that such tracking systems increase the yield of energy by a huge amount. Using microcontrollers manipulates the execution of the system with more efficiency.[4] This project addresses the factors that affect the efficiency of solar cells such as temperature, maximum power point tracking, and energy conversion efficiency. Thus, to utilize these factors a tracking system based on the function of a DC motor controlled by light sensors is fabricated.[3] The tracking system is designed using a microcontroller as well as a servo motor. The system can be programmed to rotate at different angles and also the sensitivity of the system can be encouraged by the use of Light Depending Resistors that is LDR sensors. This gives greater flexibility over existing systems. The paper explores how the single-axis algorithm could be extended to the dual-axis as well.[6] This is an approach towards a photovoltaic panel system using a Microcontroller-based application as monitoring media. The application monitors the temperature changes and conveys the necessary angle inputs.[6]

III. Objective Of The Study

The primary goal of the project is to transform the stationary panel structure into a tilting framework that can follow the sun in order to maximize the efficiency of the solar panel. A stepper motor is used to rotate the solar panel in an angular manner, four LDRs are used to align it for maximum sun exposure, and a voltage regulator and microcontroller are used to maintain a steady output voltage. This study examines how a solar tracker increases the output voltage of a solar panel under various weather scenarios.

IV. Methodology

Energy consumption is the main effect of population growth, technological advancement, and industrialization. The world's energy needs are growing every day as it expands and develops. However, the share of fossil fuels in the energy supply was decreasing as people began utilizing clean, sustainable energy sources to live in a cleaner environment. Future energy needs must be met by renewable energy sources because they are clean, sustainable, and environmentally friendly. In addition, the use of renewable energy sources has resulted in a massive rise in energy production worldwide in recent years.

In order to maximize the amount of light that falls, the solar panel is made to monitor the sun. Thus, the solar panel is positioned using four LDRs. The solar panel has one axis of azimuth, which permits left and right movement. The panel can be turned up and down using its other axis, elevation. The outcome of this recent advancement offers the solar panels a great deal of mobility. The solar tracking system's circuit is divided into three portions. The control circuit that powers the servo unit is combined with sensors, a potentiometer, and a programmed microcontroller. The input unit is composed of four LDRs and a voltage regulator. The AT89S52 microcontroller, which is fed a C program, is the heart of the embedded system. Prior to being integrated into the framework, these three stages are designed independently. Programming is carried out step-by-step and refined using this process. It has been applied successfully because it follows a straightforward, easy-to-understand, precise, and extremely sensible technique. It also makes sure that any mistakes are taken into account individually and fixed.

Solar Tracking System:

A solar tracking system can update the sun's position as its position in the sky changes from sunrise to sunset. This type of sun has only one degree of freedom of movement, that is, rotation of its axis. The concentrator must always reflect sunlight and focus it on the light receiving tube, and if the rotation angle is incorrect, focusing is not possible. Solar tracking systems track the sun by moving along both axis. Usually the angle is adjusted manually at some times of the year., and the inclination angle moves in an east-west direction. Single-axis systems are more expensive but less powerful than Dual axis system. A single-axis solar tracking system moves vertically or horizontally depending on the path of the sun and air. [1,2].

Figure 1 shows a schematic diagram of Single-axis and Dual-axis solar tracking.

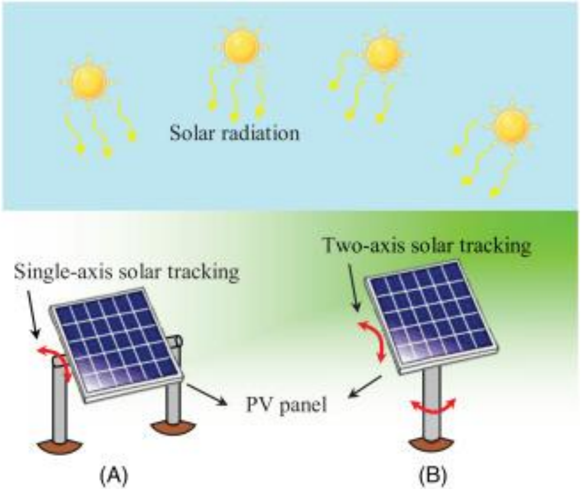

Figure 1. (A) Single-axis and (B) Dual-axis.

Single tracking solar panel system

Single-axis solar tracking techniques follow the sun by moving along one axis. Typically, the way of use also changes in certain years. inclination angle moves in an east-west direction. Single axis systems are more expensive but less powerful than dual axis systems. Single-axis solar tracking moves vertically or horizontally depending on the sun's path and the atmosphere. [1,2].

Dual tracking solar panel system

Dual-axis tracking device that follow the sun's path to collect more solar energy. Depending on the axis type, dual-axis tracking devices can be divided into two types: polar tracking and elevation-azimuth tracking. Polar tracking is also known as spin altitude tracking. Maximizing the use of solar energy. A dual-axis tracker can be operated by tracking the sun's rays rotating solar panel in different directions i.e. in all directions which is shown in Fig,

Proposed System:

Considering all the reviewed articles, solar trackers are classified as only single-axis or dual-axis devices. Some advanced tracking systems use predictive algorithms that anticipate the sun's position based on historical data and weather conditions.

V. Basic Block Diagram

Proposed system: In this system Fig.2, We will have a solar panel to track the position of the sun and always try to remain perpendicular to sun rays. It will not only track the sun in east-west direction but also track sun movement in north-south direction. This is done using a set of dc motors and 4 LDRs. The LDRs will detect the sun's direction and the motors will rotate and turn the solar panel in that direction. The LDRs have analog output hence, we need to use an ADC IC which will convert the analog input to digital for the microcontroller. To drive dc motors we need dc motor driver circuits which will ensure the proper current supply to the motors. In addition to this we will also use a voltage sensor and a temperature sensor.

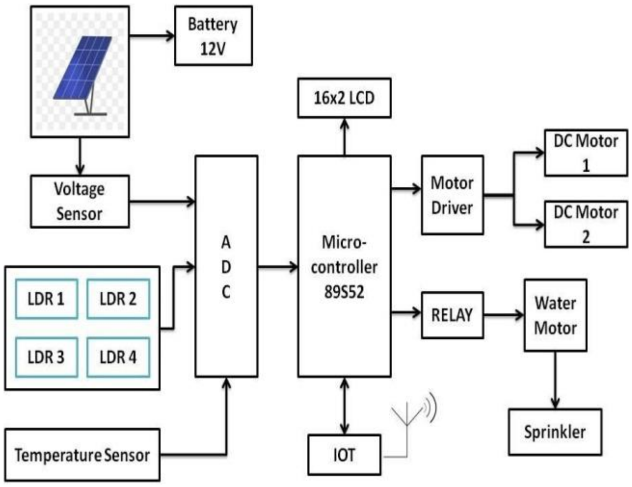

Fig. 2 Basic Block diagram

The voltage sensor will read the output voltage of the panel. The temperature sensor will sense the surface temperature of the panel. As the solar panel gets hot above certain level the water pump will get on and it will sprinkle some water on the panel surface. Due to the water sprinkler the surface gets cooled to some extend. Many solar panel water tanks have disadvantages in terms of energy efficiency and effectiveness. To switch on the water motor we will use a relay circuit. Sprinkler block installed with Water-based cleaning systems for photovoltaic (PV). The solar panel cleaning mechanism is designed to remove dirt, dust and other debris accumulated on the surface of the solar panel and increase its performance. Design and testing of self-cleaning systems for photovoltaic (PV) installations in various climates. All the sensor data is sent to the server periodically using a Wifi module. Then the data will be displayed on the server website in graphical way. The following devices are includes in this proposed system.

1. *Microcontroller and Components:*

Choose a suitable microcontroller (e.g., 89S52, Raspberry Pi) based on your project requirements. Identify and list the necessary components such as light sensors, LDR, motors, motor drivers, power supplies, LCD display, etc.

2. *Design System Architecture:*

Develop a system architecture that outlines the connections and interactions between the microcontroller, sensors, motors, and other components. Define communication protocols and interfaces.

3. *Algorithm Development:*

Design the sun tracking algorithm. Consider factors such as time, date, geographic allocation, and light intensity. Simulate the algorithm to ensure it responds accurately to changes in sunlight.

4. *Hardware Setup:*

Fig.3 Cleaning systems of various photovoltaic arrays equipped with nozzles.

Assemble the hardware components based on the system architecture. Verify that all connections are correct and the components are functioning as expected.

5. *Microcontroller Programming:*

Writeandtestthemicrocontrollercodetoimplementthesun-trackingalgorithm.Includeerror-handling mechanisms and ensure efficient power management.

6. *Sensor Calibration:*

Calibratelightsensorsandanyotherrelevantsensorstoensureaccuratereadings.Conductexperimentsto validate the sensor data against real-world conditions.

7. *Motor Control Implementation:*

Developthemotorcontrolsystemtoadjusttheorientationofthesolarpanels.Testthemovementofsolar panels under different lighting conditions.

8. *Power Supply Management:*

Implement power supply management strategies to optimize energy consumption. Consider using solar power for the microcontroller and control system.

9. *Testing and Validation:*

Conductcomprehensivetestingundervariouslightingconditionstovalidatetheeffectivenessofthesun- tracking system.Address any issues or inefficiencies identified during testing.

10. *Data Collection:*

Collectdataonenergyoutputandefficiencyimprovementswithandwithoutthesun-trackingsystem. Document the performance of the system over an extended period.

11. *Analysis of Results:*

Analyze the collected data to assess the effect of solar tracking on solar panel efficiency.

12. *Cleaning System:*

Dust can form a thick layer on the panels, reducing their ability to absorb sunlight. The amount of this reduction depends on the amount of dust present on the panel, as shown in Figure 3. Sediments can also affect the sun's bright shadow, causing a decrease in electricity Sediment concentration can also vary with weather conditions such as dust storms, pollution conditions, and even dew and humidity. If dew or moisture remains for a long time without evaporating, water will be stored on the solar panel surface. Photovoltaic (PV) solar panel water-based cleaning technology is a specially designed equipment that uses water as the main agent to clean the solar panel, as shown in picture 3.[7] These machines are designed to keep solar panels clean and free of dirt, dust, debris and other contaminants that can reduce their performance.

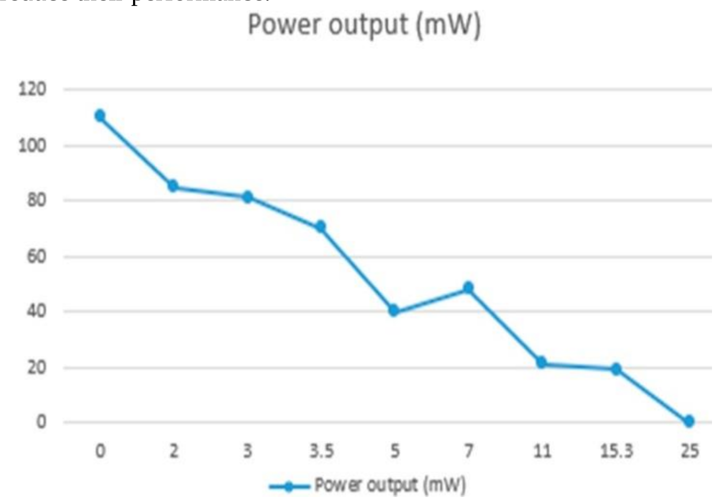

Fig.4 Power Output

VI. Results And Discussion

According to the current research, future studies on improving the performance of solar photovoltaic energy using a compressed air cooling system are as follows:

- The technology of nozzles (number, position, angle, etc.) is needed. It should be changed to improve the maintenance cost of air flow.
- To increase photovoltaic efficiency, it is necessary to combine the maximum power point detection (MPPT) feature of photovoltaic panels with different dust and temperature.
- For long-term operation of photovoltaic arrays, solar energy variation and load demand, weather conditions, etc. are taken into account to optimize the adjustment frequency and time to achieve more energy and economic benefits. It must be taken into attention.

The power output is shown in Fig.4 and Efficiency variation shown in Table 1 below

Table 1.

Panel clean/unclean efficiency	06/1/2024	15/01/2024	30/01/2024	15/02/2024
Normalized clean panel efficiency	0.76%	0.73%	0.70%	0.73%
Normalized unclean panel efficiency	0.73%	0.65%	0.58%	0.54%

The performance of clean and dirty photovoltaic systems may vary. This standing water can encourage the growth of mold, algae, or other organisms that can affect the performance of the panels and require cleaning.

VII. Conclusion

The tracking system shows an increase in output power. When we examine dual trackers, we see an increase in performance, but there is also an increase in design parameters. Dual tracker systems are best suited for areas where the position of the sun changes according to different geological surfaces and landforms. The dual tracking mechanism is an effective tool to enhance the performance of the solar system designed to follow the movement of the sun. The energy gain from single tracking and dual tracking systems are proposed.

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