DUAL AXIS SUN TRACKING SOLAR PANELS WITH EFFICIENCY MONITORING

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***Abstract* — Due of its potential to offer a long-term answer to the world's expanding energy needs, solar energy has attracted a lot of interest lately. Solar trackers are tools that monitor the sun's position and modify the inclination of solar panels as necessary to increase their effectiveness. Many configurations have been suggested to attain excellent precision and reliability using these tracking systems after thorough study. Processing of images, algorithms based on information about sun irradiance, and sensor-based techniques are all common approaches to solar tracking. It has been demonstrated that solar trackers can improve solar module efficiency by up to 25% when compared to stationary solar modules. The development of single axis and primarily dual axis solar trackers, with a priority on affordability and dependability, is a significant field of research given the rising demand for renewable energy.**

***Keywords* – Microcontroller, Image processing, LDR, RTC, Efficiency**

I. INTRODUCTION

Photovoltaic (PV) panels are used to collect energy from the sun to create solar energy, which is a renewable and clean form of energy. By enabling solar panels to track the sun's path, solar trackers help solar panels operate as efficiently as possible. Solar trackers allow solar panels to gather more sunlight and produce more energy, increasing their efficiency by up to 25–30% as compared to fixed panels. The usage of solar trackers promotes a clean, more sustainable energy mix and lessens our dependency on non-renewable energy sources. Yet, the ability of solar panels to directly face the sun determines how effective they are. Dual-axis solar trackers are useful in this situation.

With a dual-axis solar tracker, a solar panel may move with the sun as it crosses the sky, maximizing its exposure to light and raising its output. A dual-axis tracker increases the amount of electricity a solar panel can produce throughout the day by tracking the path of the sun. Due to the fact that dual-axis trackers can boost total energy by up to 50% in comparison to fixed-mount solar panels, they are becoming more and more common in solar energy systems. This makes them a useful addition to solar energy systems for both homes and businesses. Solar trackers offer cost-effective energy production in addition to improved efficiency, and they can assist in reducing emissions of greenhouse gases and lessen the consequences of climate change. The growing need for sustainable and effective energy systems and the desire to move away from conventional sources of energy that are prone to price swings and supply disruptions are what are driving the market for solar trackers.

In general, solar trackers and solar energy are essential elements in the push for a more environmentally friendly future and are crucial for lowering environmental impact and decreasing the impacts of global warming.

II. LITERATURE REVIEW

The concept and development of a "high accuracy dual-axis solar tracking system based on image processing" were presented by Joo Pombas and Joo Murta-Pina[1]. The system is made to follow the sun's path and align the solar panels optimally for generating the most power. The microprocessor manages the motor and rotates the solar panel, while the camera takes pictures of the sun & measures its location. The solar panel's DC power is transformed into AC power via the power conversion device. In order to determine where the sun is in the sky, image processing methods are used in the study's methodology. To precisely estimate the sun's precise position in the collected photos, the scientists combine template matching and edge detection techniques. The motor is then controlled by the microprocessor, and the solar panel's orientation is changed as a result. The findings demonstrate that in terms of power output, the highly accurate dual-axis solar tracking system built on image processing beats conventional single axis tracking systems. Also, the system is demonstrated to be extremely accurate, with an average inaccuracy in tracking the position of the sun compared with fewer than 1 ° c and a gain in efficiency of up to 25%.

To maximise solar energy generation, Maidugu Aji, Aisha Temitope Olomowewe and Bawa Garshima Gamiya [2] described the design, testing, and application of solar tracking systems. The dual-axis solar tracking system was designed and modelled by the authors using CAD and the simulation programme MATLAB/SIMULINK. The dual-axis sun - tracking system's primary design and simulation inputs included solar panels, an Arduino UNO microcontroller, LDR, servo motors, and a voltage regulator (LM7805). A dual solar tracking system was created by the authors using computer-aided design (CAD) tools and simulation. In the simulation, various system configurations were modelled and tested in order to evaluate the system's performance. Solar panels, engines, sensor systems, and the control unit were among the system's components that were simulated in the simulator to forecast how they would behave in various scenarios. An approach consisting of multiple steps was used to put a dual solar tracking system design into action. The analysis of solar irradiance data was one of these processes, along with system designing, simulation and testing, implementation, and performance evaluation. The overall success of a dual-axis solar tracking system, which demonstrated a 30% increase in efficiency, was subsequently used by the authors to draw a conclusion.

A sensor-free dual-axis sun tracking system was designed and implemented by Jarnu Girdhar, Prabal Bhatnagar, and Vasant Badugu [3]. This system's strategy relies on an optimization method that periodically modifies the position of the solar cell to track location of sun. Using the elevation and azimuth angles of the sun, the algorithm determines the sun's position and uses that knowledge to direct the rotation of the DC motors. After receiving the computed angles, the microcontroller instructs motor driver to turn the panel in the appropriate direction. The technology updates the sun's location on a constant basis and modifies the panel's orientation accordingly. To ensure that the system works even when there is no sunlight, the authors have added a battery-based power supply. The system uses a switched-mode power supply to control the voltage and a voltage sensor to check the battery voltage. The scientists developed a sensor-free "dual-axis solar tracking system" that precisely tracks the position of the sun to increase the energy generated by solar panels. The system is simple to implement and reasonably inexpensive.

In addition to Shubham Bari and Rohit Chavan, Jayshree Mhatre, Komal Gupta, Trupti Shah, Shruti Kuvekar, and Shaista Khanam [4] presented the design and execution of a "dual-axis solar tracking system" that uses real-time image processing methods which helps in accurate sun tracking. The phases involved in the methodology were picture image recognition, motor control, acquisition, and power generation. It was built around real-time methods for image processing and control systems. The writers captured photos of the sun and tracked its position in real-time using a camera and a microcontroller. Based on information about the sun's position, the microcontroller was coded to regulate the motion of "the dual-axis solar" tracker. The authors calculated the sun's location in the sky using a mathematical model, and then they contrasted it with the real position they discovered using a digital camera. The authors conducted a number of tests to verify the effectiveness of their "dual-axis solar tracker". They measured their system's energy generation efficiency against that of a single-axis sun tracker and discovered that their "dual-axis solar tracker" increased it by up to 40%.

Using the Arduino microcontroller, Swapnil Adhav, Anirudha Dalvi ,and Akash Singh[5] suggested designing and implementing a dual axis solar tracker system (Arduino Mega 2560). A LED Display was also used in the design, which also included implementing the system design, programming the microcontroller, testing the system, and assessing the effectiveness of the solar tracker. To ascertain the system's precision and effectiveness in tracking the sun, it was put to the test in a variety of scenarios. To enable real-time tracking of the sun, the technology adopted in this study combines image analysis and control algorithms. An affordable and effective method for dual-axis sun tracking is made possible by the usage of the Arduino microcontroller. This approach has successfully increased photovoltaic panels' efficiency and showed the potential for the further advancement in the area of solar monitoring systems. The dual-axis solar tracker built on an Arduino platform, according to the authors, displayed exceptional precision in detecting the sun's movement and produced the most energy possible from the solar panel. Also, it was discovered that the system was inexpensive to build, simple to use, and could boost efficiency by up to 28%.

In order to account for the sun's movement from the east to the west during the day and its changing radiation angle with respect to the Earth over the seasons, M. Saeedi and R. Effatnejad [6] created a design. PV panels produce more energy when they are placed perpendicular to the sun's rays' angle of incidence. In order to boost the PV panel's output power, this study will design and put into use a dual-axis solar tracker (DAST). With simultaneous movement along two axes, this straightforward mechanism adapts the PV panel in accordance with solar radiation. The control system of this device is analogue. The closed-loop DAST control system employs the Wheatstone bridge network function and light-dependent resistors (LDRs). To test the suggested system, a small DAST was created and its performance was confirmed. I-V and P-V requirements were found using the tests. Ultimately, it was discovered that the PV panel that use the sun tracker had a higher output power than the fixed panel.

Dual axis solar tracking system was created, built, and tested by Sunny Sahu, R.N. Patel, and Shruti Tiwar [7]. This condition was used to compute the system's efficiency. They dealt with real-time dual axis solar tracking technology. By using solar cells and a tiny amount of solar energy, they can improve solar energy production by up to 45%. The quantity is restricted because these solar cells are positioned in a fixed location. They employed a solar tracker to improve the energy received. Two algorithms form the basis of the entire system. When a solar panel is set in place, the first algorithm determines the sun's path as well as various azimuth as well as elevation angles. The date and place specified in the first method are modified using the second algorithm. RTC is utilized to do this. About 45% of the system is efficient. Optimizing the amount of power produced by the solar panel was made possible by the closed loop assembly technique.

Using a dual-axis sun tracker, J. Faraji, M. Khanjanianpak, M. Rezaei, M. Kia, E. Aliyan, and P. Dehghanian [8] suggested a fast-accurate approach to locate the sun. In order to reduce power consumption and enhance dynamic performance, the tracking time is shortened. A closed-loop approach using a Multilayer Perceptron (MLP) neural network, Perturbation and also Observation is used for controlling (P&O). The sun tracker will use a neural network to operate swiftly but erroneously if the sun considerably deviates from solar panels. However, if the sun moves significantly away, the solar tracker will still use P&O to operate accurately but slowly. So, integrating these two examples will enable us to monitor the sun quickly and precisely. The neural network is initially trained using the error back propagation training methodology, and then it is optimized using the Modified Particular Swarm Optimization (MPSO) technique. The findings show that the proposed approach's tracking time is 42%–49% shorter compared to the other method used for comparison. The sun tracker therefore favors dynamically better. The suggested approach shortens the surveillance period and achieves greater energy savings, enhanced effectiveness, and better dynamic.

The AADAT (Azimuth-Altitude Dual Axis Tracker) system allowed Concepcion, N.D.G., Villanueva II, A.R., Dalumpines, A.K., Magwili, G., and Pacis, M.C [9] to design a solar concentrator. In order to create a sustainable system, it was crucial for a solar installation to have a certain load modelling solar panel rating, and battery sizing. The system had one V-trough solar concentrator installed to boost the solar system's effectiveness. Generally, three preliminary design components were taken into account. They discovered that the KL ratio gives a 60° reflector angle, the geometric proportion is 2, as well as the reflectivity (ρ) of a concentrate material is 85%. In order to increase the amount of solar energy that may be captured, they were successful in constructing a dual axis tracking system. They also established the solar tracker and concentrator performance curves. The amount of solar energy captured is increased by 59.86%, 57.53%, and 55.25% each trial by integrating a dual axis tracking system and adding a solar concentrator, respectively. For home and small-scale applications, this prototype was perfect. It might serve as a replacement for typical solar systems that cannot handle roof-mounted panels in homes.
A Dual axis Photovoltaic panels tracker system was given by Mahmudul Alam Md. Sazal Miah, Shikder Shafiul Bashar, Md. Ashraful Dewan, and A. Ghosh [10]. The optimum power point tracing technique, employed in photovoltaic systems is to increase the output power of the PV array, was controlled by a microprocessor. Their endeavor can function in both phases. There are two main theories for solar tracking systems: using sensors in general (LDR) to determine sun trajectories or using mathematical statements written into a microcontroller. The method used depends on whether or not there are clouds. Although using sensors is extremely accurate, there is a significant drawback: on rainy days, the sensors were unable to precisely trace the sun's paths, and on occasionally very cloudy days, the tracker was unable to move. While using mathematical systems is not as accurate as using sensors on a sunny day, it does have one key advantage: its performance is adequate on cloudy days. In this project, both methodologies were utilized. These controllers were capable of producing a significant quantity of current. The production cost was decreased in this manner.

III CONCLUSION

In summary, a dual-axis solar tracking system is a crucial component of the technology for solar panels that aims to maximize solar cell efficiency by continuously orienting it towards the sun, up to 30-40%. The design and execution of dual-axis solar tracking systems using a variety of parts and methods has been the subject of numerous studies. These research use sensors, actuators, algorithms and microcontrollers as their constituent parts, adaptive algorithms, simulation, and sensor-less tracking as their methodologies. These were designed, put into service, tested, and optimized as part of the technique utilized in these investigations. According to studies, the adoption of these has significantly enhanced the efficacy of solar panel system overall and increased the solar cell efficiency.

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