SOLAR PANEL PRODUCTIVITY IMPROVEMENT OF SOLAR PHOTOVOLTAIC CELL APPLICATION USING A SINGLE-AXIS SOLAR TRACKING SYSTEM

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ABSTRACT

Solar power is one of the most recent renewable energy sources. The sun's energy is limitless. The key problem, however, remains optimizing the quantity of energy captured in an effective manner in order to convert energy directly to electricity from the sun's rays. Installing a solar tracking system for solar panels is one technique to improve efficiency This is done so that the sun's rays fall perpendicularly on the solar panel, capturing the maximum amount of available solar energy. Throughout the day, the tracker tracks the path of the sun in such a way that the panel surface is constantly towards the sun. All solar tracking system projects completed to date are based on a nearly identical position sensing theory. Traditionally, tracking has been accomplished by the use of several sorts of sensors that measure the sun's location. Instead of using a typical algorithm, this thesis paper provides a novel sun tracking approach. Unlike photo-conductors, light-detecting resistors, photo-transistors, or photodiodes, which cannot operate without voltage biasing, this new type of sensing algorithm is based on the voltage created in the solar panel. As light rays fall on the solar panel, it generates voltage. The globe is depleting its resources to fulfill everyday energy demands, and it is quite likely that we will run out of any naturally occurring metal, mineral, or petroleum in the near future. As a result, renewable energy solutions are in high demand today to conserve natural resources and address the energy issue. Solar energy is quickly gaining traction as a viable renewable energy source. However, solar panel efficiency is a major consideration. While the sun follows a parabolic course throughout the day, the panels used in our nation are often mounted to a pole or the roof of the home, reducing the efficiency dramatically during the day

Keywords: Solar energy, solar tracking, photovoltaic, DAST, Static Solar System Network, Packet Delivery Fraction

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1.0 INTRODUCTION

In reality, it is predicted that in the near future, the cost of power will rise, making it completely unviable and unrealistic to meet these demands with the conventional energy resources that we have used thus far, such as coal, petroleum, gas, and so on. As a result of the increase in the amount of budget allocated for the study and improvement of the most recent options, this problem has become a standing challenge before the technical society. In light of this, we have focused our research on harnessing renewable energy. Solar energy is the most abundant form of free energy available on this planet, out of all the available renewable energy sources. The international community is currently looking for greener ways to harness power and reduce greenhouse gas emissions in the atmosphere. Solar energy is a continuous and natural energy source that comes from the Sun. Photovoltaic cells are used in solar power to convert solar radiations into electricity. This device's expected lifespan is 25-30 years [1]. The sun's electric latent is great, and it was far one source of increased strength, which is supported so that global technology distribution can be cosy. The efficiency of tracking the sun can be increased by 30-40% [2]. Solar energy converts daylight into electric energy at a conversion rate of approximately 15% [3].

The cost of installing PV systems is decreasing, and governments are providing subsidies to consumers and organisations to encourage the maximum use of renewable energy. However, the efficiency of PV-based power is still a hot area of research, and more rigorous research is needed in this field. It is widely acknowledged that solar systems are the primary method for converting the sun's energy into the most transportable form of energy, namely electrical energy. Given the foregoing facts, we investigated ways to meet rising power demands using alternative energy sources, preferably those that are cheap or free, easy to harness, plentiful, and renewable. As long as the earth exists, solar energy will provide us with a steady supply of its radiations. Because the sun will continue to shine for millions of years, renewable energy sources represent an unlimited source of energy in the future

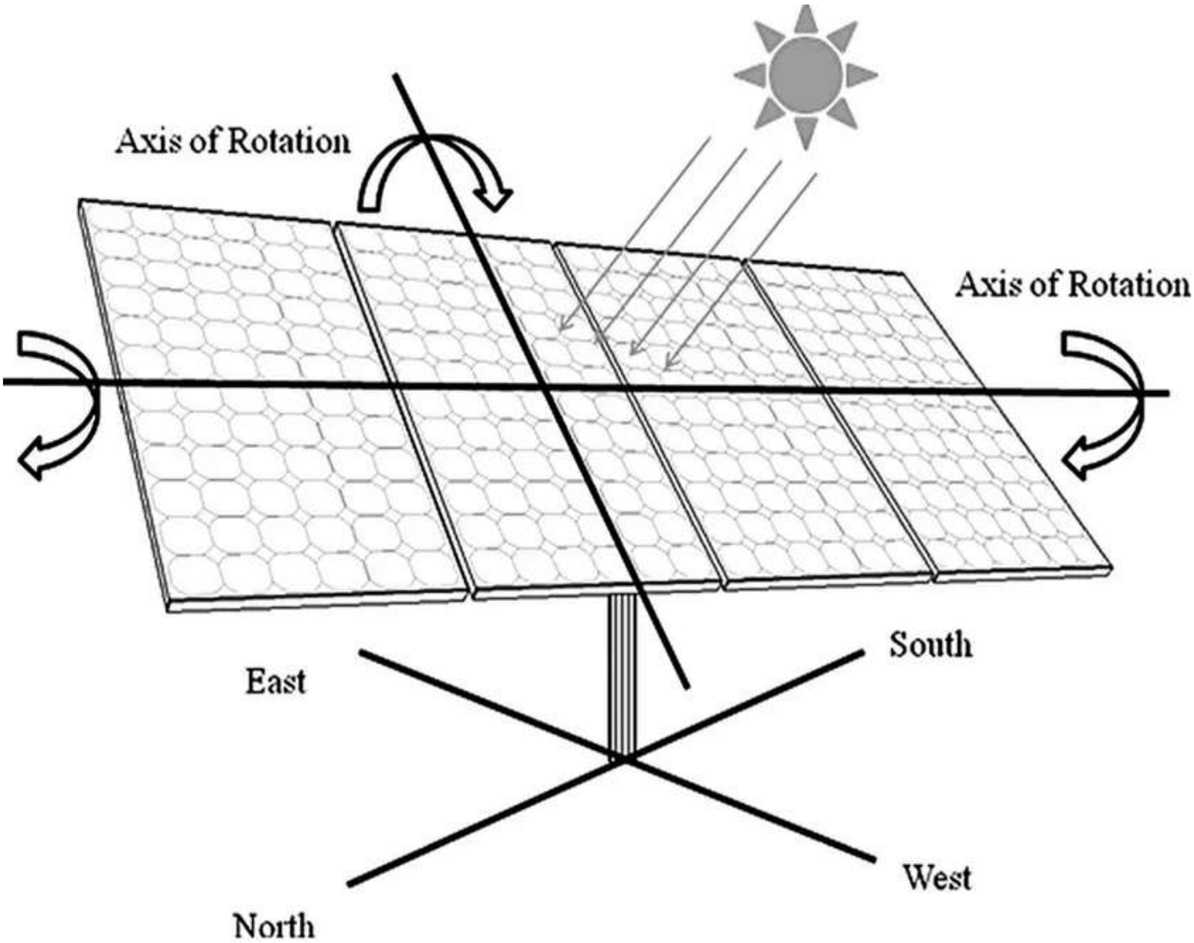

Fig.-1: Dual-Axis Solar Tracker

2.0 LITERATURE REVIEW

Aditia Yoga Pratama et al [4] The majority of solar power plants (off-grid and on-grid stations) utilise a fixed tilt angle for solar panel installation. The solar power plant's fixed tilt angle system directs solar panels toward the sun at a specific angle. For maximum energy extraction from the sun, the solar panel plane must always be normal to the incident radiation. Solar panels installed at a fixed tilt angle will only face the sun perpendicularly for a few hours per day. In this experimental study, a dual axis solar tracker (DAST) was designed and constructed to align solar panels perpendicularly with the sun. This DAST system is microcontroller-based and its primary controller is an Arduino Uno. As a DAST sensor, light-dependent photoresistors (LDR) are utilised. Servo motors are used to rotate the appropriate position. All output parameters are stored on an SD card. This DAST system is designed to control the solar panel workspace's Altitude angle in the vertical plane and Azimuth angle in the horizontal plane. This experimental study demonstrates that the output of solar panels using the DAST system is significantly greater than that of solar panels with a fixed tilt angle. *S.V. Mitrofanov et al* [5] The article describes the winter 2019 operation of a solar power station with a dual-axis solar tracking system in Orenburg (Russia). Presented is a comparison of the production of "green" energy by stationary solar panels and a solar module with a tracking system. The information gathered by the station's information-measuring system is used to analyse the operation of the photovoltaic plant. This complex consists of a remote monitoring and diagnostics system for solar power station parameters and an automated weather station. The authors provide recommendations for improving the energy efficiency of photovoltaic plants in the Orenburg region after examining the structure and capabilities of this complex, as well as the characteristics of the station during the aforementioned time period. *Kommuri Poojitha et al* [5] Solar energy is one of the primary alternatives to nonrenewable energy, and although its use is unpopular, there are a number of Maximum Power

Point Tracking (MPPT) techniques for maximising the efficiency of photovoltaic (PV) cells. The Perturb and Observe (P&O) technique is the most frequently used of the numerous methods employed in this field. This paper demonstrates the Perturb and Observe (P&O) technique for tracking the Maximum Power Point (MPP) and controlling the panel's orientation. *S.V. Mitrofanov et al* [6] The article provides a description of a MATLAB/Simulink-developed simulation model of a solar power station with an automated dual-axis solar tracker. The presented development includes a random weather generator (solar radiation intensity), automated load redundancy, and the simultaneous use of monocrystalline and polycrystalline solar cells. This paper presents modelling results that demonstrate the effectiveness of using solar modules with a dual-axis solar tracker as opposed to statically placed modules. In addition, the optimal operating conditions of a photovoltaic plant have been identified based on the conducted analysis of the modelling solar power station work in MATLAB/Simulink. The developed model will enable the study of the characteristics of a solar power plant and the prediction of the amount of energy generated by solar panels in a particular location. *Aditya Sawant et al* [7] Energy has become a necessity for human survival. The energy crisis is straining conventional energy sources. Conventional energy resources such as coal and petroleum are expected to experience a shortage in the near future. In addition, its impure nature contributes to pollution and global warming. It is time to transition to a cleaner and more plentiful energy source. Due to the abundance of solar radiation striking the earth's surface, it is regarded as a major potential source of free energy. Despite extensive research into effective utilisation of this energy, radiation collection efficiency is inadequate. Dual Axis Solar Tracker is one of the techniques that can provide a highly effective means of utilising more solar energy. Single-axis and dual-axis solar tracker systems are described in this paper. Microcontroller-based dual Axis Solar Tracker with LDR (light-dependent resistor) sensor was designed. In addition, a computational result was obtained to calculate system efficiency. Dual Axis trackers were discovered to be 25% more effective than single Axis trackers. *Prachi Rani et al* [8] This article implements a solar photovoltaic (SPV) cells-based single-axis tracking system on the Arduino Uno platform for maximising daily power output. The central concept of this article is the implementation of a solar tracking system with a single automatic axis. Experiments are conducted to determine the optimal alignment of solar panels with the Sun in order to obtain maximum solar radiation. This system monitors maximum light intensity in terms of maximum power point (MPP). When the light intensity decreases, the lens's alignment is automatically adjusted to capture the maximum amount of light. This article demonstrates the implementation and analysis of a single-axis solar tracker, whereas there are numerous solar axis trackers on the market. In addition, the proposed method can rapidly identify the axis and align it with the sun's rays in order to achieve MPP output regardless of motor speed. *Singgih Hawibowo et al* [9] In the future, when fossil fuel supplies will be depleted, solar power plants are one of the energy converters that will be required to sustain human life. It is also extremely useful in areas without access to electricity. Solar panels are typically mounted on a structure with a static orientation. If the direction of the solar panel is able to track the movement of the sun's rays, the amount of electricity generated will be maximised. This research aims to examine the technical and economic aspects of a solar tracker and driver system for a solar panel. LDR sensors, two stepper motors, and a microcontroller make up the system. The results of the experiment revealed an error of 1.30° in the east-west direction and 0.85° in the north-south direction. A life cycle cost analysis demonstrates that solar panels with a capacity of 200 Wp or more will benefit economically from the use of the solar tracker system. *Nedyalko Todorov Katrandzhiev et al* [10] The Sun provides us with free, renewable energy that can be converted into electricity or heat by photovoltaic panels and solar collectors, respectively. This paper presents the algorithm and hardware block diagram for a single-axis solar tracker. Also, a comparison is made between a solar tracking photovoltaic system with a single axis and a fixed system. A solar tracking system with a single axis can collect up to 30 percent more solar energy than a static system.

3.0 METHODOLOGY

the methodologies used to design and implement this system with a variety of hardware and software tools are discussed. Here is a brief description of the entire development cycle for this microcontroller-based system. First, a briefing was given regarding the designing of schematics with a CAD tool, taking into account the objectives of our work; next, the PCB layout designing for hardware prototyping was demonstrated and discussed; and finally, the bill of materials required to assemble the hardware was provided. Also discussed were the flowchart design and firmware components used to drive this system

Instead of an Adaptive Mechanism or Predefined Motion, the implemented system used an Automated Tracking Mechanism. The developed hardware prototype was a closed-loop control system that uses sensor data as feedback to compensate for errors and properly align the system. As seen in the following block diagram, the sensors used to measure certain physical parameters served as system inputs, whereas the stepper motors used for actuation served as system outputs in this solar-tracker. The microcontroller, which acts as the system's brain, was responsible for continuously scanning each sensor on a time-shared basis, measuring these parameters, analysing the values obtained, and then, based on the conditions, sending commands to the stepper motors. These stepper motors rotated the attached solar platform.

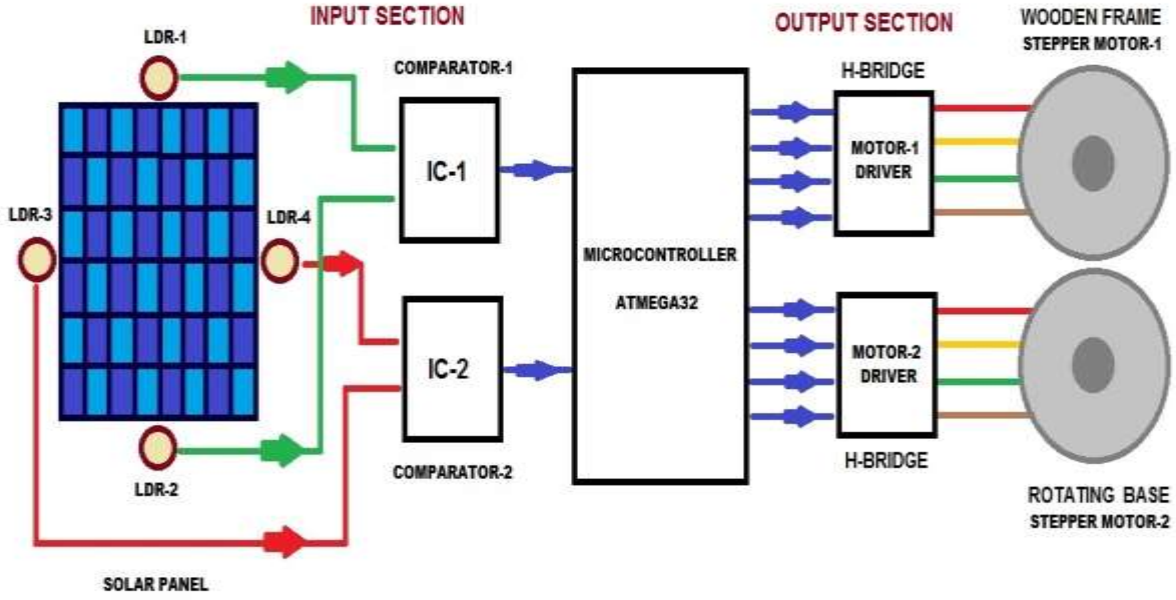

Fig.-2: Block Diagram of the System

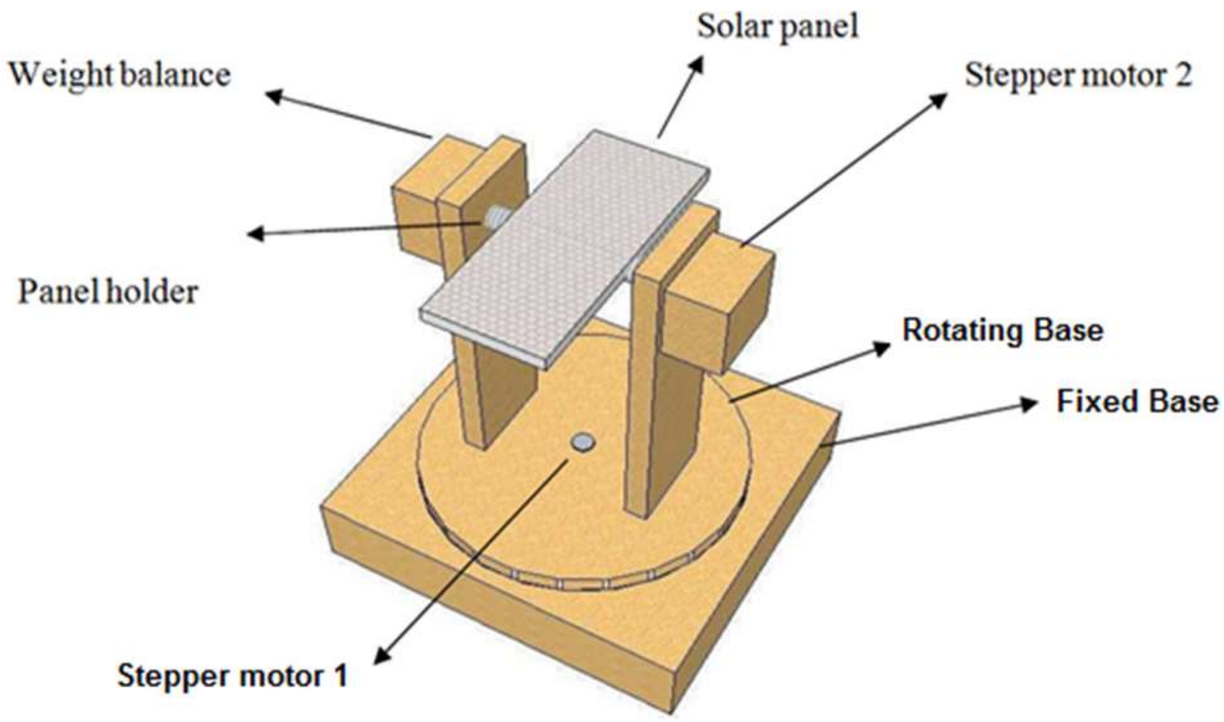

Fig.-3: The Complete Prototype

4.0 RESULTS AND DISCUSSIONS

The sole purpose of this thesis was to enhance the performance of solar photovoltaic mobile systems. We adopted the automatic sun monitoring device for this purpose. During the course of our thesis, we conducted numerous experiments to determine the viability of increasing efficiency through an automatic sun monitoring device, and as a result, we finalised the device. In addition, we conducted experiments to determine the solar panel's characteristic curves. This turned into a crucial experiment due to the fact it became obvious that we needed to recognise the characteristics of the panel we will be working on for our thesis. The characteristics of solar panels are determined with the aid of the modern voltage curve (I-V curve) and the power voltage curve (P-V curve). Thus, we concluded our experiments to determine which panel curves to utilise. This experiment was conducted in a straightforward manner. It is obvious that to find a current versus voltage curve, we must exchange the load against the solar panel and take the corresponding current and voltage readings. We progressively altered the load across the terminals of the solar panel and measured the current and voltage for that load. Voltage and current values are determined by progressively increasing the load. The results of our experiments are presented in the table below.

Table-1: Voltage & Current Varying with Load

Voltage / V	Current/ mA
0	165.5
4.70	158.7
6.15	159.4
8.05	157.7
11.82	156.7
16.5	147.1
17.5	121.2
17.8	116.1
18.1	104.3
18.6	80.8
19.1	54.7
19.3	41.5
19.4	33.2
19.5	27.7
19.6	23.4
18.7	18.6
19.8	8.4
20.3	0

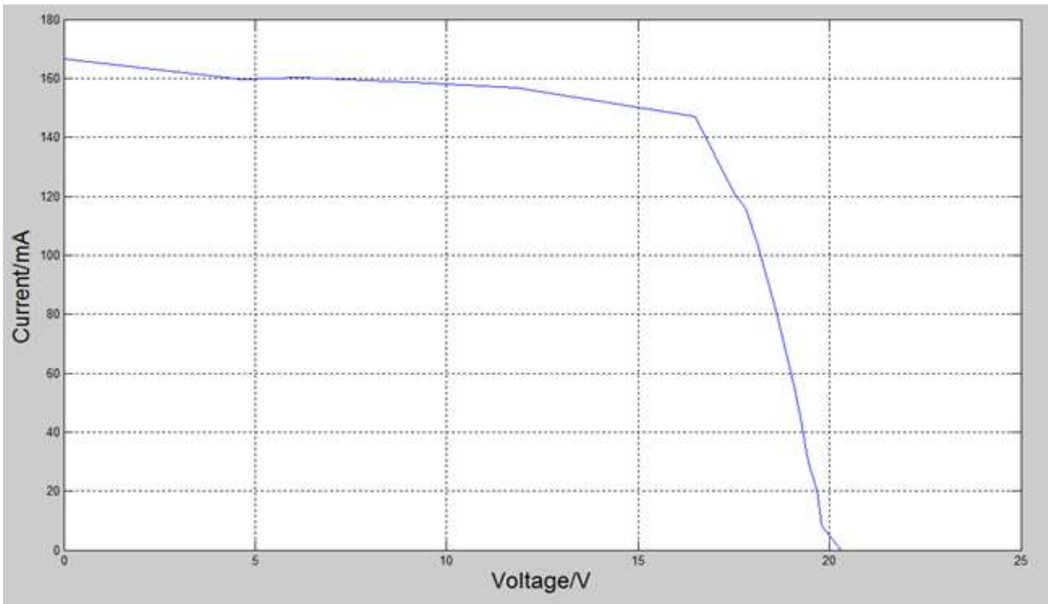

Fig. 4:. I-V characteristics curve

We used the trapezium rule in MATLAB to determine the overall location and, consequently, the total power under each of the road graphs. Then, utilising the constant solar panel as a baseline, we determined how much additional energy we gained through manual and automated adjustment. Observe the calculations as follows:

Constant panel average power = 10.32142 watt

General energy of the manually adjusted panel = 15,67601 watt Total energy of the automatically adjusted panel = 14,41692 watt Electricity production by manually adjusting the panel:

((15,67601 - 10,32142)/10,32142) x 100 = 52 % (approx.)

Automatic panel adjustment increases output by 40 percent: (14.41692 - 10.32142)/10.32142 x 100 (approx.)

According to the calculation above, our system is approximately 40 percent more efficient than a fixed solar panel array. Below is a line graph depicting two phenomena (fixed and manual adjustment) of the 50-watt solar panel

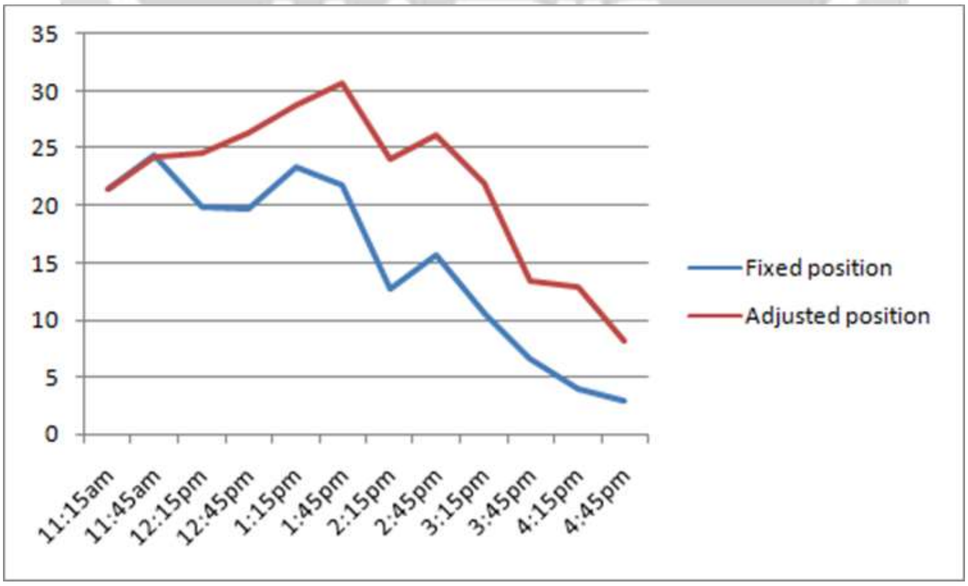

Fig.-5: Power vs. time curve for 50 watt panel

5.0 CONCLUSIONS

A dual-axis solar tracker was created in this work. Multiple tests and calibrations were performed to achieve the desired results. A dual-axis solar tracker was found to be more efficient than a single-axis solar tracker. Multiple tests were conducted, and the results demonstrate that moveable arrays of solar panels can increase efficiency by 40 percent or more, which is almost 1.5 times greater than the amount we receive from a fixed panel. Therefore, it can be concluded that it is possible and practical to make solar panels portable in order to make them greener, as even a 1 percent improvement in the current state of the world would be worthwhile – and the automatic solar tracking system can be 40 percent more efficient than constant panels; the ideal way to harvest more solar energy..

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