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Design and Implementation of Development Solar Generating Module for High-Efficiency Solar Energy Station

Mr. Amol G. Kharabe,
Departmet of Electronics (Communication)
Tulsiram Gaikwad-Patil college of
Engineering and Technology,
Mohgaon, Nagpur

Prof. Rahul Dhuture
Departmet of Electronics (Communication)
Tulsiram Gaikwad-Patil College of
Engineering and Technology
Mohgaon , Nagpur.

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***Abstract*—** This paper aims to develop and analyse a hybrid solar generating module for a high-efficiency solar energy station. The module utilises two solar cells, with one being used for the reflected section and the other for solar tracking. The solar tracking system is equipped with two LDRs and a servo, allowing it to adjust its position and maximise its exposure to sunlight. The module is controlled by an ESP32 microcontroller and uses two voltage sensors to monitor both solar concepts. Data collected from the module will be sent to a ThingSpeak server, where it will be displayed in graph form.

Keywords- IOT Technology, Thing Speak, Solar Generation.

I. INTRODUCTION

With the increasing demand for clean energy sources, solar power has become a popular choice for powering homes and businesses. However, the efficiency of solar panels can be affected by various factors such as reflection and shading. To address these issues, a hybrid solar generating module has been developed that uses two solar cells to improve the efficiency of solar energy stations. This paper will analyse the performance of the module by using a solar tracking system with two LDRs and a servo to maximise exposure to sunlight. The data collected from the module will be sent to a ThingSpeak server, where it will be displayed in graph form, allowing for easy analysis and interpretation.

The hybrid solar generating module is controlled by an ESP32 microcontroller, which enables the module to monitor and adjust its operations for maximum efficiency. The module is also equipped with two voltage sensors to monitor the voltage of each solar cell, allowing for more accurate tracking of performance. The combination of these features makes the module highly efficient, cost-effective, and easy to integrate into existing solar energy systems. This paper aims to demonstrate the benefits of using a hybrid solar generating module and provide valuable insights into improving the efficiency of solar energy stations.

II. LITERATURE REVIEW

[1] T. Mitani,et. al (2019) y. In this paper the authors have suggested a novel analysis technique for pumped storage and thermal power generators with a detailed introduction of renewable energy sources (RESs).

[2] F. Capitanescu and L. Wehenkel, (2019) . The author in this paper addresses operational planning for thermal power generators and output decisions for pumped storage, this paper uses Tabu search and interior point methods.

[3] G. J. Os´orio, et. al (2020) The author demonstrated the advantages of expanding the integration of renewable energy sources in the insular system. +e main focus of this paper is on profit maximisation, cost efficiency, GHG reduction, and time consumption in power generation.

[4] T. Mai, et. al (2021) In this paper authors used an integrated approach in combining spatially explicit resource potential analysis with high spatial resolution modelling of the US electricity system. Various wind supply curves, reflecting variations in siting regimes such as regulatory, physical, and social land-use factors, are analysed in this study to determine the impact of potential wind growth.

[5] B. Setiawan, et. al (2021) In this paper the authors have optimised a hybrid energy system for catamaran ship. +e authors have discussed PV performance, generator performance, dual-input buck boost, and simulation.

[6] Miller, I., et. al (2022) In this paper, we present a model for estimating emissions from integrated power generation and energy storage. The model applies to emissions of all pollutants, including greenhouse gases (GHGs), and to all storage technologies, including pumped hydroelectric and electrochemical storage. As a case study, the model is used to estimate the GHG emissions of electricity from systems that couple photovoltaic and wind generation with lithium-ion batteries (LBs) and vanadium redox flow batteries (VFBs). To facilitate the case study, we conducted a life cycle assessment (LCA) of photovoltaic (PV) power, as well as a

synthesis of existing wind power LCAs. The PV LCA is also used to estimate the emissions impact of a common PV practice that has not been comprehensively analysed by LCA—solar tracking. The case study of renewables and battery storage indicates that PV and wind power remain much less carbon intensive than fossil-based generation, even when coupled with large amounts of LBs or VFBs. Even the most carbon intensive renewable power analysed still emits only ~25% of the GHGs of the least carbon intensive mainstream fossil power. Lastly, we find that the pathway to minimise the GHG emissions of power from a coupled system depends upon the generator. Given low-emission generation (<50 gCO2e/kWh), the minimising pathway is the storage technology with lowest production emissions (VFBs over LBs for our case study). Given high-emission generation (>200 gCO2e/kWh), the minimising pathway is the storage technology with highest round-trip efficiency (LBs over VFBs).

[7] A. Ghafoor, et. al (2019) This paper presents a study about an off-grid (stand-alone) photovoltaic (PV) system for electrification of a single residential household in the city of Faisalabad, Pakistan (31.421N, 73.081E, 184 m). The system has been designed keeping in view the required household load and energy available from the sun. The complete model for the sizing of the complete PV system has been presented to determine the required PV power rating, battery storage capacity, size of charge controller and inverter to fulfil the required load. Using this model, the peak power and area of PV modules, capacity of battery backup, size of charge controller and inverter was calculated to be 1928 Wp and 12.85 m2 , 9640.5 W h, 56.65 A and 1020 W, respectively. The economics evaluation using life cycle cost (LCC) analysis of the complete system has also been carried out. The LCC of the system was found to be PKR. 457,306 whereas the annualised life cycle cost (ALCC) was determined to be PKR. 31,963 yr1 , respectively. The unit electricity cost has also been calculated and was found to be PKR. 14.8 kW h1 . The results show that the unit cost of electricity produced using off-grid PV systems is lower than the unit cost charged in case of conventional electric supply to the residential areas. It is concluded that off-PV electricity is technically and economically viable technology for the electrification of residential applications.

[8] Al-Addous M, et. al (2019) In this work, power production of PV modules and dependence on weather conditions is examined and modelled. Weather data has been collected and summarised in the context of this work as well. Temperature induced deteriorations on system level performance are quantified and modelled through a specially designed cooling system to capture the system characteristics. Generated models can be used to properly estimate the power production potential of the installed PV systems and to adequately size the

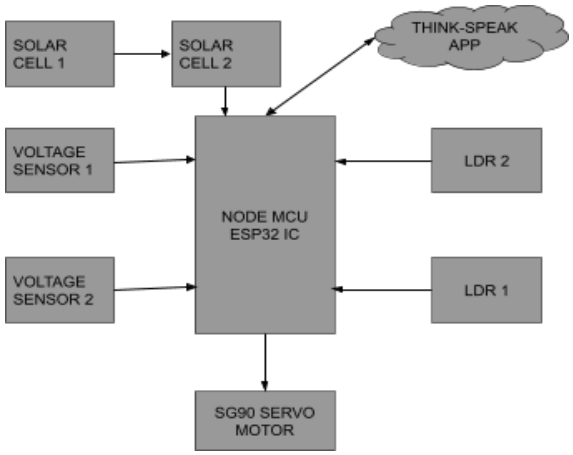
power plants to match desired load profiles. Experimental verification is presented in this manuscript with all relevant results that are needed to analyse the performance of off-grid PV systems

[9] R. V. Zaitsev, et. al (2019) In this article the authors designed the concept of a hybrid solar generating module equipped with a mirror concentrator of solar radiation and solar cells cooling system for use in high performance solar energy stations. Concentrator of solar radiation provides a 1.5-time increase of electrical power generated by such a module, and a water-cooling system can reduce the equilibrium temperature of the module up to 10 degrees and twice reduce efficiency losses from solar cells overheating. The proposed concept will reduce the number of modules needed to build solar energy stations.

[10] Jha, Nishant, et. al (2020) In this paper the author has found global energy needs have risen in recent years, and traditional energy sources such as fossil fuels are no longer viable. To meet the growing electricity demand, attention has moved to renewable energy sources such as solar and wind energy. Furthermore, the development of clean energy is vital for combating climate change. Various studies have shown the effectiveness of using hybrid systems (combination of solar photovoltaic and wind energy systems) for generating power. However, a significant amount of energy gets wasted. To prevent the wastage of energy, a dual-energy generation system for integrated grids has been suggested in this paper

III. METHODOLOGY

Due to critical environmental issues, nowadays most power systems have to accommodate a significant level of penetration of renewable intermittent generation. In our proposed system we used IoT Technology. In this paper the hybrid solar generating module for high-efficiency solar energy stations is a system designed to maximise the efficiency of solar energy generation. The system utilises two solar cells, one for the reflected section and the other for solar tracking, along with two voltage sensors, a solar tracking system with two LDRs and one SG90 servo, and an ESP32 based microcontroller to monitor and control the system. The voltage data collected by the microcontroller is transmitted to the ThingSpeak server, where it is analysed and graphed to provide real-time monitoring of the system's performance.

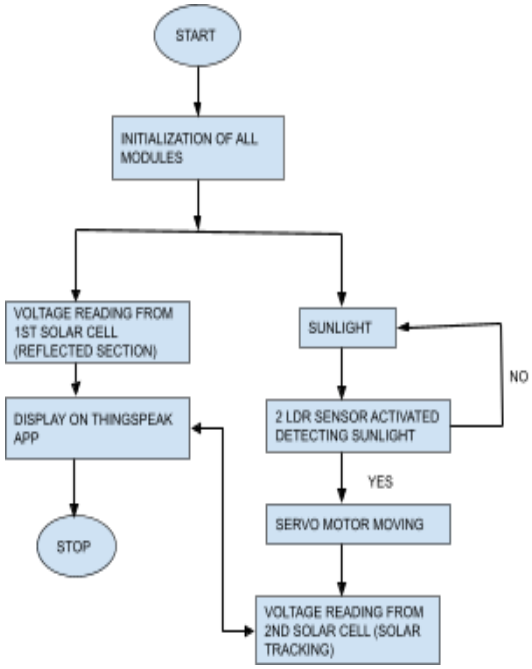


Block Diagram

DESCRIPTION

In the above figure we used Node MCU ESP32 as a microcontroller, and two solar cells, two LDR SG90 Servo motors as an output device and in the input device we used two voltage sensors, and a Thinkspeak server to the microcontroller.

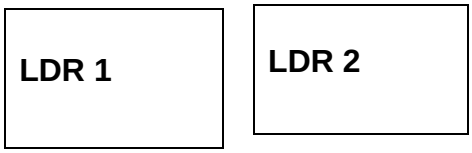
FLOW CHART



WORKING

The paper title is “Development And Analysis Of Hybrid Solar Generating Module For High-Efficiency Solar Energy Station". The goal is to optimise solar energy generation and utilisation. This paper

involves creating a High-Efficiency Solar Energy Station with a Hybrid Solar Module. It utilises an ESP32 microcontroller, two 1.3W solar cells (one for reflected light, one for solar tracking), two voltage sensors, and a solar tracking system with two LDRs and one SG90 servo. Data is sent to Thingspeak Server for real-time monitoring and analysis, presented through graphical outputs.



IV. SYSTEM REQUIREMENT

HARDWARE REQUIREMENT

1. Node MCU ESP32 IC Microcontroller
2. Voltage Sensor
3. Solar Cell
4. SG90 Servo Motor
5. LDR

SOFTWARE REQUIREMENT

1. Arduino IDE
2. Proteus
3. Things Speak

IMPLEMENTATIO

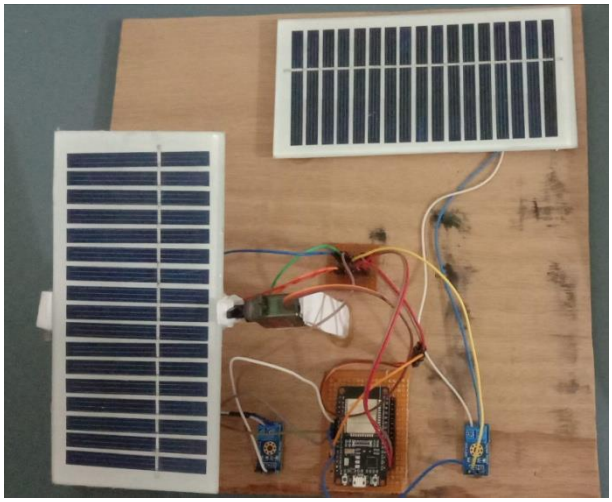
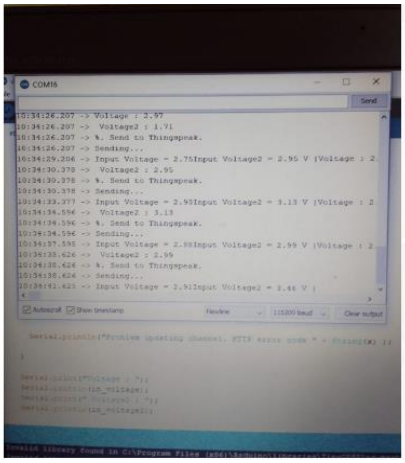
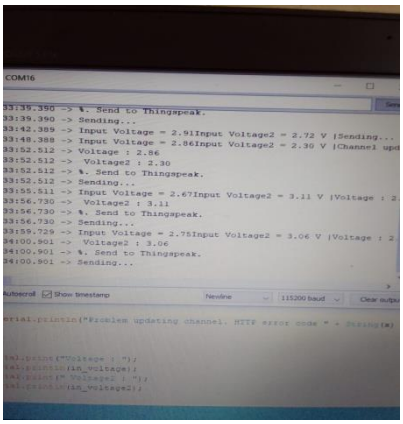


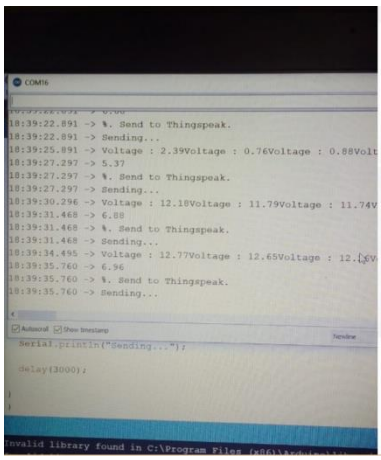
Fig. shows the experimental setup of the system

RESULT

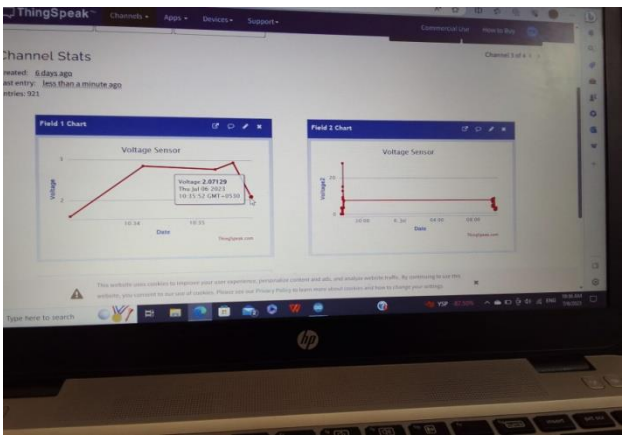
The results of the paper demonstrated significant improvements in solar energy generation and utilisation. By utilising a hybrid solar module, which captures both direct sunlight and reflected light, and implementing a solar tracking system that continuously adjusts the solar cell's angle, the station achieved higher energy output compared to fixed solar panel setups. Real-time data monitoring and analysis through the Thingspeak Server allowed for effective performance evaluation and optimization. The graphical outputs provided a clear visual representation of the system's efficiency, confirming its potential as a promising renewable energy solution with increased energy production and utilisation.

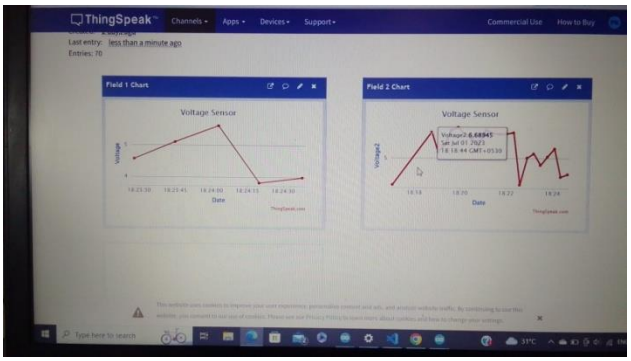






Data is sent to Thingspeak Server for real-time monitoring and analysis.





The data is presented through graphical outputs.

V. CONCLUSION

The hybrid solar generating module for high-efficiency solar energy stations is an innovative approach to maximise the efficiency of solar energy generation. The system uses two solar cells, one for the reflected section and the other for solar tracking, along with two voltage sensors, a solar tracking system with two LDRs and one SG90 servo, and an ESP32 based microcontroller to monitor and control the system. The microcontroller sends the data collected by the voltage sensors and LDRs to the ThingSpeak server for analysis and visualisation. The solar tracking system ensures that the solar cell is always facing the sun, maximising the amount of energy generated. The hybrid solar generating module is a cost-effective and sustainable solution for renewable energy production. This paper has the potential to contribute to the development of solar energy technology and reduce our dependence on fossil fuels.

VI. REFERENCE

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