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SMART IOT BASED SOLAR PANEL CLEANING SYSTEM

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Abstract. The goal of this project is to make life better for people who use solar panels. We provide an open and honest dust- and speck-removal system that makes use of cutting-edge technology that has improved performance, honesty, uniformity, cost, and scalability. These days' cleaning systems provide roughly 32% greater power output than a dirty solar panel. The universe itself is the controller of this system. This technique also reduces the number of people needed to clean solar panels. This is a method for automatically washing solar panels. Manually washing the solar panels is a tedious and time-consuming task. In this study, we propose a timed system that uses water and wipers to clean solar panels. Internet of Things (IoT) technology is used to carry out the operation. microcontroller and several sensor modules will undoubtedly handle system management. The Android application may be used to control the system. The system sends the consumer a notification message informing them of the various processes that have been run. It's possible that the system may be made transportable so that it can be deployed in a variety of settings. A 5V, 500mA controlled power supply is used in this project. For voltage regulation, the 78053 authority is used, which is incurable. The second 230V to 12V step down transformer's AC output is rectified by a full-wave bridge rectifier.

Keywords: Solar panel, Photovoltaic system, Light Dependent Resistor, Internet of Things server, Direct Current motor, wiper.

I INTRODUCTION

The sun is a powerful energy source, and the sun's energy is abundant in the natural world. If all of the sun's energy could be harnessed, it would be more than enough to meet global energy demands. However, the weather prevents that from happening. Solar panels allow for the direct conversion of solar energy into other kinds of usable energy. Solar power, in particular, is of great interest since it can generate electricity without increasing greenhouse gas emissions. The photovoltaic method of extracting energy from the sun has been considered by several alternatives. It has the potential to meet the rising demand for electricity. The solar panel's effectiveness is diminished by environmental factors such as dust, moisture, and temperature, thus meeting these requirements is vital. As such, tests comparing solar panel efficiency with and without dust accumulation were conducted. A dust removal system must be planned for and implemented as part of this project. The major goal of this assignment is to provide a system for automatically removing dust and debris from the solar cells. Snow, high temperatures, plant pollen, dust, and dust all reduce

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the efficiency of solar (PV) electricity. It is estimated that dirt can reduce a PV panel's efficiency by as much as 50 percent in some environments. Traditionally, cleaning has been done by hand. Crash and panel damage, mobility issues, insufficient maintenance, and other issues are only some of the risks associated with manual cleaning. The automated dirt cleaning system of PV panels eliminates the problems associated with manual cleaning, while simultaneously providing thorough cleaning and preventing efficiency fluctuations due to dust buildup. Solar panel effectiveness after one day, one week, and one month of dust accumulation was studied. One day, one week, and one month after cleaning the surface, the efficiency of the solar panel was also calculated. Finally, a comparison of the two demonstrates that the photovoltaic panel's efficiency increases significantly. The new layout improves the solar panel's functionality.

In contemporary times, automation has emerged as a crucial pillar of various industries as the world progresses towards increased mechanisation. Market 4.0 is focused on the creation of intelligent environments for manufacturing processes. It involves the implementation of cyber-physical systems that enable interaction between makers. Solar energy generation plants typically produce a vast number of solar panels, which are available in various configurations. Solar panel farms are commonly located in arid and rural regions, particularly in developing countries. The efficiency of solar panels is contingent upon several factors, including the presence of dust and debris on the panels, which can significantly diminish the power output of solar farms. This variable is a primary contributor to reduced performance. The utilisation of solar energy in power generation has been facilitated by the incorporation of ARDUINO, a microcontroller that features a built-in wifi module.It is imperative to monitor in order to achieve maximum power efficiency. This aids in restoring optimal power output from nuclear power plants while also detecting faulty solar panel connections, as well as mitigating the impact of dirt accumulation on panels which can reduce efficiency, among other issues that affect solar performance. Presented here is an automated solar energy tracking system based on the Internet of Things (IOT) that facilitates remote solar power monitoring through online means from any location worldwide. The Aurduino controller-based system is employed to monitor the specifications of photovoltaic panels. The solar energy display system is designed to continuously monitor the solar panel and transmit the power output to an online Internet of Things (IoT) system. In the following procedure, IOT TELNET is utilised to transmit solar power specifications to an IOT TELNET server via an online platform. By utilising a dependable graphical user interface, it is possible to exhibit this criterion to an individual and generate a clear understanding of the outcome decline. Once the predetermined limit for outcome specifications is exceeded, the automated cleaning system is activated. It can be inferred that a decrease of approximately 40-50% may occur if the panels are not adequately cleaned within a period of 1-2 months.In order to address this issue and enhance the efficacy of power generation, it is imperative to conduct regular cleaning of the components.An automated cleanser has been developed to remove dust from the panels at regular intervals.The system operates through a controller control circuit that utilises DC electric motors for the purpose of cleaning panels.This paper presents the notion of enhancing efficiency through the utilisation of an automated cleaning mechanism for solar panels.

In their work, Writer [1] elucidates the process of preparing for a tailored, low-power, self-sufficient Industrial Internet of Things (IoT) controller that is specifically designed for the purpose of cleaning photovoltaic (PV) boards. The controller, which is distinct from the control treatment of the mechanical device, has been designed to enable remote monitoring via the internet. Additionally, it has been equipped with the capability to run VPN, IP tables, and other security features that are not currently available in existing devices. The author in reference [3] elucidates that the impact of destruction or deposition is a crucial examination in the utilisation of photovoltaic or PV technology. The author presents a methodology for achieving autonomous operation of a robotic vehicle through the use of photovoltaic technology for cleaning purposes. The Digital Robot Experimentation System is employed to showcase a PV control terminal, with the Robotic Operating System (ROS) being utilised for the purpose of vehicle control calculations. This text presents specialised information pertaining to mapping, restriction, establishment of means, and avoidance of acquisition.

The author [4] initiates the discussion by highlighting the adverse impact of residue accumulation on solar panels, which significantly reduces the efficiency of the plant. To address this issue, the author proposes the introduction of a cleaning robot to enhance the performance of solar panels. The challenges faced by developers in the maintenance of solar panels are having an impact on the owners of solar energy systems. The designer's illustration portrays a simplistic configuration, however, they have precisely delineated the methodology required to achieve optimal outcomes - exemplifying an increase in electrical power ranging from 70 to 130% subsequent to the purification process.

In their study, the authors [5] analyse crucial duties related to the performance outcomes, awareness, and mitigation of power issues arising from accumulation on a solar panel. The electrical characteristics of photovoltaic systems, namely voltage and current, are analysed in relation to shading caused by the accumulation of dirt and debris. The act of shielding oneself from pollutants is categorised into two distinct forms: vulnerable shielding, such as protection against air pollution, and hard shielding, which occurs when a solid material, such as accumulated debris, obstructs sunlight. The final outcome illustrates that the PV component is influenced by subtle colour variations in the present, while the voltage remains consistent with previous measurements. The performance of a photovoltaic (PV) module in challenging shading conditions is contingent upon the extent of shading, whether it affects only a few cells or the entire array of cells within the module. If a few cells of a photovoltaic (PV) module are shaded, the unshaded cells will still receive solar irradiance and generate some electrical output. However, the voltage output of the PV module will decrease due to the shading effect.

The study conducted by the author [6] examines the existing assessments on the influence of residue testament on the performance of photovoltaic panels, specifically in the context of PV. Furthermore, the study identifies certain challenges that need to be addressed in order to further investigate this area. The investigation into the state of education has been divided into two distinct phases. The first phase encompasses an analysis of research conducted between the 1960s and the 1990s. The second phase involves an assessment of research conducted after the 1990s. A proposal table has been developed to aid in determining the appropriate cleaning and maintenance schedule for photovoltaic structures

based on the prevailing climatic and environmental factors, given the abundance of information on insurance coverage.
The current system entails the provision of a photovoltaic panel cleaning mechanism, accompanied by an isometric 3D illustration, intended for implementation on expansive solar farms. The novelty of the present research study is attributed to the utilisation of the Web of Things technology and the incorporation of autonomous cleaning functionality. However, it is necessary to conduct techno-economic analysis before implementing the cleaning system depicted in the aforementioned illustration.

The proposed system involves the installation of solar panels in locations that may be considered disorganised or untidy. The accumulation of dirt and bird droppings has a negative impact on the power generation efficiency of solar panels. The manual cleansing of solar panels can be both arduous and challenging.
The employment opportunity involves the utilisation of Internet of Things (IoT) technology. We will address the resolution of this matter by examining the techniques employed for the elimination of dirt through the utilisation of the Internet of Things (IoT). Our team has designed a rudimentary yet practical dust removal apparatus, and has also devised an innovative approach to cleaning particulate matter from photovoltaic panels through the application of Internet of Things technology.

- The primary objective of this system is to develop a mechanism for removing dust from photovoltaic systems.
- This paper proposes a programmable system for cleaning solar panels utilising water and a wiper.
- Comparing the Existing system with Proposed System.

II WORKING METHODOLOGY

Solar panels that are virtually implemented are organised into various configurations. The objective is to monitor the performance of each array and issue a notification when the efficiency falls below a specified threshold. Each chosen option is linked to a corresponding hardware component that monitors its operational efficiency. The hardware comprises a voltage sensor, a current sensor, and a temperature sensor. By utilising a voltage and current sensor, it is possible to ascertain the quantity of voltage and current generated by a particular type. The DHT 11 sensor facilitates the acquisition of temperature and humidity measurements within its surrounding environment, thereby enhancing the user's ability to analyse data. The acquisition of performance parameters through sensing units and additional arithmetic logic unit (ALU) operations is facilitated by software programmers. The programming code is composed in languages that are supported by the Aurduino Integrated Development Environment, namely C and C++. Subsequently, this code is uploaded onto the ESP32. The ESP32 is a microcontroller that features an integrated wifi component. In the context of solar power plants, the Internet of Things (IoT) is utilised to gather data, which is subsequently transmitted to cloud storage through the assistance of ESP32.

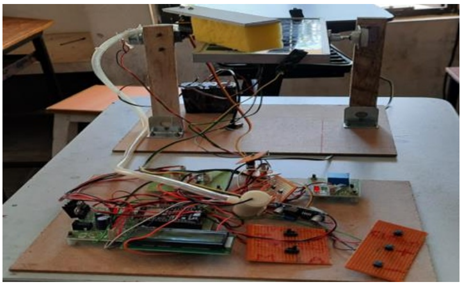

Fig.1. Hardware kit

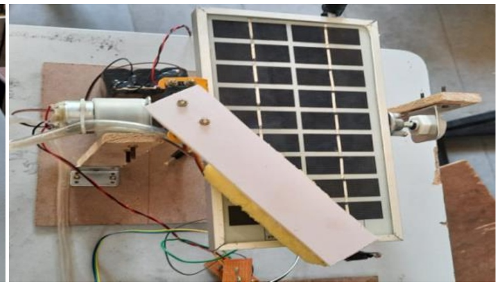

Fig.2. Ldrs and solar panel cleaning system

Two Light Dependent Resistors (LDRs) are positioned in close proximity to each other on the periphery of the solar panel to measure the luminous flux intensity. The operation of the tracker is determined by the utilisation of these LDRs. In the event that the initial Light Dependent Resistor (LDR) detects a higher intensity of light, the photovoltaic panel is subsequently oriented towards it through the utilisation of an ESP32 controller. Conversely, the second LDR facilitates the opposite orientation. The Arduino is regulating the stepper motor solely based on the information received from the LDRs.
The programming language utilised for the Arduino is C. In addition, the Arduino is responsible for controlling the water pump that dispenses water onto the surface of the solar panel with sufficient pressure to effectively cleanse the entire panel. The primary aim of this paper is to achieve maximum solar exposure throughout the day, a feat that can only be accomplished through the utilisation of a solar tracker. Therefore, the optimal amount of sunlight is extracted. The resultant power output is stored within a 12-volt direct current battery. The Light Dependent Resistors (LDRs) detect and measure the optimal amount of solar irradiance incident on the solar panel. Provided that the initial LDR is exposed to solar radiation, it transmits data to the Arduino, and the solar panel remains within the boundary of the said LDR. The transmission of data will cease once the sunlight exceeds the boundary of the initial LDR. The second Light Dependent Resistor operates in a comparable manner. Upon receiving information from the second Light Dependent Resistor (LDR), the panel is oriented towards the perimeter of the aforementioned LDR. The solar tracker functions to optimise the capture of solar radiation by tracking the highest intensity of available sunlight. The cleaning of the panel is another aspect of the work. The on/off switch is being controlled by the pump. Once the pump is activated, it facilitates the flow of water through the piping system towards the nozzle. The nozzle is utilised to disperse water onto the solar panel, facilitating the removal of dirt and dust particles from its surface.[2]

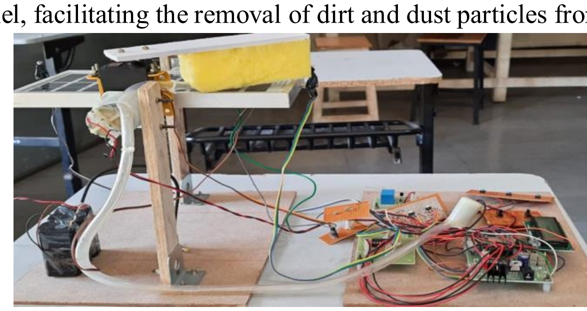

Fig.3. water sprinkle addition on Solar panel.

III RESULTS & DISCUSSIONS:

The present study employs a server-based approach to monitor the solar generation needs. In general, there exist two potential methods for monitoring optimal sunlight, namely single-axis and dual-axis. The uniaxial solar tracker rotates about a single axis, specifically in an east-west direction or its reverse. The dual-axis solar tracker facilitates rotation along two perpendicular axes, namely the east-west and north-south axes. According to research findings, employment of a single axis solar tracker results in an efficiency increase of approximately 30% in comparison to a static photovoltaic panel. Similarly, utilisation of a double axis solar tracker leads to a higher efficiency gain of around 36% when compared to a static photovoltaic panel. The efficacy of solar panels is primarily diminished by various external factors, including dust, dirt, darkness, and avian excrement, which may deposit pollen onto the photovoltaic panel. The efficiency of the photovoltaic panel is reduced in dusty atmospheres. Hence, it is imperative to regularly monitor and maintain the cleanliness of the solar panel. Therefore, the cleaning of solar panels also plays a significant role.

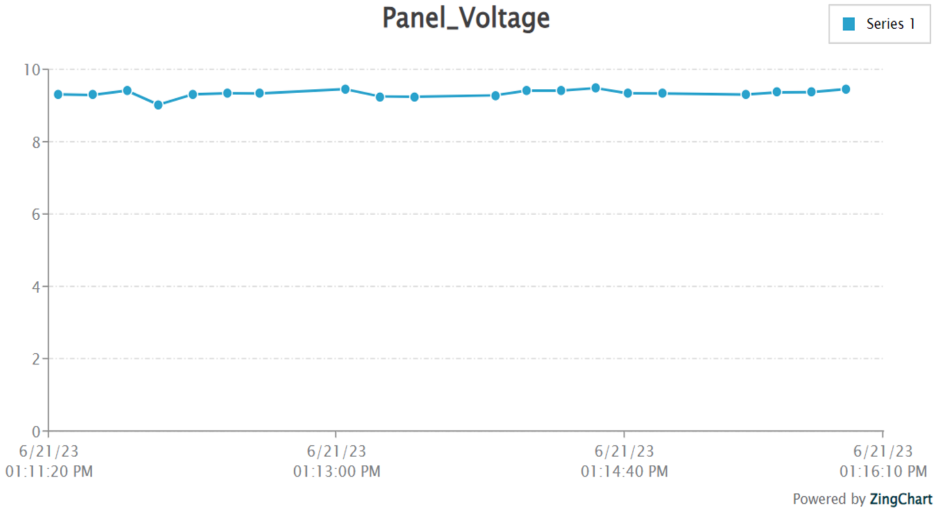

Fig.4. Solar panel volatge in cloud server.

S.N	Time	Current in Amps	Voltage in Volts	Power in Watts	Efficiency in %
1.	6:30am to 8:30am	0.26	6.15	1.725	57.5
2.	8:30am to 10:30am	0.29	6.85	2.06	68
3.	10:30am to 12:30pm	0.38	7.98	3	100
4.	12:30pm to 2:30pm	0.38	7.99	3	100
5.	2:30pm to 4:30pm	0.345	7.15	2.515	83

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6	4:30pm to 6:30pm	0.245	6.09	1.515	50.5

Table1: Power output & Efficiency At different Voltage & Current

S.No	Panel_Voltage	Date
1	9.47	2023-06-21 13:15:57
2	9.39	2023-06-21 13:15:45
3	9.38	2023-06-21 13:15:33
4	9.32	2023-06-21 13:15:22
5	9.35	2023-06-21 13:14:53
6	9.36	2023-06-21 13:14:41
7	9.50	2023-06-21 13:14:30
8	9.43	2023-06-21 13:14:18
9	9.43	2023-06-21 13:14:06
10	9.30	2023-06-21 13:13:55
11	9.26	2023-06-21 13:13:27
12	9.27	2023-06-21 13:13:15
13	9.47	2023-06-21 13:13:03
14	9.35	2023-06-21 13:12:33
15	9.36	2023-06-21 13:12:22

Fig.5. Solar panel output voltages in table format.

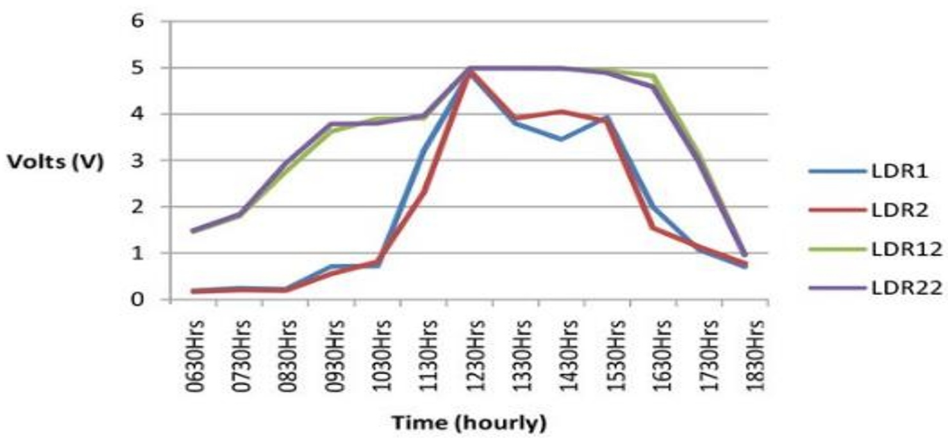

Fig.6. Solar panel output voltages at different timings.

CONCLUSION

The proposed system functions as an integrated system that encompasses both tracking and cleansing capabilities. Typically, the accumulation of dust on the surface of a photovoltaic panel can lead to damage of the aluminium strip. The negative effects of photovoltaic panel damage can be mitigated through the implementation of a cleansing system, ultimately resulting in an improvement in the panel's performance. Consequently, the longevity of the solar panel can be increased, leading to a reduction in manual cleaning costs, while also enhancing tracking efficiency. The utilisation of radar technology on an individual basis has been found to enhance efficiency by approximately 30%. Additionally, the implementation of a cleaning system has been observed to increase performance by 50% on a monthly basis.

REFERENCES

[1] R. Divya, K. Sheeba, J. Gayadhiri Dhevi, S. Sandhya, S. Vennila "Automatic Cleaning of Solar Panel with Maximum Power Tracking by using Arduino".
[2] M. Sreenivasulu Naik, C. Radhamma, S. Yunus "PV Based Automatic Irrigation System".
[3] Anchit Garg, Priyamitra Munoth, Rohit Goyal " Application of Soil Moisture Sensors in Agriculture: A Review"
[4] Dr PUSHAN KUMAR DUTTA, Dr KETHEPALLI MALLIKARJUNA " Sensor based Solar Tracker System using Electronic Circuits for Moisture Detection and Auto-Irrigation"
[5] The International Conference on Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES14 "Influence of Dirt Accumulation on Performance of PV Panels
[6] "Non-conventional Energy Sources" – G.D RAI
[7] Soujanya Kulkarni, Sanjeevkumar R A Modified Transister Clamped Hbridge –based Cascaded Multilevel inverter with high reliability International Journal of Research in Advent Technology, 6 (6) (2018)June
[8] A. Bharathi Sankar, R. Seyezhai "Simulation and Implementation of Solar Powered Electric Vehicle" Department of EEE, SSN College of Engineering, Chennai, India, Circuits and Systems, 2016, 7, 643-661 Published Online May 2016 in SciRes. http://www.scirp.org/journal/cs http://dx.doi.org/10.4236/cs.2016.76055
[9] R A Sanjeevkumar Sumit A Novel Generalised Topology of a Reduced Part Count Supply Multilevel Inverter with Level Boosting Network to Improve the Quality of GlobalTransitions Proceedings (2021), 10.1016/j.gltp.2021.08.019ISSN 2666-285X
[10] Gangesh Shukla1, Karmit Raval2, Dhruvi Solanki3, Urvashi Patel4, Dhaval Dave5 "A study on Campus-Friendly Solar Powered Electric Vehicle" B.Tech Student, Dept. of EE, Parul University, Vadodara, Gujarat, India Asst. Professor, Dept. of EE, Parul University, Vadodara, Gujarat, India, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 06 Issue: 02 | Feb 2019 www.irjet.net
[11] Tathagata Pachal, Akhilesh. K. Dewangan, "Electric Solar Vehicle – RayRacer" Thesis for: B.Tech - Mechanical Engg Advisor: Ashok Kumar Sahoo, Akshaya Kumar Rout, Isham Panigrahi April 2016 DOI:10.13140/RG.2.1.4276.5201.
[12] "SMART SUN TRACKING WITH AUTOMATED CLEANIN SYSTEM FOR PV MODULES" AMIRAH AFIQAH BINTI AHMED
[13] B. Karur and S. R A, "Multi-level Transformerless PV inverter Based Real and Reactive Power Injection for Single Phase System," 2020 IEEE International Conference on Distributed Computing, VLSI, Electrical Circuits and Robotics (DISCOVER), 2020, pp. 258-262, doi: 10.1109/DISCOVER50404.2020.9278
[14] Dr. K. Hema Latha, Design and Development of Solar Powered Vehicle Assistant Professor, Mechanical Engineering Department Muffakham Jah College of Engineering and Technology, Banjara Hills, Hyderabad, India. International Journal of Engineering Research & Technology (IJERT) http://www.ijert.org ISSN: 2278-0181 IJERTV8IS080267 (This work is licensed under a Creative Commons Attribution 4.0 International License.) Published by : www.ijert.org Vol. 8 Issue 08, August-2019
[15] RITVIK MALIYA1, MOHD NAZIM2, JP KESARI A REVIEW PAPER ON SOLAR ELECTRIC VEHICLES Student, Dept. of Mechanical Engineering, Delhi Technological University, New Delhi , Dept. of Mechanical Engineering, Delhi Technological University, New Delhi, Associate

professor, Dept. of Mechanical Engineering, Delhi Technological University, New Delhi International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 08 Issue: 03 | Mar 2021 www.irjet.net p-ISSN: 2395-0072
[16] Kavya Prayaga, R A Sanjeevkumar, T Anathapadmanabha, H R Sudarshan Reddy Modelling of Nine Level Cascaded Hbridge PV Power Fed Inverter Using Matlab/Simulink International Conference on Advanced Computing and Communication System (ICACCS- 2017) (2017) Jan.06-07