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Smart IoT Based PV Panel Cleaning System

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Abstract: ***By using photovoltaic (PV) solar panel, the sun's energy is captured and converted into a usable form. Green energy is the most common kind of energy on Earth and also one of the most accessible. The regenerative characteristics of solar energy, employs symbolizes the future of power generation. Numerous research is being undertaken to determine how to harvest the most energy from the sun, however, dust accumulation on solar panels and air pollution lower solar cell energy output by 28 to 40 per cent in different regions of the globe, including tropical countries like India. This article focuses mostly on IoT technologies to describe the creation of a Smart Solar panel cleaning system. Consequently, dust monitoring, intelligent analysis, and system management, it may increase the overall efficiency of the solar PV panel.***
Keywords: Solar panel, NodeMCU, Sensors, Wiping Mechanism, IoT

I. INTRODUCTION

As the world advances towards the 4.0 INDUSTRY REVOLUTION, automation has become a vital support system for several organizations. Industry 4.0 is a cyber-physical system in which machines in the manufacturing process communicate with one another to create an intelligent environment. Solar power stations employ many arrays of tens of thousands of solar panels to produce energy.

Solar panel farms in most tropical countries have a great deal of dirt and dust. One of the numerous factors that impact the efficiency of solar panels is the presence of dirt and dust on panels, which may reduce the amount of energy generated in plants. NodeMCU is a microcontroller for solar power systems containing a WiFi module. It helps our efforts to restore dependable electricity from solar power plant by keeping a watch out for issues such as weak connections between solar panels, dust accumulation that affects output, and other variables that might affect solar energy production. Consequently, we present an internet of things (IoT)-based automated solar power monitoring system that allows monitoring to be conducted remotely from any location on Earth.

We deploy a system based on a NodeMCU controller to monitor the functioning of the solar panel array. This solar panel monitoring system maintains a continual check on the panels and transmits information about their power production to an internet of things (IoT).

Here, we transfer solar power parameters to the IoT Blynk server via the internet using Blynk app. A streamlined user interface enables us to display this value to the user and trigger an alert if the output unexpectedly drops. An automated cleaning process will activate when output parameters fall below a particular threshold. If the panels are not thoroughly cleaned every 2 months, 40-50% loss might be predicted.

In order to increase the efficiency of power production, frequent cleaning is necessary. The wiped clean the dust automatically at specified intervals. The system utilizes a controller circuit to driven dc motors to clean the panels. This paper explores the possibility of enhancing production by cleaning solar panels.

II. THE PROPOSED SYSTEM

The proposed automatic solar panel cleaning system consists of following subsystems:

1) The dust monitoring system is the first subsystem; it employs a microcontroller to activate the water motor pump when dust particles are detected by the solar PV panel.
2) The second Subsystem; it employs a cleaning device for wiping surfaces. In this configuration, a geared motor, belt, pulley, and windshield wiper are wired to a NodeMCU and L293D.
3) Third subsystem represents the Arduino board is connected to the internet through an ESP8266 chip in this arrangement. The ESP8266 SoC enables NodeMCU to connect to a wireless network since it has a full-featured Wi-Fi Stack. This module storage and processing capabilities may be linked to specific sensors and other devices. The server receives parameters for the solar panels, dust sensors, voltage and current sensors and DHT 11.

Fig. (1), Explains the functioning and operation of the proposed system is summarized below with relevant details.

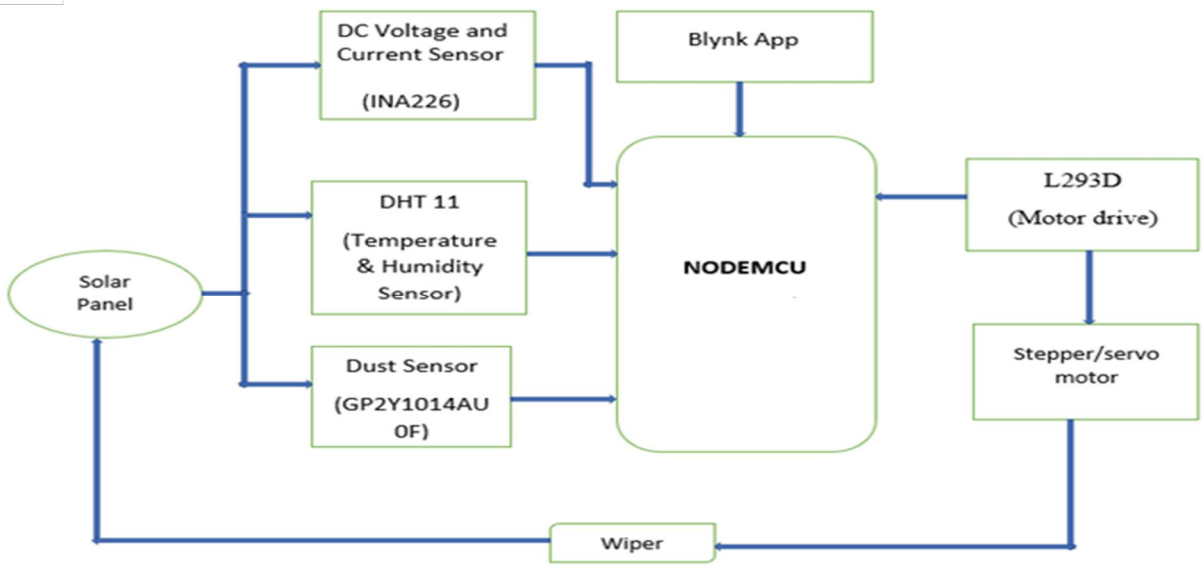

Fig:1. Block Diagram of Proposed System

III. FUNCTIONING OF THE PROPOSED SYSTEM

The sensing section where an optical air quality sensor, GP2Y1010AU0F, is used to detect dust particles. This sensor is made up of an infrared emitting diode and a diagonally assembled phototransistor. This design will detect the dust around the solar panel's surface using the average dust reflection. This approach is very functional and capable of detecting extremely small particles such as dust. This sensor has a very low power consumption (20mA maximum, 11mA normal) and can operate with very small voltage. With a sensitivity of 0.5V/0.1mg/m^3, the sensor will produce an analogue voltage proportionate to the detected dust density.

DHT11 is a sensor for measuring both temperature and humidity. The Voltage and current sensor, constantly gives voltage and current data that could indicate a problem of solar PV power production.

The brain of this system is NodeMCU. It is a microcontroller that measures the output power of a PV panel in real time and processes the impacts of collected dust on the output power, the output is obtained from the Blynk app. The Other component of this proposed system is the wiper system, which is controlled by the microcontroller through a relay that is powered by solar electricity generated by the solar PV. The effects of accumulated remaining particles on the solar panel are tested by referring to the result obtained from sensors and microcontroller in a dusty environment. Furthermore, this wiper system functions as an automated cleaning with relation to the solar panels.

Fig. (2), shows that, the wiper mechanism comprises of a water sprayer and an electric DC motor control system that draws power from solar panels through dc-dc buck converters. When tiny particles accumulate on the surface of the solar panel, the automated wiper mechanism activates.

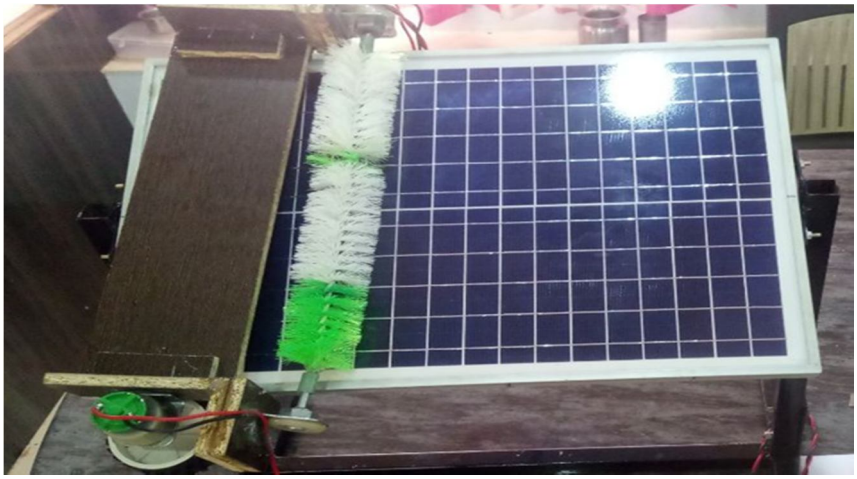

Fig:2: Experimental Setup of Solar panel Cleaning System

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A. Dust Monitoring System

Dust settling on solar panels reduces the amount of sunlight reaching the PV module. Consequently, the quantity of energy generated is reduced. Therefore, this subsystem would detect dust particles impacting solar PV panel power generation, leading to the activation of the water pump. This subsystem is responsible dust detection. The NodeMCU microcontroller manages the operations of the system.

B. *Water Pumping*

The water pumping mechanism consists of L293d motor driver, 9V dc water pump, and Wiper. The L293D is a motor driver is required to run a dc motor. Due to its function as a low-power current amplifier, it can also drive motors with high current. A dc water pump transforms electrical energy into mechanical energy, enabling vertical water movement. This application employs a NodeMCU microcontroller programmed to clean the panel every day. The water pump activates when the average dust density reaches the threshold value. A water pump submerged in a water reservoir pumps liquid to a sprinkler system at the end of a water pipe, which eventually saturates the panel. After a 5-second, the wiping mechanism cleans the panel. The sensors measure their respective parameters which would be uploaded to the cloud. The required operations are performed further and updated. These data could be accessed at any point of time from user through mobile application. The user can turn sprinkler and wiper on or off through mobile application remotely from anywhere within its range.

Fig. (3), shows the flowchart of solar panel cleaning system. The sensors measure their respective parameters which would be uploaded to the cloud. The required operations are performed further and updated. the master unit, sends the command to the wiping unit to perform cleaning action. This master unit comprises sensors to sense light intensity, dust density, temperature/humidity, and output power in order to generate automatic cleaning signal and display the condition of solar panels. Where the translated code will be written using Arduino IDE and the unit communicate through an internet cloud-based platform known as Blynk app.

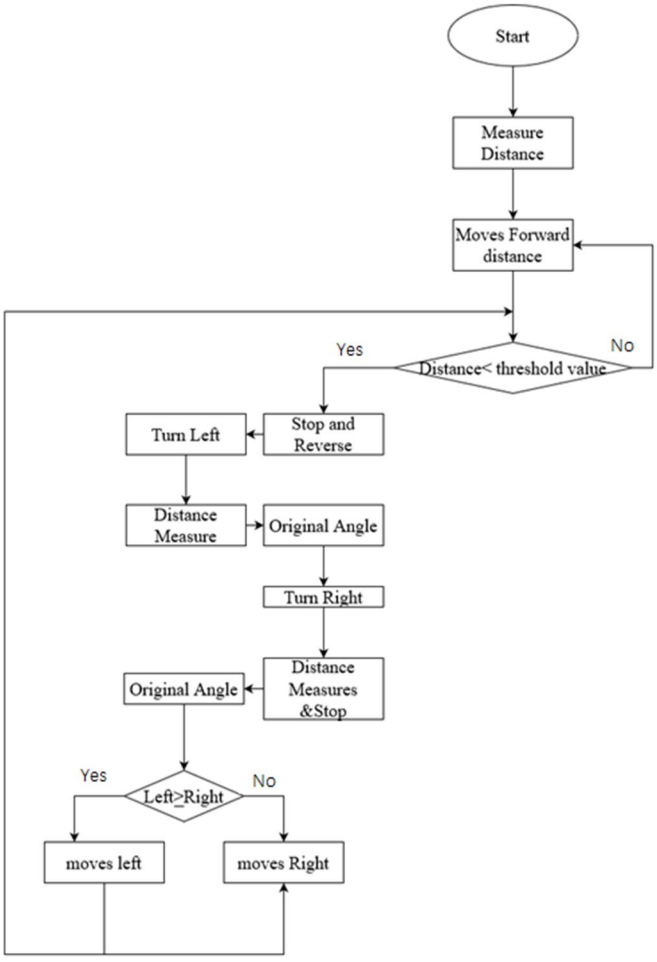

Fig:3 Flowchart of Solar Panel Cleaner

IV. RESULTS AND DISCUSSION

This Paper investigated several ways to reduce the detrimental effects of dust on solar panels. Large amounts of dust accumulating on the solar panel may significantly lower the output voltage measured from the panel. Cleaning a PV module with water increases its performance and efficiency by removing most of the dust accumulated on the panel. The programmed-cleaning system requires no external power source since it draws its energy from the PV module. The system's components are assembled in a lightweight manner. The foundation for IoT-based PV module cleaning is realistic, and the cost for scheduled cleaning has shown to be more inexpensive. Their results were amazing, cleaning the panels increased production by over 10 per cent, equating to more power. Also, how much would be spent on their wages prompted us to build a system that eliminates energy waste and pay expenditures. The experiment showed that the solar panel's productivity improved by 16%, from 36W to 52W, as the greatest amount that can be created.

Table:1 COMPARISON OF SOLAR PANEL VOLTAGES BEFORE AND AFTER CLEANING

month (Aug/Sep 2022)	Dust Density (µgm)	Voltage (V) Before cleaning	Voltage (V) After cleaning
Aug 1	0.05	19.15	22.02
Aug 12	0.20	19.02	21.87
Aug 23	0.30	18.87	21.70
Sep 6	0.40	17.95	20.64
Sep 18	0.50	17.65	20.29

The Table. (1), shows the comparison of solar panel output voltage before and after cleaning it. The values of dust density (µgm) and PV panel output voltage is taken once in every 12 days in the month of Aug/Sep 2022. From this table and Visualization, it can be observed that output voltage of solar panel gets increased after cleaning it and also, we observe that deposition of dust on the solar panel in more due to high humidity from mid of Aug to Sep which affect the PV panel output voltage.
Fig. (4), Shows the graph which gives the relation between dust density (µgm) and solar panel output voltage. Fig. (5), Shows mobile display which shows measurement parameter using Blynk app.

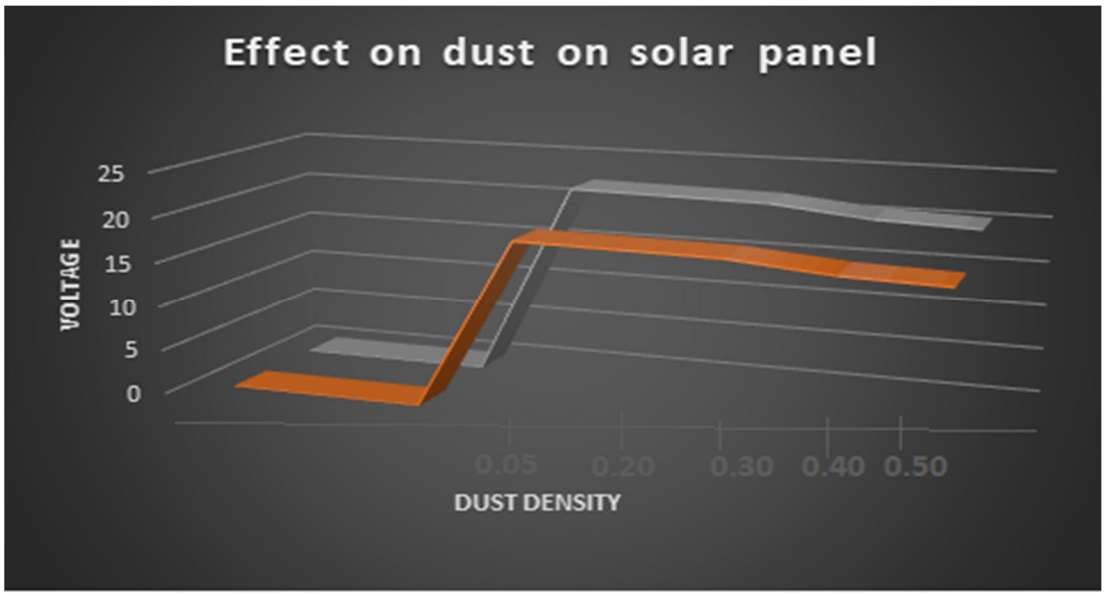

Fig: 4. Relationship between Voltage vs Dust Density

Fig:5. Output of Blynk app

V. CONCLUSION

As part of this paper, the proposed a solar panel cleaning system based on the Internet of Things was prototyped, which is used to remove dirt from solar panels when situations like fog and dust need to be removed. Large amounts of dust deposited on the solar panel can significantly lower the output voltage measured from the panel. By washing away the particles and dirt accumulated on the panel's surface resulting improve the panel's efficiency and effectiveness. The PV module automated cleaning system having components are a lightweight collection of gadgets. Which gives an IoT-based cleaning framework for PV modules is reasonable and economical. The proposed system results indicated that the measured output voltage could be increased by up to 9% - 18% by keeping PV module cleaning regular. The IoT-based solar panel cleaning mechanism will analyze the system's parameters, allowing the user to make informed decisions.

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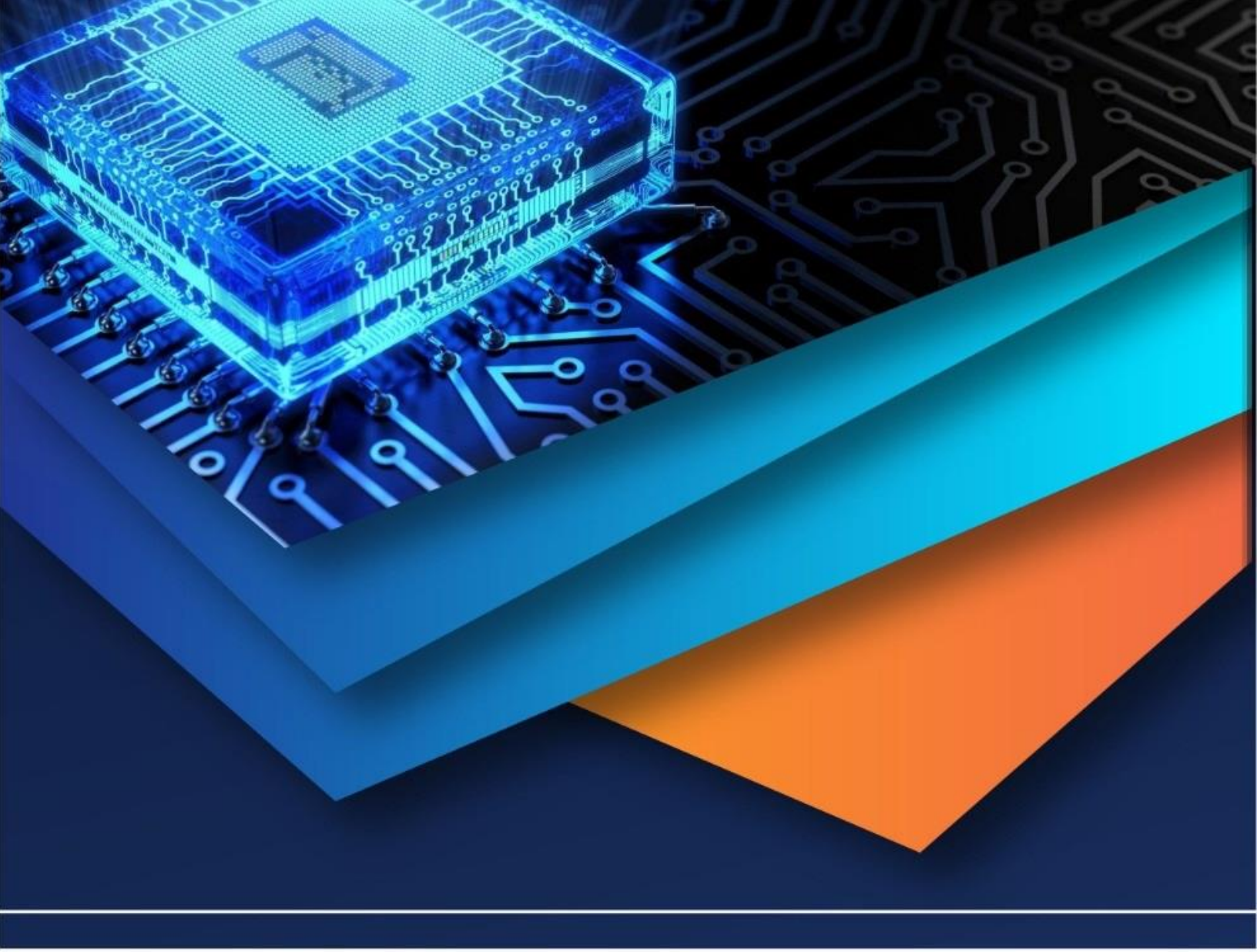

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