

DEVELOPMENT OF IOT BASED ADVANCE SOLAR PANEL CLEANER SYSTEM

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ABSTRACT

Solar energy is very common because of its sustainability and efficiency. Solar panels do have the tendency to gather dust, dirt and debris that bring down their performance, and thus regular cleaning is a must. The proposed system presents an automated system of cleaning solar panels in the form of inclined rows, which are typical of large solar farms. The contaminants are swept out in a methodical manner by systematically moving along the panels, and the natural inclination of the panels makes the gravity help to carry the debris downward, which helps in increasing the cleaning speed and consumes less energy.

Keywords- Arduino, IOT, photovoltaic, solar panel, solar power monitoring system, Ubidots.

1. INTRODUCTION

The productivity of solar power generation has gained even greater significance, especially in large industrial units where solar panels are mainstream. Despite being eco-friendly and sustainable, the efficiency of a panel is usually approximately 32 percent and the capability of the panel is decreased due to dust and dirt, bird droppings and other debris, thereby shading the sunlight. Even the presence of a dusty layer can considerably lower the energy production level, which is why it is

necessary to clean it periodically. Such conventional ways of cleaning by hand, however, are tedious, time-consuming, consume a lot of water and dangerous, especially in large or difficult to reach instalment. In order to overcome such a problem, a system of automatic cleaning of solar panels can be created on the principle of a mechanism based on a microcontroller that automatically cleans the panel at predetermined intervals. The system then controls a moving cleaning of assembly, which is used to remove dust and debris as efficiently as possible and keep the performance consistent with minimal effort and error by human intervention. This is also a cost-effective method, which does not require much water and can readily be incorporated into the existing solar systems. Overall, this automation would make solar energy production more efficient, safer, and more dependable and sustainable.

2. LITERATURE REVIEW

- Jeju K. et al., 2014. Computer, Communications, and Control Technology (I4CT), International Conference on. IEEE, 2014 “Development of Android based on-line monitoring and control system for renewable energy sources.” Development of an online monitoring and control system for distributed Renewable Energy Sources (RES) based on the Android platform. This

method utilises the Bluetooth interface of an Android tablet or mobile phone as a communication link for data exchange with the digital hardware of the Power Conditioning Unit.

- Yoshihiro G. et. al., 2007INTELEC 07-29th International Telecommunication power plant with fully DC-powered centre equipment.” Goto, Yoshihiro, explained that an integrated system that manages and remotely monitors telecommunication power plants has been developed and has started operations. The system is used to operate and maintain more than 200,000 telecommunication power plants, which include devices such as rectifiers, inverters, UPS’s and air-conditioning plants installed in about 8000 buildings. Features of the system are to integrate the management and remote monitoring functions into a single system and improve user interfaces that use information and communication technology.
- Kabalci, Ersan, Gorgon A. and Kabalci Y., 2013. Power Engineering, Energy and Electrical Drives (POWERENG), Fourth International Conference on. IEEE, 2013. “Design and implementation of a renewable energy monitoring system.” Introduction to an instant monitoring infrastructure of a renewable energy generation system that is constituted with a wind turbine for current and voltage measurements of each renewable source. The related values are measured with the developed sensing circuits and processed by the 18F4450 microcontroller of Microchip. The processed parameters are then transmitted to a personal computer (PC) over a universal serial bus (USB) to be saved in a database and to observe the system instantly. The coded visual interface of monitoring software can manage the saved data to analyse daily, weekly and monthly values of each measurement separately.

- Mayamiko N., Zennaro M., and Bagula A., 2011. “SM 2: Solar monitoring system in Malawi.” Kaleidoscope: The Fully Networked Human? –Innovations for Future Networks and Service (K-2011), Proceedings of ITU. IEEE, 2011. In this paper, the performance analysis of PV modules is supposed to be monitored continuously for their parameters, open voltage Voc, short current Isc, temperature, isolation, time, etc. In the proposed system, no person needs to be present physically on site, so the real-time monitoring system is used. Home automation unit, sports using a wireless sensor network. This monitoring system is used to check PV modules' performance analysis daily. Different platforms like microcontrollers, ASICs, PIC microcontroller and embedded systems are used to design the system based on this performance, and in recent years, cloud-based systems have emerged.

3. PROPOSED METHODOLOGY

- Internet of Things:

Internet of Things (IOT) is when objects, both living and non-living, are connected through sensors, actuators, software, and a network. These objects can collect and share data without needing any human help. This technology lets people monitor and control devices from a distance by using existing network systems. It helps improve efficiency, accuracy, and cost savings, and also reduces the need for human effort. IOT can work with sensors and actuators to create more complex systems like smart grids, smart homes, smart transportation, and smart cities. These systems can talk to each other smoothly through a shared computing system. The Human Machine Interface (HMI) is a key part of IOT systems because it allows people to communicate with machines. Through HMI, users can watch and control systems,

and get feedback that helps them make better decisions. HMIs are used in many areas, including operating systems and machinery interfaces. The main goal of this project is to create a control facility with a strong and user-friendly interface. Platforms like Ubidots offer a simple and effective way to monitor data and control remote systems.

• Ubidots – open-source platform:

Ubidots is an IOT platform that lets developers take sensor data and turn it into useful information. It allows users to send data from internet-connected devices to the cloud, where it can be displayed, processed, and used to make real-time actions or send alerts. Ubidots uses REST API with HTTP, HTTPS, MQTT, TCP, and UDP protocols to ensure secure and efficient data communication. Its system works well with data sources, variables, values, and events, making it easy to build IOT applications that collect, process, visualize, and connect with other web services. Another easy-to-use platform for creating IOT solutions is Ubidots. It allows users to create dashboards, graphs, and custom modules to track and manage systems effectively. Data is stored on various mediums where it can be processed and used by other applications. This is useful for making business decisions, enabling machine communication, and supporting research. Besides cloud-based monitoring through Ubidots, local monitoring can be done using LCD (Liquid Crystal Display) screens, which are common modules that show real-time system information.

4. HARDWARE COMPONENTS:

- Microcontroller (NODEMCU ESP32):
- Light Sensor (LDR)
- Limit Switches
- Water Pump
- Relay
- Bluetooth Sensor
- DC gear motor



Hardware component use :

Table 1

S. No	Integrated Circuit	Components	Purpose
1	Micro Controller	Nodemcu (ESP32)	The central unit controlling all the sensors and motors
2	Sensor	Light Sensor (LDR)	Use detects the intensity of light and the appropriate time for cleaning.
3	Motors	DC Motors (100 rpm) (Generic L293D Motor Driver) Pump Motor	To drive the system. To spray water for cleaning the panels

4	Com muni catio n	Bluetooth Module (Nodemcu)	For wireless communication with the mobile
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5. SOFTWARE COMPONENTS:

- Arduino IDE
- Ubidots
- Embedded C

6. OBJECTIVES

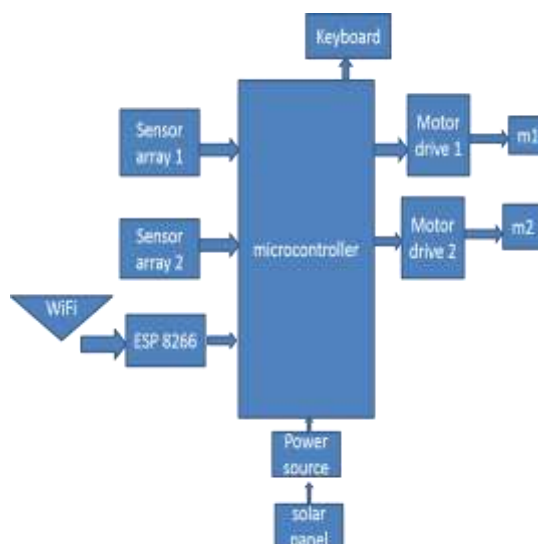
- Developing renewable energy is important because of climate change and the need for secure energy supplies.
- Direct sunlight can be turned into solar energy, which can help meet energy needs worldwide.
- Right now, cleaning solar panels is costly, takes a lot of time, and uses a lot of water.
- In desert areas, using wet methods to clean panels is not practical or effective because there is not enough water.
- The performance of solar panels depends a lot on how clean the glass surface is. • Up to 40% of energy can be lost because of dust, dirt, and other debris.
- In deserts with high sunlight, where solar panels are often installed, cleaning is needed often because of the dusty conditions.

7. BENEFITS

- Automated cleaning, which makes it less labour-intensive.
- Significantly better performance of solar panels through surface cleaning.
- Less maintenance expenses in solar installation of a large size.
- The operation was energy-efficient owing to regulated cleaning cycles.
- Low chances of breaking the panel as a result of highly-developed cleaning units.

- Scalable design, which can accommodate big and small solar farms.
- Enhance the effectiveness of solar plates.
- Defeat this plate with this system so that the life of this plate might be longer than that of other plates.
- Dust or other particles are sometimes deposited on solar cells for so long that it damages the aluminium strips of the solar plate. So we avoid this damaged by this system.

9. BLOCK DIAGRAM



The block diagram illustrates a solar panel cleaning system that is automated and has a Wi-Fi connection or a microcontroller to enhance the efficiency of the system by means of identifying the presence of dust and engaging a cleaning device. The system is composed of the following major parts: a solar panel, the source of power (power supply), a microcontroller, the sensor arrays, Wi-Fi (ESP8266) and a keyword interface. The solar panel also doubles as the origin of power and the base on which the operation of the system should operate, and the power unit controls and provides the stable voltage to all other parts. A sensor array continuously checks dust concentration and surrounding conditions and sends the data to the microcontroller,

which then interprets the data and decides when a cleaning is needed. The Wi-Fi module allows monitoring and control over distance, whereas the keyboard offers manual input on the configuration and operation of the system.

On the load end, the cleaning mechanism of the system is constituted of motor drives and motors. The motor driver enhances the control signals of the microcontroller to drive Motor 1 and Motor 2, which process the movement and cleaning functions, including brushing or wiping the panel surface. When dust is read or when a cleaning function, including brushing or wiping the panel surface. When dust is read or when a cleaning schedule is reached, the microcontroller switches on the motors to activate the cleaning process and switches them off after the cleaning task is done. A built-in system provides good cleanliness with minimal human intervention, efficient cleaning, and reliable cleaning. In general, the design improves the work of solar panels, the maintenance work is much less complicated, and it is very helpful in large sizes or dusty areas, where cleaning during the night cannot be easily provided, and it is expensive.

10. PCB

The block diagram shows an automatic solar panel cleaning system that uses a Wi-Fi connection or a microcontroller to make the system work better. It can detect dust and turn on a cleaning tool when needed. The system includes several main parts: a solar panel, a power supply, a microcontroller, sensor arrays, a Wi-Fi module (like ESP8266), and a keyboard interface. The solar panel not only provides power but also serves as the base where the system operates. The power supply ensures a steady voltage for all other parts. The sensor array keeps checking dust levels and environmental conditions and sends this information to the microcontroller. The microcontroller then decides if cleaning is necessary based on the data it receives. The

Wi-Fi module allows the system to be monitored and controlled from a distance, while the keyboard lets users manually adjust the system's settings.

On the cleaning side, the system uses motor drivers and motors. The motor driver takes signals from the microcontroller and sends them to Motor 1 and Motor 2, which handle the movement and cleaning actions, such as brushing or wiping the solar panel. When the system detects dust or reaches a scheduled cleaning time, the microcontroller turns the motors on to start the cleaning process and turns them off once the cleaning is done. The system is built to keep the panels clean with very little need for human help, making cleaning more efficient and dependable. Overall, this design makes solar panel maintenance easier, especially in large or dusty areas where it's hard to clean during the night and expensive to do it manually.

11. RESULT



purpose	Performance	
	Before	After

1. Cleaning Effectiveness	Dusty panel	Clean panel
2. Efficiency Improvement	1. Solar output 16v 2. current (6 amp)	1. Output 18V 2. 7 amp
3. System working	Manual	Automatic
4. Time Taken	7 min	5 min (increase lifespan)



Monitoring system

Operate Time Duration

- Starting Time: 2 min
- Reset Time : 2 min (forward & Reverse)
- Time Taken: 5 min

Monitoring system: a system operated by the user to control buttons such as the ON/OFF switch, PUMP, Forward, and Reverse. It helps to monitor and control the system remotely through the internet.

Table I. Results Obtained

Performance Metrics	Standard Panel Rating	Dusty Panel Rating	Cleaned Panel Rating Using the Proposed System
Voltage (V)	20.10 V	17.23 V	19.60 V
Average Current (I)	8.80 A	6.13 A	7.20 A
Power (P_{out})	176.88 Watts	105.62 Watts	141.12

The system is an automatic monitoring tool that is simple to use and easy for people to handle. It takes about 5 minutes to operate, which makes things more efficient and helps the system last longer. It also cuts down on the need for manual work, lowers the cost of keeping it running, and offers a good, effective solution.

12. CONCLUSION

To sum up, this system and its methods offer an efficient way to automatically clean an entire row of solar panels. It uses a cleaning unit attached to a movable frame that can move both across the width and along the length of the solar row. When moving downward, the unit can actively clean the panels, but when moving vertically, it doesn't use active cleaning to save energy. The system combines mechanical parts and air to clean the surface of the panels, removing dirt, foreign objects, and dust. This helps produce more solar electricity and makes the panels last longer..

13. FUTURE SCOPE

Solar panel cleaning machines are expected to do really well in the expanding solar energy market. In the future, these systems will use new technologies like IoT and AI to keep track of dust levels on panels, changes in weather, and how well the panels are performing. This means the machines will clean the panels automatically and in the most efficient way possible. The new tech will include dry cleaning systems that don't use any water, fully robotic machines that do all the

cleaning without needing a person or regular maintenance, and machines that run on solar power, which means they use very little water and need very little upkeep. All these features can work together with solar tracking systems and smart sensors, which will make the whole process more productive and reliable. As solar energy becomes more popular in many areas like farming and energy-efficient buildings, automated cleaning machines will be essential to keep production running, reduce the need for manual labor, and help create more sustainable energy sources.

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