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Design of Automatic Solar Panel Cleaning System using IOT - Review

Prof. Sagar Mali, Miss. Vaishnavi Kumbhar, Mr. Prathmesh Shirke, Mr. Avinash Patil, Mr. Sai Awale

Prof. Sagar H. Mali
Asst. Prof.
Department of Electrical Engineering

Miss. Vaishnavi Popat Kumbhar
Student
Department of Electrical Engineering

Mr. Prathmesh Prakash Shirke
Student
Department of Electrical Engineering

Mr. Karan Arvind Sutar
Student
Department of Electrical Engineering

Mr. Avinash Krishna Patil
Student
Department of Electrical Engineering

Mr. Sai Raghunanad Awale
Student
Department of Electrical Engineering

Abstract – Energy is still a critical issue globally, and in India, it poses significant challenges for both urban and rural household. Approximately 60% to 70% of the country's energy demand is met through fuelwood and agricultural residues. Although solar energy is a renewable source, its efficiency is often compromised due to dust accumulation on the surface of solar panels, which blocks sunlight and reduces power output. Therefore, developing an automated system to regularly clean the panels surfaces can significantly enhance their performance and over energy generation.

The research focus on developing an automated system for periodically cleaning the surface of solar panel to improve their efficiency. Additionally, electricity generation productivity is enhanced through the integration of IoT technology.

Key Words: Solar Panel, Dust, Efficiency, Cleaning.

1.INTRODUCTION

In recent years, there has been a growing global transition toward renewable energy, motivated by the urgency to decrease reliance on fossil fuels and address climate change impacts. Among the various renewable energy technologies, solar power stands out as a highly promising solution because of its widespread availability and long-term sustainability.

The sun emits energy at an exceptionally high rate, making solar energy abundantly available in nature. If fully harnessed, it could more than meet the global energy demand. However, atmospheric conditions such as clouds, dust, and temperature variation limit the efficiency of solar energy conversion. Solar panels are used to convert sunlight into more usable forms of energy. With growing environmental concerns, there is an increasing interest in renewable energy sources, particularly solar energy- as it generates electricity without producing carbon dioxide emissions. Among Various alternatives, photovoltaic technology has emerged as a promising solution to meet the growing global energy demand. However, efficiency of solar panels is significantly affected by environmental factors such as dust, humidity, and temperature. To address this, the present work focuses on analyzing the performance of solar panels with and without dust accumulation. The project involves the design and implementation of an IoT based automatic dust clearing system, aimed at maintaining panel efficiency through regular, automated cleaning.

A major challenges affecting solar panel performance are the buildup of dust, dirt, and other particles on their surface. The layer of dirt can block the amount of sunlight reaching the photovoltaic cells, thus reducing the overall efficiency of energy generation. Photovoltaic (PV) systems, widely known as solar, play a leading role in the energy transition by converting sunlight directly into electrical power. Nevertheless, the energy conversion efficiency of solar panels is often compromised by environmental influences such as dust, shading, and temperature fluctuation.

Traditionally the cleaning system was done manually. Manual cleaning has disadvantages like the risk of staff accidents and damage of the panels, movement difficulties, poor maintenance etc. The automatic dust cleaning system of solar panels has taken to overcome the difficulties arise in the traditional cleaning and produces an effective, non- abrasive cleaning and avoids the Fluctuation in performance caused by dust accumulation. The studies Carried out of the evaluate the efficiency of dust collected on it for one day, one week and a month. The efficiency of solar panel also calculated after cleaning the dust at least one day. And finally comparing both systems efficiency is considerable. Consequently, the proposed system enhances the overall performance and the efficiency of the solar panel. Thus, the developed model enhances solar panel performance.

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2. CLEANING METHODS FOR SOLAR PANEL'S –

2.1 Natural removal of dust –

Natural forces such as wind, gravity, and rainwater help to some extent in removing dust from solar panels, but their effectiveness is limited. It has been observed that tilting the solar panel array to a vertical or inclined position during early morning, late evening, nighttime, or rainy days can aid in dust removal more effectively.

2.1 Mechanical removal of dust-

Mechanical methods such as brushing, blowing, tilting and ultrasonic vibration are commonly used to remove dust from solar panels. Brushing systems, often designed like windshield wipers, clean the panel surface using machine-driven brushes or broom, however, these methods face limitation: the fine and adhesive nature of dust reduce. Cleaning efficiency is often reduced by harsh environmental conditions, which also make maintenance challenging, while the expansive surface area of solar arrays requires high powered cleaning systems.

2.2 Electrostatic removal of dust-

If there is a high potential on the surface of the solar panels, the charged and uncharged dust will be attracted to the panels because of the electrostatic forces. As a result, dust particles become electrically charged by solar panels, acquiring the same polarity. This causes electrostatic repulsion between the particles, eventually causing them to be repelled and floating away from the panel surface. However, this strategy cannot be used in PV system, because of the effect of the rain on earth.

3. OBJECTIVE

- To enhance panel performance through effective cleaning.
- To make the system automated using Arduino.
- To avoid the manual work.
- They avoid dust associated problems on solar panels.

4. COMPONENTS USED-

1. Rain Sensor
2. Servo Moto
3. ESP 32
4. Water Pump
5. Wiper
6. Battery
7. Battery holder
8. Water pump
9. Solar Panel

5. OBJECTIVE

- Literature Survey.
- Design of model
- Material selection
- Fabrication.
  - i. The first frame is fixed.
  - ii. The second frame is a movable aluminum structure designed to move horizontally.
  - iii. The third frame consists of brush mechanism that moves vertically.
  - iv. The above frames are controlled by ESP 32.

5. WORKING PRINCIPLE-

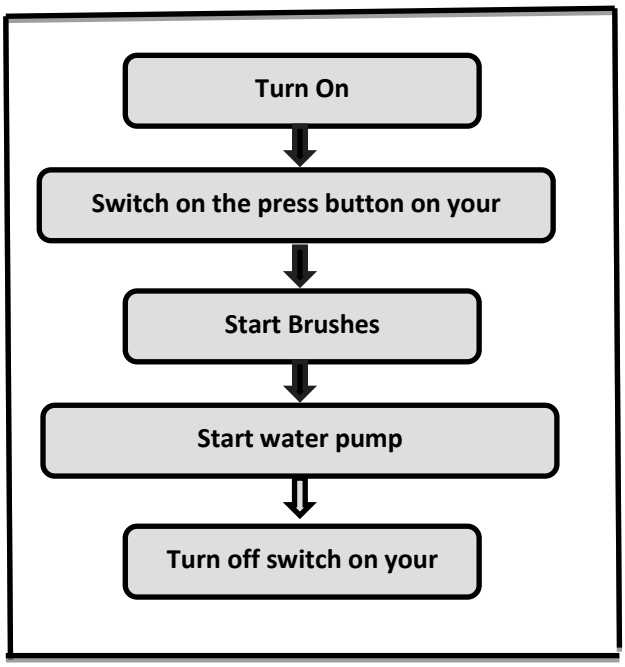

Fig. 1 Flowchart of Cleaning System

Fig.2 Solar panel Cleaning Model

6.CONCLUSIONS

Based on the test results conducted on the automatic solar panel cleaning and cooling system based on IoT, it can be concluded that the system can operate automatically in terms of cleaning the solar panel surface when it is detected to be dirty and cooling the solar panel.

The condition of the solar panel can be monitored from anywhere the user is located through the application of IoT technology, where the monitoring process is related to the solar panel's condition, whether it is currently undergoing the solar panel cooling process or the solar panel surface cleaning process. Through the application of IoT technology, users can also control the electrical devices connected to the solar power system.

Most automated cleaning solutions are tailored for large-scale installation and do not effectively accommodate smaller systems like those found on residential rooftops. For users with limited space, this often restricts them to smaller arrays. Our proposed solution offers a significant advantage for these smaller- scale applications.

The system is designed for seamless integration with rooftop solar panel installations. The rack and pinion mechanism work as it was designed to do. The linear actuator system worked very nicely and was able to achieve the required design parameters.

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