

Solar Panel Cleaning Robot

Ghaywat Shital¹, Gaikwad Sakshi², Ghodake Samiksha³, Gaikwad Kaveri⁴

U.G. Student, Department of Mechatronics Engineering sanjivani KBP Polytechnic Kopergaon, Maharashtra, India^{1,2,3}

Associate Professor, Department of Mechatronics Engineering Sanjivani KBP Polytechnic Kopergaon,
Maharashtra, India⁴

ABSTRACT: The dust particles accumulating on the solar panels will prevent the solar energy from reaching the solar cells, thereby reducing the overall power generation. Power output is reduced as much as by 50%, if the module is not cleaned for a month. In order to regularly clean the dust, an automatic cleaning system which removes the dust on the solar panel is developed. In this paper, the problem is reviewed and the method for dust removal is discussed. A robot cleaning device is developed and it travels the entire length of the panel. APIC microcontroller is used to implement robots control system. The robot provided a favourable result and proved that such a system is viable by making the robotic cleaning possible, thus helping the solar panel to maintain its efficiency.

KEYWORDS: automated cleaning system, renewable energy maintenance, dust removal mechanism, autonomous mobile robot, microcontroller-based system, energy efficiency, robotic automation, smart maintenance system, surface cleaning technology, and sustainable energy systems.

I. INTRODUCTION

Solar energy has become one of the most widely used renewable energy sources for generating clean and sustainable power. Photovoltaic (PV) panels are commonly installed in large solar power plants, industries, and residential areas to convert sunlight into electrical energy. However, the performance and efficiency of solar panels are significantly affected by environmental factors such as dust, dirt, bird droppings, and other particles that accumulate on the panel surface over time. This layer of dust blocks sunlight from reaching the photovoltaic cells and results in a reduction of power generation efficiency. Therefore, regular cleaning and maintenance of solar panels are essential to ensure maximum energy output and long-term reliability of the system.

Traditionally, solar panels are cleaned manually using water and labor, which can be time-consuming, costly, and sometimes unsafe, especially for large solar farms or panels installed at heights. Manual cleaning also requires a large amount of water, which may not be available in dry or desert regions where solar plants are often installed. In addition, frequent manual maintenance increases operational costs and may not always provide consistent cleaning results.

To address these challenges, the development of an automated solar panel cleaning robot has gained significant attention in recent years. A solar panel cleaning robot is designed to automatically remove dust and dirt from the surface of solar panels using mechanical brushes, motors, and control systems. The robot moves across the panel surface and performs cleaning operations with minimal human intervention. This automated approach helps in maintaining the efficiency of solar panels while reducing labor effort, water consumption, and maintenance costs.

The solar panel cleaning robot typically consists of components such as a microcontroller, motor driver, cleaning brushes, wheels or tracks for movement, and a power supply system. Some advanced systems also include sensors and wireless control for better monitoring and operation. By using robotic automation, the system can provide regular and efficient cleaning, ensuring that solar panels operate at their maximum performance level.

II. LITERATURE SURVEY

Recent research and development have increasingly focused on automated and robotic solutions to address the problem of dust accumulation on solar panels, which significantly reduces the efficiency of photovoltaic (PV) systems. Several academic studies and prototype developments highlight different approaches for improving the cleaning process of solar panels through automation and intelligent control systems.

In a study reported in the International Journal of Engineering Research and Technology (IJERT), researchers developed an automated solar panel cleaning robot powered by a DC motor and controlled using a microcontroller. The system used rotating brushes and a simple mechanical frame to remove dust from the panel surface. The prototype demonstrated that automated cleaning could significantly improve solar panel efficiency while reducing the need for manual maintenance.

Another research work presented a solar panel cleaning robot powered by solar energy itself, making the system energy-efficient and suitable for remote solar installations. The robot moved along the surface of photovoltaic panels using wheels and used a brush mechanism to remove dust particles. The study highlighted the advantage of using renewable energy for powering the robot, thereby making the system more sustainable and environmentally friendly.

A different approach focused on the development of a semi-autonomous solar panel cleaning system using sensors and microcontroller-based control. In this system, sensors were used to detect the presence of dust on the panel surface and activate the cleaning mechanism automatically. The system also emphasized reducing water usage by using dry cleaning techniques such as rotating brushes or microfiber rollers.

III. METHODOLOGY

The methodology of the solar panel cleaning robot involves designing and developing an automated system to remove dust and dirt from photovoltaic panels to maintain their efficiency. First, a lightweight robotic frame is designed to support components such as motors, wheels, cleaning brushes, and the control system. The robot is able to move across the solar panel surface using DC motors and wheels, which allow it to cover the entire panel area for effective cleaning.

A rotating brush mechanism is installed at the bottom of the robot to remove dust and debris from the surface of the solar panels. The brush is driven by a motor and works while the robot moves across the panel. The entire system is controlled using a microcontroller that manages the movement of the robot and the operation of the cleaning mechanism through motor driver circuits.

The robot is powered using a rechargeable battery or solar energy, making the system energy-efficient and suitable for continuous operation. Finally, the prototype is tested on solar panels to observe its movement, cleaning efficiency, and improvement in panel performance after dust removal. This methodology helps in developing a cost-effective and automated solution for maintaining solar panel efficiency.

IV. EXPERIMENTAL RESULTS

Figure 1. The dust sensor detects dust on the solar panel and sends the signal to the ESP32/Arduino microcontroller. The microcontroller processes the data and controls the system. The solar panel provides power to charge the battery and supply energy to the robot. The I2C LCD display shows system status and dust level. The L298N motor driver receives control signals from the microcontroller and drives the DC motors, which move the robot and operate the cleaning mechanism to remove dust from the solar panel.

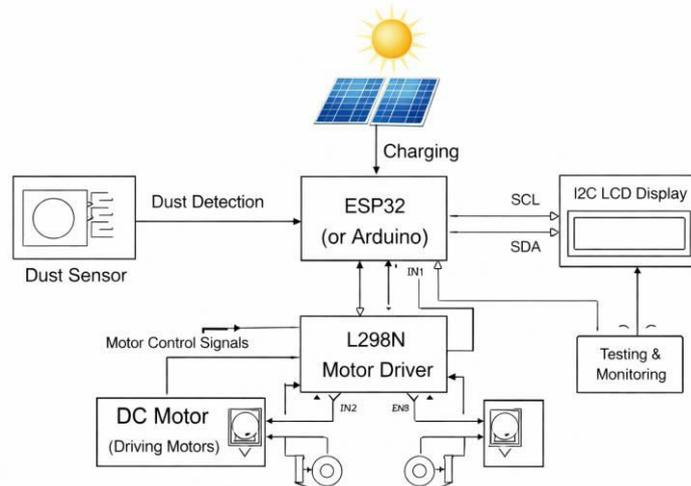


FIGURE:1

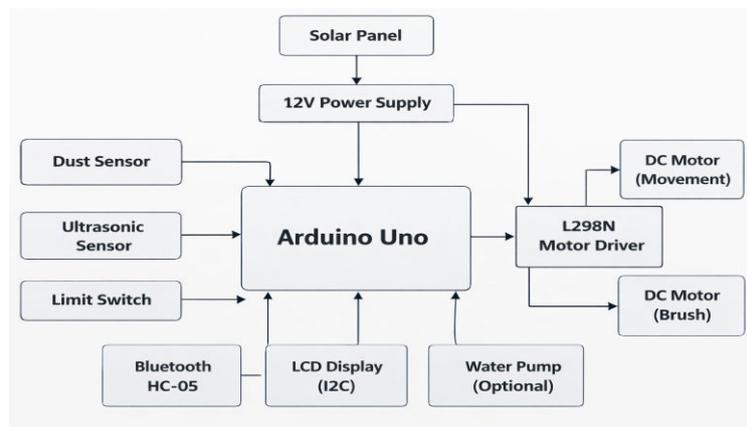


Figure:2

Fig. 2. The solar panel and 12V power supply provide power to the system. The Arduino Uno acts as the main controller. Sensors such as the dust sensor and temperature sensor send data to the Arduino. The Bluetooth HC-05 enables wireless control. The Arduino sends signals to the L298N motor driver, which operates the DC motors for robot movement, brush cleaning, and water pump. The LCD display shows system status.

V. CONCLUSION

The solar panel cleaning robot developed in this project provides an efficient and practical solution for maintaining the cleanliness of photovoltaic panels. Dust, dirt, and other environmental particles often accumulate on the surface of solar panels and reduce their ability to absorb sunlight, which directly affects power generation. The designed robot helps solve this problem by automatically cleaning the panel surface and ensuring that the panels operate at maximum efficiency.

The system integrates different components such as sensors, a microcontroller (Arduino), a motor driver, and DC motors to perform automated cleaning operations. The microcontroller acts as the main control unit that processes sensor data and controls the movement and cleaning mechanism of the robot. The motor driver controls the DC motors responsible for the robot's movement and brush rotation, enabling effective removal of dust from the panel surface.

The use of solar power and a rechargeable battery makes the system energy-efficient and suitable for continuous operation. The addition of communication modules and display units helps in monitoring and controlling the system easily. The overall design demonstrates a cost-effective and reliable solution that reduces the need for manual cleaning, saves time, and minimizes maintenance effort.

In conclusion, the solar panel cleaning robot improves the performance and efficiency of solar energy systems by ensuring regular and effective cleaning. The project highlights the importance of automation in renewable energy maintenance and provides a foundation for further improvements such as fully autonomous navigation, better sensing mechanisms, and advanced control systems for large-scale solar installations.

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