https://doi.org/10.31871/IJNTR.9.9.9
International Journal of New Technology and Research (IJNTR)
ISSN: 2454-4116, Volume-9, Issue-9, September 2023 Pages 01-05

Design and Testing of Cleaning System for Solar Panel Using Bluetooth

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***Abstract*— A solar panel generates electricity by letting light into the solar cells. Solar panels in Gulf region must be regularly cleaned due to the numerous dust storms that occur there. It will be incredibly expensive and time consuming to complete the operation manually. The objective of this research is to create a technology for self-cleaning solar panels using Bluetooth. Cleaning must be done frequently if electricity output is required to be more efficient. At predetermined time periods, the dust from the solar panel must be automatically cleaned off. The proposed work uses dc motors that are powered by a controller circuit with Bluetooth to clean the solar panels. The primary objective was to create a self-cleaning system with an appropriate controller that can clean solar panels. The bulk of the dirt that has been deposited on the solar panel is removed when cleaning it with water, which boosts cleaning effectiveness. Arduino Mega 2560 controller controls the water pump, motor and wiper. As the cleaning system drives power from solar panel battery, no other power sources are needed. This work investigates the potential for cleaning solar panels to increase the output. As a result, the solar panel is constructed and maintained for the automated system, as well as enhance panel capacity.**

***Index Terms*— Arduino micro controller, automatic cleaning system, Bluetooth, motor driver, PV modules, roller brush, wiper, and water pump.**

I. INTRODUCTION

With rising demand for solar energy, solar panel efficiency is much more important than ever. The normal peak efficiency for transferring energy to usable electricity is 11% to 15%. Solar panels, on the other hand, are inefficient. Pollution further reduces the PV panel's efficiency. Commonly known that dirt build-up on panels can reduce efficiency annually up to 27%. Different types of dimming (the casting of a shadow by an object) have an impact on solar panels. The solar panels' surface area, which serves to cover and shield the cells from the sun's rays, is what makes dimming difficulty.

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Dust is one of the things that prevent the sun's rays from reaching the cells. This can damage the cells, preventing power from reaching them and decreasing effectiveness of solar panels. Solar panels surface has significant role in dust collection, which affects performance as wind directs dust movements towards certain areas of the panels' surface. If the solar panels' surface is smooth and not rough, less dust may adhere to them. Using the android firmware, water pump, roller brush and motor are controlled to clean and move up & down the solar panel, a microcontroller unit is used to program this proposed project and develop the android firmware to work as a controller in this project.

Keeping the solar panels clean is very important. Solar panels are often designed to function by passing light through solar cells. However, dirt, pollen and other pollutants block light from entering solar cells, decreasing energy production. The operation of solar panels can be impaired if they are dirty. Cleaned panels emit more energy than dirty panels under the same conditions. Because the dust or dirt prevents light from reaching the cells.

The effectiveness of solar panels is crucial now-a-days. The output voltage drops because of dust accumulation on the solar panel. Hence, to increase the output, the designed cleaning system cleans the solar panel effectively. The controller is powered by battery which is charged by solar panel. All the rotating motors and water pump are controlled by an application software in the mobile phone connected to the controller via Bluetooth module (HC 05), and the motor driver (L298N) controls the up and down direction of the motor.

In the event that the solar panel has dust on it, the cleaning system descends, now the roller brush fixed to the structure rotates to clear the dust, and the water pump spouts water to clear away any leftover dust. Additionally, the cleaning system's wiper removes soiled water of the solar panel's surface. The lower limit switch state changes to high when the cleaning system reaches bottom, at low status the operation is reversed.

II. REVIEW OF RELATED LITERATURE

The results of dusting have been studied using dead leaves, pollen and bird droppings. Dust significantly affects performance and resistance of solar panel. The maximum loss in power increases from 10 to 30%. It was observed energy consumption increased because of dust accumulation on panels. The strength and power of solar panels is enhanced by easy-to-manage and inexpensive cleaning processes. Energy consumption is also lower at this stage. The final result shows that the maximum power reduction has been achieved [1].

Internet-of-Things (IoT) developers have clearly defined

opportunities, problems, obstacles, and technical requirements such as RF sensors, sensors, actuators, mobile phones, etc. Specific implementations have been created for IoT. The first part covers the various systems that have applied smart technology to date. The second part has devices description and their requirements [2]. Removal of dust methods such as common methods, automatic methods, self-cleaning nano membranes and electrostatic methods are viewed in this article [3].

SB Halbhavi et al. Adding cleaning equipment that automatically detects dirt on solar panels creates conditions for dirt to spread regularly. If the control panel is not cleaned, module performance can decrease by 50%. In this article, the automatic system is fabricated using an (8051) microcontroller controls a DC motor. This arrangement has sensor (LDR). While the photovoltaic modules are being cleaned, a mechanism including sliding brushes has been arranged. In daily energy production, the developed automatic cleaning system gives more energy output approximately 30% than a dust-accumulating PV module (module kept fixed on the ground) [4].

This article analyzes about performance of test setup of power generated by the cleaned panel. Output power may be significantly reduced because of large dust accumulation on the control panel. Dry cleaning removes dust particles from surfaces, but the cleaning effect can be seen with wet cleaning. Most dirt on solar panels are removed by water cleaning the solar panel. The cleaning technology does not require an additional extra power source due to the solar panel itself can generate the energy needed to turn ON the microcontroller, also stores in the battery. Setup is very easy. Comparing the cost of manual wiping and automatic wiping of dust, it is found cost of automatic cleaning is significantly more economical and less expensive, especially in systems with many solar panels. Microcontrollers are used for visual programming applications and also to reduce installation costs. Power capacity varies according to different weather conditions. Regular routine cleaning ensures a change in capacity measured before wiping and after cleaning, demonstrating superior cleaning technique performance [5].

This work is very useful particularly to researchers, designers, users and owners of photovoltaic systems due to; it proposes a novel technique to prevent the performance degradation of photovoltaic panels and frequencies. Optimal cleaning performances through the Internet of Things are adopted, especially in the desert regions and also in the dusty environment, the areas in general, Middle East, Jordan, and North Africa in particular. Based on the type of dust, losses of energy from stationary solar panels can be notable. Soil Dust and bird waste droppings form spots on panel causing it to temporarily shut down. The efficiency of solar panels is improved by cleaning dirt on solar panels. This experiment was carried out above the Najashi Mosque in Salt City (Jordan), where the cleaning of solar cells of a power generation plant using different cleaning techniques was studied [6].

Accumulation of dirt and bird droppings is the main cause of poor solar panel performance. This article discusses the newest and most popular designed cleaning systems and manufactured for solving problems related to collection and accumulation of dust [7]. This article includes investigation of possible causes of dust collection, dust demerit analysis, mathematical modeling of unwanted dust accumulating solar panels, wiping mechanisms discussed in the materials.

A viable feasible solution for photovoltaic setup to survive in this dust-covered environment. Also this work provides useful idea to researchers on the development status of various techniques to minimize the impact of dust collection through appropriate elimination, cleaning and recovery. Potential future challenges for these cleaning mechanisms are also discussed [8].

In this work the design steps of a self-cleaning system for a (PV) system are well explained, also experimental study of performance of a self-cleaning photovoltaic system is designed under all climatic conditions for solar power plants in India. The system not only cleans the photovoltaic system but also saves it from hail. The outcomes of this work show that solar power efficiency is significantly improved and therefore electricity output increases in all climatic conditions [9].

Brushes equipped with smaller robots will use little amount of water. These robots although are self-cleaning and generally very sturdy, they require significant redesign and cost savings, such as special tracks, high temperatures, and difficulty in maintenance. Here one more type of robot introduced uses water to wash and clean the panels with a water jet. Also they are productive in dehydrated and sandy environments, their main demerit is that they need more water. [10, 11]. Automatic cleaning machines are productive but have bulk investment and costs for operating the system, requires separate arrangement, electrical power, maintenance and labor [11]. Another study found that dust accumulation caused 78.3 percent performance loss and 78 percent power loss for amorphous Silicon (non-crystalline form of silicon) modules, 77 percent and 77 percent for cadmium telluride (CdTe), respectively, and 70 percent for cadmium telluride. and 71 percent of semi crystalline or polycrystalline Silicon modules [12]. The result is the development of solar panel cleaning robots, an ingenious solution that combines advanced technology to effectively navigate and clean solar panels without the need for manual labor. Solar panels are equipped with various tools to clean the surface of dirt and other impurities common in Africa to maintain their peak performance [13]. Skilancer Sun Cleaning created waterless solar cleaning robots to eliminate the cost of water and related infrastructure including tankers, tanks, pipes and plumbing. [14, 15].

With appropriate cleaning methods, these unwanted particles can also be removed from the panel surface. Several research projects have been conducted to accomplish various software prototype cleaning techniques. Output has increased by 35% approximately thanks to the use of cleaning techniques based on lever control and adaptive motors. The microcontroller (MCU) based automated dust cleaning system is designed in order to clean the control panel every two hours, thereby increasing efficiency by 1.6% to 2.2% approximately. [16] - [20].

III. METHODOLOGY

A. Proposed Cleaning System Block Diagram

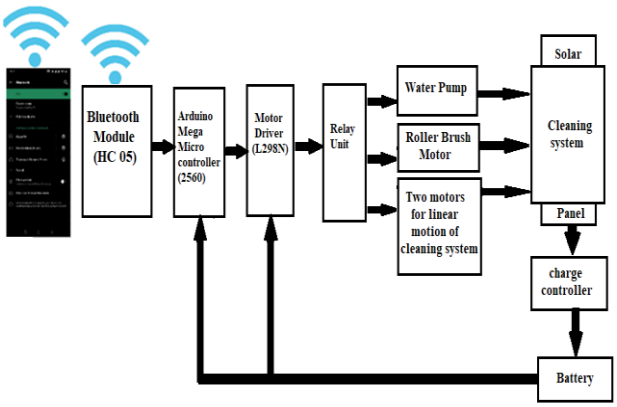

Fig. 1 Block Diagram of the proposed cleaning system using Bluetooth

The block diagram of the proposer cleaning system is shown in Fig. 1. When sunlight falls on the solar panel top surface, the PV solar panel generates direct current (DC) that is stored in the rechargeable battery. The charge controller prevents overcharging of the battery. The battery powers the microcontroller (Arduino Mega 2560). The L298N motor driver is used to change the direction of the pinion motor (forward and reverse direction) connected to the cleaning system. When the solar panel's surface is dirt, the Bluetooth will activate the cleaning system, which cleans it with water, roller brush and wiper, thus improves the output voltage of the solar panel.

B. Proposed System Working

The Arduino Mega 2560 microcontroller is powered by a battery charged by a solar panel. The controller controls all information coming from Bluetooth and limit switches. All motors and water pumps are controlled by mobile phone application software connected to the controller through Bluetooth module (HC 05) and the motor driver (L298N) controls the up and down direction of the motor. To limit the upper and lower positions of the cleaning system, two limit switches are attached to the lower and upper ends, respectively. The limit switch sends a high signal (1) to the controller whenever the cleaning system contacts them.

First, the Bluetooth module is initialized and paired with the mobile phone, and the controller starts receiving data from the application (app) on the mobile phone. The controller now checks application data, the status of the top limit switch (TLS) and the bottom limit switch (BLS). When the application data sends the ON signal (1), it will check whether TLS state = 1 and BLS state = 0 as well as TLS state = 0 and BLS state = 0, then the controller will trigger to operate roller brush motor, water pump and pinion motors. The motor connected to the system will move downward.

When application data = 0, it will check if TLS state = 0 and BLS state = 1, then the controller will turn OFF the water pump, activate the roller brush motor and the pinion motors connected to the system to move up. This process continues to clean the solar panel until the user sends an OFF (0) signal from the mobile application through the Bluetooth module to the controller.

C. Tinkercad Simulation

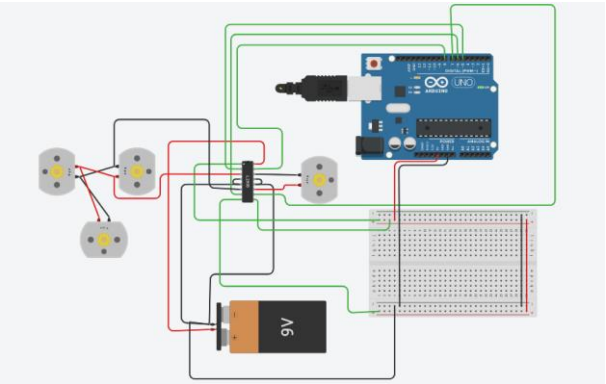

Fig. 2 Tinkercad design and simulation of the solar panel cleaning system

The circuit shown in Fig. 2 is designed in Tinkercad to test each motor operation, the circuit has solar panel, battery, Arduino Mega 2560 microcontroller, DC motors and L298N motor driver. After adding the necessary code for circuit operation, Tinkercad software is used to simulate the above system. The simulation results show that the forward and reverse operation of the motor is successful.

IV. EXPERIMENTAL SET UP

Complete installation of solar panel cleaning system

In Fig.3 below, the complete installation of the self-cleaning solar panel is shown. Dust can be cleaned in three ways in a cleaning system:

1) The wiper is mounted at the front to remove dust particles that accumulate on the solar panels as the cleaning system moves up and down using a rack and pinion arrangement. Limit switches are provided above and below the solar panel and limit the movement of the self-cleaning system to a fixed position above and below the solar panel.

2) A soft roller brush is attached to the body of the self-cleaning system through a DC motor that rotates the roller brush smoothly on the solar panel and cleans the remaining dust, if any, after the dust is removed by windshield wiper.

3) A water pump with a tank is located below the installation to pump the required amount of water to the sprinkler. This sprinkler is mounted above the installation system to spray water onto the solar panel surface and clean the dust completely.

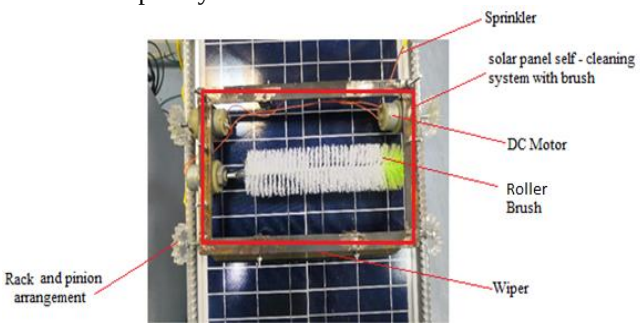

Fig. 3 Top view of the solar panel cleaning system using roller brush

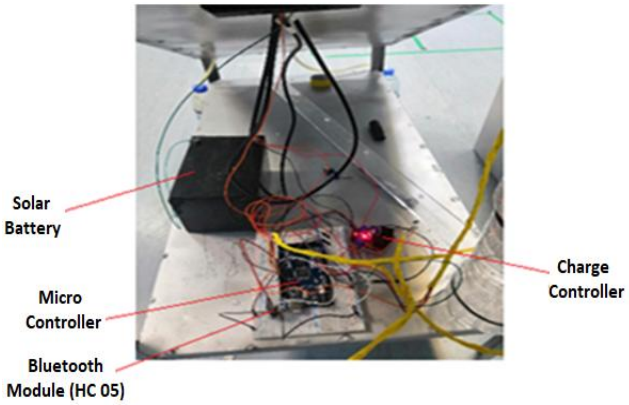

Fig. 4 Bottom view of the solar panel cleaning system

Fig. 4 above shows the bottom view of the solar panel cleaning system. The proposed system has a charge controller, which charges the battery during the day when sunlight hits the solar panels. All motors, pumps and microcontrollers are powered by this battery. An Arduino Mega 2560 microcontroller board is used to control all the motors for the up and down movements of the cleaning system as well as the rotation of the roller brush to clean dust on the plate surface solar battery. The controller also controls the amount of water to be pumped and completely cleans remaining dirt on the solar panel surface. Additionally, the HC 05 Bluetooth module is connected to the microcontroller for wireless control of the entire installation.

V. Results

1) The voltage of the solar panel was tested in three different ways depending on the amount of dust. In Fig. 5, the solar panel open circuit voltage is tested with full of dust. It shows 16.24 V DC at 10 AM morning.

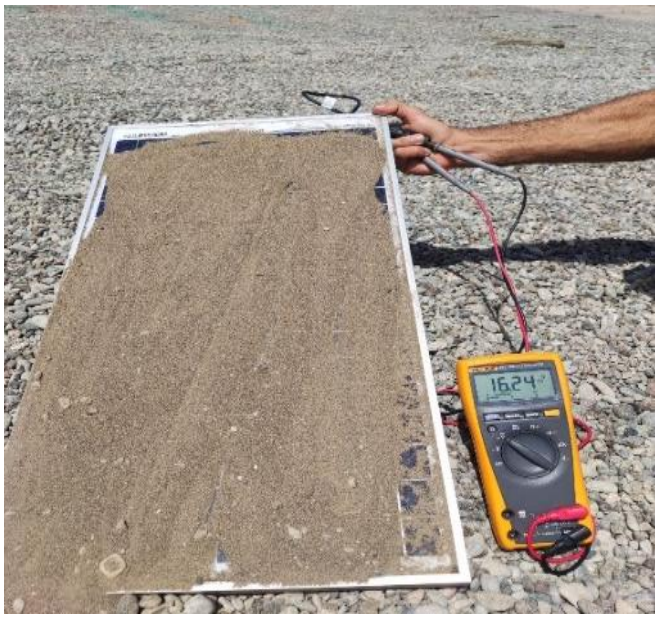

Fig. 5 Solar panel voltage with full of dust

2) The Fig. 6 shows the output voltage of the solar panel when 80% dust was cleaned by wiper and roller brush of the cleaning system. It shows 20.41 V DC at 10.10 AM morning.

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Fig. 6 Solar panel voltage after 80% cleaning of dust

3) The Fig. 7 shows solar panel output voltage after 100% cleaning of dust using wiper, roller brush and water sprinkler of the cleaning system. It shows 21.34 V DC at 10.20 AM morning.

Fig. 7 Solar panel voltage after 100% cleaning of dust

VI. Conclusion

The main objective of the research work presented in this paper is to develop a solar panel cleaning system suitable for cleaning the panels to improve the output voltage of the solar panels. From Fig. 5 to Fig. 7, it shows an improvement in the output voltage from 16.24 V DC with full dust on the solar panel surface to 21.34 V DC with the solar panel cleaned 100 % using this recommended cleaning system. This article highlights the impact of dirt on the efficiency of solar energy systems. The performance and efficiency of solar panels is greatly affected by dust, which reduces maximum power output by about 24%. Dust accumulation on panels has led to

power loss, which can be mitigated by introducing a Bluetooth-controlled solar panel cleaning system. This system increases the electricity production capacity of solar panels. Finally, the output power can be improved by this cleaning system.

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