Study on Solar Panel Cleaning Robot

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Abstract—Solar energy, being a noteworthy wellspring of sustainable power source, is significant in satisfying future energy need. To ensure efficient operation of photovoltaic panels, it is fundamental that the system presents proper cleaning operation to all obstructed materials that may impede the solar light-based radiation. The amassing of dirt or particles like residue, water, sand and greenery on the outer surface of the solar-based photovoltaic panel deter or divert light vitality from achieving the solar oriented cells. This is a noteworthy issue since the light obstruction materials play as resistance that diminishes the performance of solar photovoltaic. The target of this study is to delineate innovation of robotics technology for cleaning photovoltaic boards. The proposed strategy screens the power generation and cleans the photovoltaic surface when required progressively on mobile app. The enhancements accomplished by the unique structure and the created model confirmed the common sense of the proposed design.

Keywords: Self-Cleaning, IoT. Dust Detection, Mobile Robot,

I. INTRODUCTION

The power generated by using conventional methods is a costly process and has a harmful effect on the environment that steer the attention towards utilizing and developing the renewable and sustainable energy sources [1-4]. The most common renewable energy is solar-based energy. It has gotten a huge attention from researchers and industrial sectors for several reasons like: inconstancy of crude oil prices, awareness of environment friendly power sources, backing of local government by creating rules and policies for supporting renewable energy sector, low prices of PV panels. The ability of glass cover of the solar system to break through the sunlight radiation across the collector surface would determine the efficiency of solar systems. The solar system utilizes solar cell to generate electricity by converting sun energy radiation [5-6]. The system involves four components, namely: panels, battery, charge controller unit and load. Regularly fixed on rooftops and wired by an inverter into a building, solar PV board changes over the direct current generated by solar cells into electric current. The deposition and accumulation of dirt and residue particles called as soiling highly degrades the energy production [7-8]. Residue deposition and dirtying of the board glass is one of the serious issues in the quickly extending solar powered vitality advertise particularly in situations that experience the ill effects of residue, airborne particles and moistness which results in changes in board's electrical qualities. The amassing of residue particles break down the performance of solar powered cells and results in measurable misfortunes in the produced power because of the sun irradiance dispersing consequences for the surface of the solar board [9-11].

The efficiency of solar based panels subsidence radically when a little segment is obstructed by fallen trash or a film of residue and precipitation is found to have practically no cleaning impact. Cleaning of solar-based boards after the installing on the top of a building is troublesome as residue particles do not enable the sun-oriented radiations to enter in the board appropriately causing a decrease in conversation productivity of the board and prompting expanded charging time of the batteries.

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Cleaning with a brush and water is the most common and traditional method. Automated cleaning by using robotics has likewise been put to handy use. Be that as it may, manual cleaning is hard in the cruel desert conditions, water and its transportation to the destinations where the power plants are settled are expensive, and there is uncertainty in future worker wages[12-14]. The electrostatic travelling wave is utilizing as other cleaning system that is proposed by Masuda et al. [16] and it is still under development. It is automated cleaning process and require neither consumables nor mechanical movable components and has incredibly low power utilization. The current techniques for cleaning surfaces are costly, interruptive, wasteful, and possibly harming the surfaces of collectors. But the automated cleaning system maintains the solar collector clean along the working time to ensure maximum reflectiveness and generated power. The aim of this investigation is to design and develop an automated Cleaning system for a solar - based collector to minimize and eliminate the effect of dirts and soiling the performance of solar systems. The developed system will be able to monitor the power production and clean the PV surface as soon as required in real time using mobile app.

II. MATERIALS AND METHODS

Fundamentally, robots are designed in such technique that they lessen human intercession from work escalated and unsafe work environment. The cleaning robot for PV panel with Android bolstered block diagram consists of three elements, namely: input, processor and output as shown in Figure 1. The primary element of the project is input mechanism, which includes each of the Android control switch unit, IP camera, sensors of voltage and current. This info information and data later send to the second element, which is a processor advancement (type Wemos D1 ESP8266 based microcontroller) that integrated by using the Arduino IDE. The last element is the output source consists of DC-motor for controlling robot movement, media server for sending video from the IP camera to the android apps, and Bluetooth module integrate with android apps to test the level of both voltage and current. A camera is appended at the forehead of the robot to register and show the perspective on the climates on the representative's screen for powerful perception, identification and speedy investigation. In this improvement procedure Hardware prerequisite for the advancement of the project are appeared Table 1 and 2

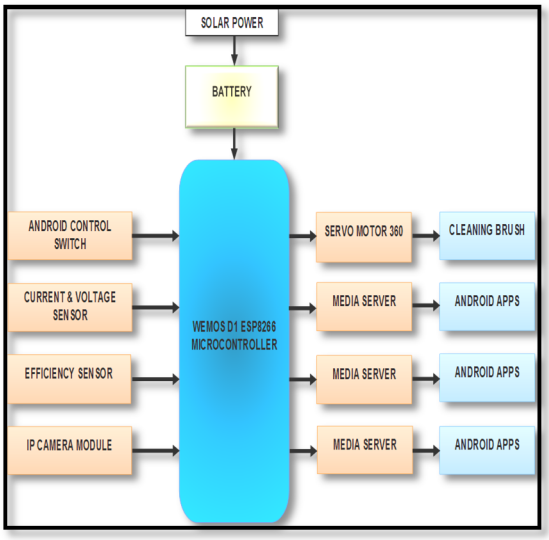

Figure 1: Block diagram

TABLE 1:
HARDWARE REQUIREMENT FOR THE DEVELOPMENT OF THE PROJECT

Hardware specification	Quantity
Servo motor	5
Rechargeable battery	1
Wemos d1 esp8266 microcontroller	1
Mini ip camera module	1
Voltage sensor	1
Current sensor	1
5v solar panel	3
L298h motor driver	1

TABLE 2:
SOFTWARE REQUIREMENT FOR THE DEVELOPMENT OF THE PROJECT

Software specification	Software name to be utilize
Source code	Arduino ide
Designing and simulation	Proteus
Monitoring cleaning robot	Blynk app
Monitoring ip camera	P2p cam viewer app

The circuit diagram shown below is consisted of the Arduino-based microcontroller, L289N motor driver, 5V PV panel, and motors as shown in Figure

2. The diagram as well involves three switches to control the cleaning robot like on/off-bottoms and motion of the robot. The PV panel is provided with a rechargeable battery as a power supply.

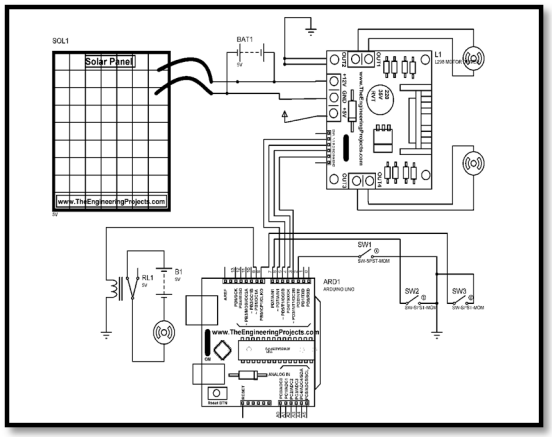

Figure 2. The Proposed System

The circuit simulation has been designed to directly test the coding for the microcontroller. Close to that the element utilized in this study is furthermore been simulated to make schematics and electronic prints for fabricating printed circuit boards (PCB). The model simulation comprised of microcontroller, motor driver and servo motor which include in the cleaning procedure together with the solar panel simulation to charge the robot framework as shown in Figure3.

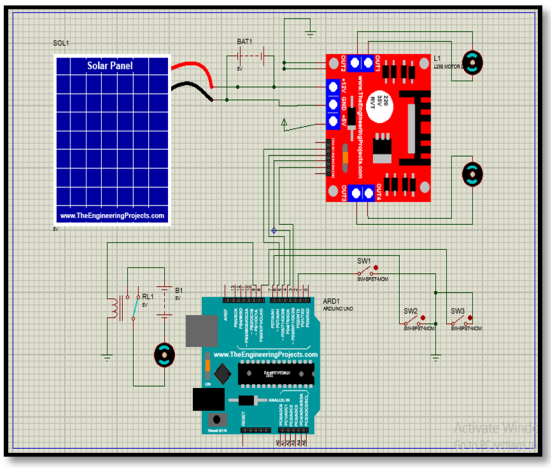

Figure 3: Circuit simulation using .

The prototype robot is further developed as 3D design. This design has been improved to fulfill some features through reducing unnecessary components, difficulties and enhance the robot looks and effectiveness. Figure 4 shows 3D cleaning robot design.

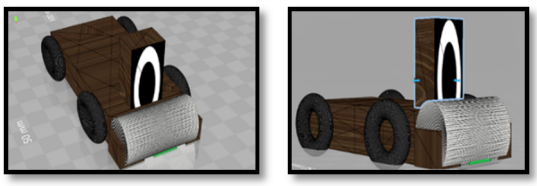

Figure 4: 3D design of solar panel cleaning robot.

According to preliminary collected data and information during the design stage, appropriate elements and software are selected. For the hardware component, the Wemos D1R2 Arduino microcontroller is chosen as system development panel, which play a centric and a crucial role in monitoring other elements function like: motor driver, servomotor, sensor of voltage and current and cleaning brush. Meanwhile the software component is Arduino software utilized for coding and programming of the system. The Android is linked to microcontroller through Blynk software.

An efficient cleaning technique must be carried out on demand with minimum requirements. The developed system includes three major segments as shown in figure (1). The first one is sensing, processing the dirt & dust density and delivering SMS notification massage to the operators when necessary. The second one is the sensor of current and voltage with Arduino Uno-microcontroller to determine the online output of the PV panel, and processing the amassing dust imact on the output energy.

The third segment is wiper system with windscreen that start with signal from a microcontroller using relay, which is ignited once the rated output power reach 50%. It works as an auto cleaner that is fixed on the solar PV panel. Also, it consists of washing water sprayer, electrical D.C. power for driving the windscreen wiper system provided from the solar panel using D.C. to D.C. step down converter. In this study, the effects of accumulated dust on the solar collector surface will be examined by analyzing the obtained results from sensors and microcontroller in dusty environment. The light dependent resistance sensor (LDR) is connected to microcontroller as shown in figure 1. It is utilized to differentiate between the day and night. Hence, this cleaning system works depending on the electrical power of the PV solar panel in case of dust accumulation.

The Arduino coordinated advancement condition (IDE) is provided by the Arduino project, which is a cross-stage application written in Java language. It incorporates a code manager with many features like highlighting of syntaxes, automatic indentation brace matching and gives straightforward a single tick system to order and upload program to the board. The Arduino IDE bolsters C and C++ languages using unique tenets to sort out the code. The Arduino IDE provides a product library called Wiring from the Wiring venture, which gives numerous normal information and output process. In remote sensing control, the target is identified to design a user friendly application and responsive in which all the system parameters are provided in details. The Blynx software is adopted to develop the

application. The online output data of voltage and intensity level of dust is shown by the responsive app. using the Wi-Fi module. The cleaning process of PV modules is started by pressing on the push button to operate the motor wiper.

Nowdays, Blynk software is utilized widely for design application to be used in several electronics devices and project. It is integrated with IOS and android devices to monitor and control various microcontrollers -based project. Furthermore, it is internet-based and able to do system monitoring through connecting to the android internet. Its design is simple, easy to use, and user friendly. The software is supported by many tutorials that enable the user to learn more and more about the functionality. In this study, the blynk app will be installed on android device to do several tasks like: monitoring and switch control of robot, displaying values of voltage , current, level of battery charging, and efficiency as shown in Figure 6.

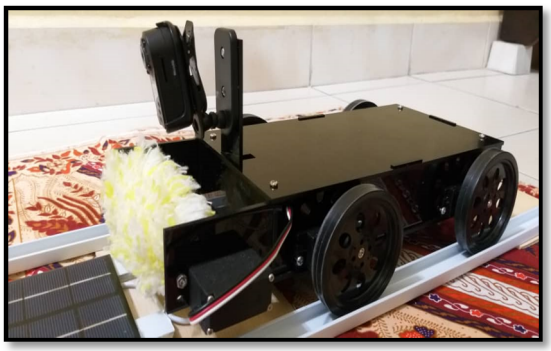

Figure 5: Final design of solar panel cleaning robot

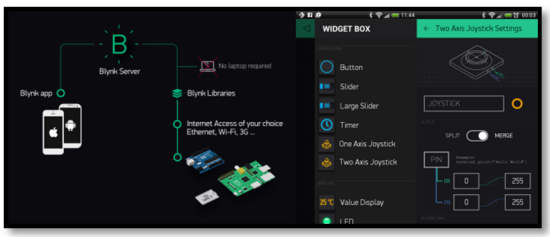

Figure 6: Blynk apps interface

III. RESULT AND DISCUSSION

At the beginning, the feasibility of designed system should be verified by carrying out the robot simulations as shown in Figure 7. This action as well verifies the reliability of the adopted control strategies that was clarified above. The circuit simulation demonstrates the electronic devices that are used in the current study by using software to display the system performance. Proteus software was used to simulate the system. The simulation compromise of three steps and there is a switch to control each step. When the simulation coding verified, the process starts. Once the switch closed in the first step, the motor move forward and brush starts cleaning process. While the second switch closed, motor reverse its direction and cleaning process is done in backward direction by controlling with robots as shown in Figure 8. Finally, both of the motor and brush stop when the switch closed in the third step as the process is ended. Later on, the battery is charged by the power supply of the PV panels.

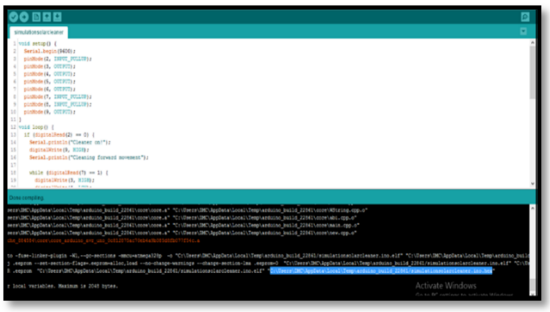

Figure 7: Verified simulation coding

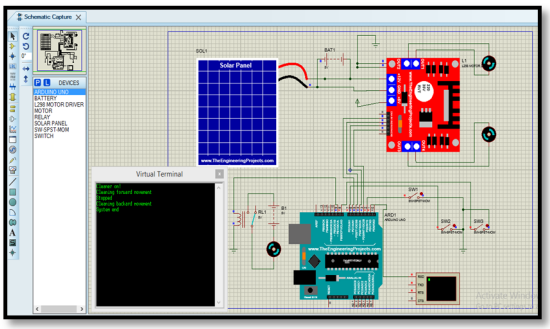

Figure 8: Proteus Circuit Simulation

For real verification, the station over was controlled the sytem over Arduino by utilizing the control software. Mobile robot was tested and approved its suitability in cleaning solar panel where it expressed good mobility and capability of passing over the PV panel. The cleaning robot has effectively finished the cleaning operation. The operation includes the forward and backward motions along the rail according to program utilizing Arduino. The cleaning brush likewise effectively turned and clean the hindrance like residue and dry leaf all through the procedure. In general the cleaning procedure had a beneficial testing as appeared in Figure 9.

The function of the IP camera is monitoring the cleaning operation and conditioning of PV panels. It is connected to the internet and can display on android and PC windows systems. It can be used also for video recording and image capturing during cleaning. All the extracted data are successfully documented and stored in the file. Generally, the IP camera approved its reliability during monitoring the cleaning operation as revealed in Figure 10.

Figure 9: Robot start cleaning process

Figure 10: IP camera monitoring panels cleaning process

The performance of PV panels has been evaluated under two conditions. Firstly, the solar system is tested under dust condition and later examined after robot cleaning of panel surface. The two evaluations were performed under sunlight to make fair comparison based on produced current and efficiency. Further, the assessment was extended to check the functionally of developed mobile app in term of monitoring the system performance. All the information and data have been collected & analyzed and the performance comparison was depending on current and efficiency.

To perform first evaluation (i.e under dust condition), a small amount of powder was spread over the panel under sunlight radiation. The produced current and efficiency rate was monitored by using Blynk app, which is connected to the PV panels. The experiments were conducted under two conditions for 2 minutes. The first twenty readings of current and efficiency have been collected and recorded for analysis. The results revealed an improvement in system performance where the produced current was increased from 0.35 to 0.95 A while the efficiency rate was raised up from 35% to 94.95% after robot cleaning.

IV. CONCLUSIONS

The cleaning technology of the Solar PV panel is extremely improved the efficiency of power generation and enhanced panel durability. The dust and residue deposition minimize the radiation falling on solar cells and in turn reduce electricity generation. In this study, a cleaning robot system was developed and implemented. The cleaning robot was tested and achieves successful result. Both of produced current and of efficiency rating was improved by using the developed system. The remote monitoring based on IOT ensures comprehensive monitoring and increase the efficiency rate of the system. Currently, this robot is not for commercial use and there is future work of development to add more functions for different applications. With more advances of technology, more developed and efficient cleaning methods are taking their way to practical use to reduce the power losses due to dust accumulation on the panel surface. Therefore, the automation of solar power plant will support and enhance the decision-making of large scale solar fields.

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