

Design and Development of Smart Self-Cleaning Solar Panel System

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Abstract—Solar power, being a noteworthy wellspring of sustainable and renewable energy source, is critical in satisfying the future vitality need. However, collection of fine particles, dust and water from the air above the solar panel will prevent sunlight from reaching the surface of the solar cell. This is a noteworthy issue since the light block materials present as external impedance that lower the solar based photovoltaic execution. In this study, a flexible cleaning gadget is developed, which ventures to every part of the whole length of the solar panel. The technique presented is also able to monitor the electrical power generated from the solar cells and instructions for cleaning solar cell photovoltaic surfaces can be activated when required by using Internet of Things (IoT) mobile applications. The results revealed that the external resistance could reduce the performance of the solar panel up to 22%.

Index Terms — *Self-Cleaning, Internet of Things (IoT), Dust Detection, Solar energy*

I. INTRODUCTION

Recently, Solar energy has gotten huge attention as a result of an instability of crude oil prices, the increase of awareness on environmental issues, the supporting policies and subsidies taken by the local government to promote renewable energy sectors and the reduction of photovoltaic (PV) panel prices. The performance of the solar system can be determined based on the ability of solar radiation to penetrate the surface of the solar panel [1-4].

The Solar PV utilizes solar cells to transform solar radiation into electrical energy. The solar system consists of four elements: panels set, a battery, a charge controller and load. Generally, for a residential solar system, the solar panel is fixed on the roofs, wired to the building by an inverter and the received direct

current from the solar panel is converted into electric current. The soiling represented by the accumulated dust and dirt deposits on the PV surface has a detrimental effect on the process performance [5-7]. Residue deposition and ruining of the panel glass is one of the serious issues in the quickly extending solar energy sector, particularly in situations that experience the ill effects of residue, airborne particles, and moistness which results in changes in panels' electrical qualities. The gathering of residue particles disintegrates the execution of solar based cells and results in measurable misfortunes in the produced power because of the solar irradiance dissipating consequences for the solar panel surface. Solar panel effectiveness drops radically notwithstanding, when a little part is obstructed by fallen garbage or a film of residue and rainfall is found to have next to zero cleaning impact [8-10].

Cleaning of the solar panel after the establishment on the top of the house, factory and shops is troublesome as residue particles don't enable the sun radiations to pass through the panel appropriately coming about the diminished change effectiveness of the panel. The easiest, most effective and safe method is to clean the surface of the solar panel using a brush and water. To make this process more practical, the mechanically and automatically clean process has been used. This can help where in manual cleaning, there is a need for the cleaning tool to be transported to power plant areas which involves high cost of work [11]. Another cleaning system [12-13] that utilizes an electrostatic traveling wave for cleaning dust is a work in progress dependent on the novel idea previously proposed by Masuda et al. [14]. It requires no consumables and mechanical moving parts due to automatic operation and has incredibly low energy utilization.

Current strategies for cleaning reflective surfaces are costly, interruptive, wasteful, and conceivably harming to collector surfaces. So, a mechanized, productive cleaning process that needs neither water nor moving parts to maintain the solar-oriented collectors clean for most extreme reflectance and vitality yield. The point of this work is to plan and process the cleaning of solar based panel framework and to wipe out the effect of residue and foulness on the performance of power generation from the solar panel. The proposed technique is able to monitor the power generated and also clean the PV surface when required via a mobile app.

II. EXPERIMENT APPARATUS AND SETUP

A successful cleaning technique ought to be performed when needed with least prerequisites. The proposed framework comprises of three fundamental parts as illustrated in Fig. 1. The first part is the sensing part where GP2Y1010AU0F, an optical air quality sensor is used to sense dust particles. This sensor work together with an infrared emitting diode and a phototransistor that was put together diagonally. This arrangement will detect the dust around the solar panel surface with the mean of the reflection from the dust. This technique is very functional and able to detect very fine particles like dust. This sensor has a very low power consumption (20mA max, 11mA typical), and can be powered with up to 7VDC. The sensor will output an analog voltage proportional to the measured dust density, with a sensitivity of 0.5V/0.1mg/m3.

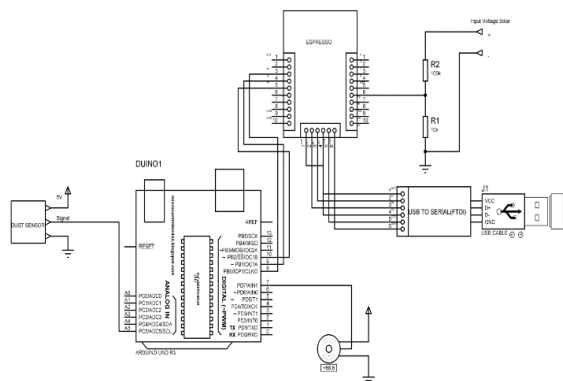


Fig. 1 The Proposed System with 3 parts

The second part is the brain of this project, Arduino Uno. Arduino Uno is a microcontroller that measure the PV panel output in real time, and process the accumulated dust effects on the output power. The third part of this project is the windscreen wiper system that controlled by the microcontroller via a relay which energized by the solar power produced from the solar PV. In this study, the impacts of residue that amassed on the solar based panel are examined by alluding the outcomes which are gotten from sensors and microcontroller in a dusty environment. In addition, this windscreen wiper system works as an automatic cleaner to the solar panels. The windscreen wiper

system consists of a water sprayer and an electric DC control that uses D.C to D.C step down converter to supply electricity from solar panels. Thus, the power generated from the solar panel will activate the automatic windscreen wiper system when there is the accumulation of fine particles on the surface of the solar panel or when instructed to do so via the IoT application.

The Arduino integrated development environment (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. Arduino is a single-board microcontroller that uses the Atmel AVR processor as a brain [16]. The Arduino IDE supports the languages C and C++ using special rules to organize code [17]. The Arduino IDE provides a product library called Wiring from the Wiring venture, which gives numerous normal information and output process.

The fundamental point in remote client control is to make or design an application that is able to provide a response to the detail parameters and easy to be used. The application was made by utilizing Blynx software as shown in Fig. 2 and Fig. 3. The responsive application demonstrates continuous solar based module information of output Voltage and residue level Intensity utilizing Wi-Fi module as shown in Fig 4. Using the push button, an activity control to the motor wiper is actuated and will start the cleaning mechanism of the PV module with a wiper.

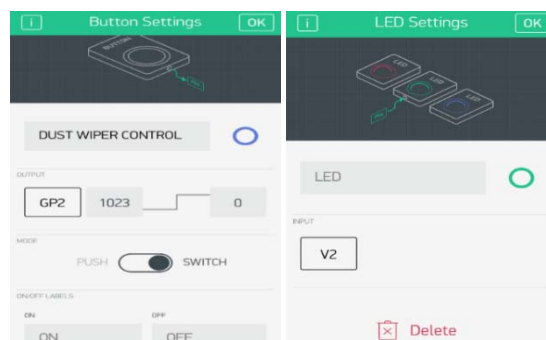


Fig. 2 App button settings using Blynx



Fig. 3 Voltage display and settings

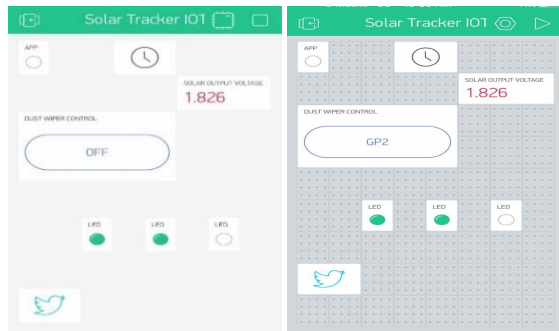


Fig. 4 IoT app design

III. RESULT AND DISCUSSION

The proposed framework model was put for testing in an open environment in Kuala Lumpur for a period of five days. The system was left to continuously track sunlight (different tilt angles) and the output calculated change in efficiency for a standard PV-module with proficiency of 16.9 % by measuring the daily voltage output. The results of the output voltage are shown in Table 1. From the result in Table 1, it can be observed that the output power accumulated by the solar panel was reduced due to the accumulation of dust on the surface of the solar panel.

Another soiling test was conducted by loading the wheat flour on the solar panel surface with its density being increased by 10 g/m² daily. In this analysis the PV panels have been tested under dust accumulation. For the analysis, powder being used as dust. A little amount of powder been sprinkled on the panels and placed under sunlight.

TABLE I
PROTOTYPE RESULT

| DAY | OUTPUT VOLTAGE (V) | DIFFERENCE (V) |
|-----|--------------------|----------------|
| 1 | 12.14 | - |
| 2 | 11.47 | 0.67 |
| 3 | 10.84 | 0.63 |
| 4 | 10.22 | 0.62 |
| 5 | 9.53 | 0.69 |

Blynx application is connected to the panels for monitoring the current produced and efficiency rate of the panels. Based on the reading the average current produced is 0.35A, just 35 % of the efficiency rate. On the other hand, the panels have been tested after cleaning. Once the system finished cleaning the panels, the performance of current and efficiency been observed again. Based on the reading, the average current produced is 0.95A and the efficiency rate is 94.95%.

The final design of the project discusses the completed system of the project. In this stage, the final outcome of the project prototype and system being discussed, which compromise both hardware and software implementation and their performance.

Fig. 5 shows an autonomous robot that utilizes microfiber-based brushes to wipe out solar panels from dust and residues. It is designed to be suitable for large rows of the panel that are mounted in a dry and sandy atmosphere. The developed system utilizes a PV panel with a battery for storing energy that enables night cleaning process and locating of PV Panel at the rail bottom to be cleaned by a robot itself. The system is moving on the guided rail that is fixed at the PV edge. Furthermore, the system is remote sensing in which cleaning orders and statistics are obtained from any device connected to the internet.

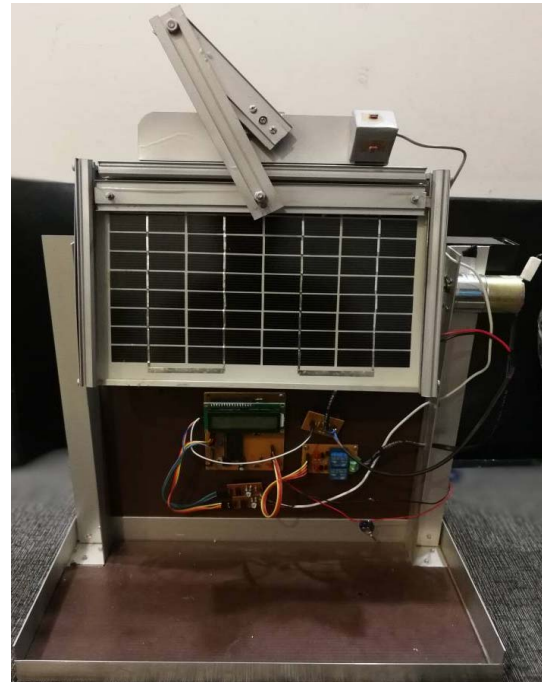


Fig. 5 Prototype Final Design

IV CONCLUSION

The technology of PV Solar panel cleaning can extremely improve the efficiency of generating power and enhance the durability of Solar panels. The radiation falling on the solar cell is affected by the dust deposition, hence the produced energy is reduced. The IoT based remote sensing would maintain convenient plant monitoring and give an ideal solution for high efficiency. The developed system was not currently expected for commercial utilize, merely a base solution for the future development of various applications. As innovation propels, there will be progressively proficient methods for cleaning and anticipating energy misfortune in solar panel modules as there still is today. Along these lines, computerization and intellectualization of solar-based power plant monitoring will improve future basic leadership process for huge scale solar powered power plant and lattice combination of such plants. The sustainable power source is eco-accommodating, contamination free and can be utilized for household appliance and industry on three phases.

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