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Design and Development of a Dry-Cleaning System for Photovoltaic Panels

Mohammed Abdul Muttalib[1], Dina Mourad[2], Tamer A.A.Ismail[3], Abdul Latif Syed[4]

[1] Faculty of Technology and Education, Helwan University, Egypt,
[2] Faculty of Technology and Education, Helwan University, Cairo, EGYPT,
[3] faculty of technology at El Sahafa. Ministry of higher education,
[4]Faculty of Engineering, Helwan University, Egypt

Abstract - *The amount of power generated will decrease if dust particles on the solar panels block sunlight from entering the solar cells. If the appliance is not frequently cleaned, power production can decrease by as much as 42%. An automatic cleaning system that eliminates dust from the solar panels has been designed to periodically clean the dust. The topic is reviewed and the dust removal technique is discussed in this study. A cleaning robot that travels the whole length of the board has been designed. The robotics control system is implemented using the Arduino Uno microcontroller. By enabling automatic cleaning, the robot produced a successful outcome and demonstrated the viability of such a system, assisting in the preservation of the solar panels' effectiveness*

***Key Words*: photovoltaic panels; photovoltaic panel maintenance; dry cleaning; the dust; the design; cleaning robot**

1. INTRODUCTION

The performance of photovoltaic (PV) panels when exposed to dust under standard test circumstances (STC) is indicated by the photovoltaic soiling index (PVSI) (Menoufi, 2017). Soiling is the term used to describe the build-up of dirt on solar panel modules. It is a significant loss issue, especially in desert regions where there is little rain and even frequent dust or sand storms (A. Abid et al., 2018). The characteristics of soiling accumulation on solar panels are influenced by the local environment and the dust qualities, which include shape, component, weight, and size

(Maghami et al., 2016).In article (Pradhan & Panda, 2017), a real-time experiment has been carried out to examine the impact of various conditions, including the soiling effect, on the operation of the PV system. Other researchers (Mohammed et al., 2020)suggested a method to lessen the amount of energy used by regulating the devices for the home. Additionally, in the article (Slamet et al., 2020).The authors proposed an adaptive PI controller with a robust maximum power point tracking (MPPT) controller that is based on fuzzy logic. In dusty conditions, such a controller can be useful for maximizing PV power.

Researchers have proposed a variety of dust-accumulation mitigation techniques, including (Said et al., 2018)(Ghosh et al., 2019)(Plessis et al., 2020), although efficiency is still significantly hampered by dust accumulation, particularly in arid regions. A PV module's efficiency is drastically reduced. Numerous methods were put forth by researchers to lessen dust build-up on PV panels. Several coating approaches, such as metallic anti-corrosion, drag-resistant coatings, self-cleaning coating

(Kawamoto, 2019).The authors of (Chaichan & Kazem, 2020). recommended washing the solar module with a salt solution to lessen the energy loss caused when the module is contaminated by soil and dust, but their suggestion only had a minimal impact. However, in this article we will concentrate on studies of the impact of dust on solar cells in a different area of Egypt dedicated to researchers, designers, and engineers dealing with Additionally, (Chaichan & Kazem, 2018) has a section specifically for books.

Dedicated to several articles describing the physical properties of dust in Egypt and how they affect solar systems. There is a discrepancy between the amount of available energy and the increasing demand for energy in a developing country, as is the case in the Arab region (Al-Hamadani, 2020). Several strategies have been proposed to bridge this gap by researchers such as (A. J. Abid & Al-Naima, 2020). However, dust widens this disparity due to less power generation. Traditional cleaning with HR takes time, costs money, and is best done during the day.

It conflicts with the system manufacture timer. Especially in large solar farms, it is difficult to monitor the dusty parts of the array, so the researchers (A. J. Abid et al., 2018).presented their results.

Plan to use a wireless monitoring system to monitor the entire group. The authors of the article [3] make a general proposal to mitigate the (potential) impact of dust collection on PV performance. They divide the globe into three categories: low latitudes (humid, humid dry, and tropical dry) make up the first group. The second group is the mid-latitude climate (steppe, Mediterranean, grassland climate); The third group is the climate of high latitudes (the climate of the taiga and tundra). This indicates that there is less dust formation at the high-latitude site due to the higher plate inclination angle, as shown in

(Hashim et al., 2019). While the cleaning robot (Cai et al., 2019)is equipped with sticky feet, a rotating brush, and a dust suction model, cost and ease of use must be considered. In (Riawan et al., 2018), a prototype is shown

However, it doesn't appear feasible because it takes a long time to clean and isn't appropriate for the oblique angle where the majority of PV arrays are situated. A novel brush is described in (Parrott et al., 2018) that has an aluminium core with a silicone rubber top put on it. However, this device needs a guide rail and is not self-powered. in (Hammoud et al., 2019). a robotic cleaner was presented with three motors for the power generation of a coastal PV-power plant at Zahrani Lebanon. The dry-cleaning results, published in (Al Shehri et al., 2017), showed a very effective, non-abrasive cleaning. While the motor speed is proportional to the amount of dust, the use of a sensor to detect it is described in (Al Baloushi et al., 2018). Although this model looks premium, it is not very cost-effective. Five motors were used in an intelligent cleaning robot presented in (Antonelli et al., 2020), which increased the cost and complexity of the device. Another small robot was presented in (Sorndach et al., 2018), but its main drawbacks included cleaning time in a large solar farm and tilt angle.

In this article, a new photovoltaic array cleaning system that is cost-effective, self-powered, reliable, easy to use, and durable is introduced. After completing all mechanical, electrical, and electronic works We started building a prototype. We want to state that most of the system components are refurbished or recycled.

1.1 Automatic cleaner for photovoltaic panels

Even the accumulation of small dust on a single plate reduces the efficiency of producing electricity. For this reason, the surface of the plate should be kept as clean as possible. Current human-based solar panel cleaning techniques are a waste of time, water, and energy. Solar panel cleaning has not been run automatically, so it is necessary to build automatic cleaning devices that can easily clean and move the glass surface of photovoltaic panels. Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

1.2 The aim of the research

The purpose of this study is to develop an effective photovoltaic panel cleaning robot in a group and monitor the status of photovoltaic panels using dust sensor and light sensor techniques. The measurable objectives for this project are as follows:

A. To design and produce an efficient automatic cleaning system for photovoltaic panel arrays;

B. to develop a faster and more reliable robot cleaning mechanism;

C. to develop a fully functional dust control device.

- **Scope of the search**

The scope of the study is to produce and improve a solar panel cleaning robot system using Arduino UNO which can monitor the surface condition and output parameters of solar panels. So, the project scopes are:

- Use Arduino UNO as the main system.
- Using two stepper motors as the movement of the cleaning robot and cleaning brushes.
- The automatic cleaning system can clean more than one photovoltaic panel.

Use the dust sensor to monitor the status of the photovoltaic panels and take the appropriate decision.

1.3 PV energy efficiency

The efficiency of a solar PV panel is measured by the panel's ability to convert sunlight into usable energy for the benefit of humans. Maximum efficiency = {(maximum power output) / (incidence radiation flux * collector area)} * 100.

2. Methodology

To prevent the performance and efficiency of the modules from declining as dust, grime, and debris build up on their surface, cleaning mechanisms are designed and installed in solar arrays. Therefore, the device must be sufficiently cost-effective to enable quick recovery of the initial investment through increases in panel output power. The primary design principles, aside from the financial implications, include minimal human involvement in the operation, optimum cleaning, and durability in arid environments like dust, strong winds, and high temperatures. to function as a self-cleaning component that lowers the effects of pollutants without using water. To assess the system's performance in the actual world, a prototype was made.

2.1 system block diagram

Figure 1 shows the block diagram of the proposed design. A microcontroller at the Centre of the system reads and processes data from numerous sensors to keep track of how the thing is working. Here, a single-board microcontroller called Arduino UNO is employed. Open source prototyping platform Arduino offers its users a variety of services, including simple-to-use hardware and software. It enables users to control different outputs and components and is simply attached to a variety of sensors. Arduino is the best option for this application because of its ease of use and affordable, accessible platform. On the mechanism, light and dust detection sensors are installed in strategic locations to track the amount of dust buildup on the PV panel surface. The microprocessor triggers various motors based on the values read by the sensors.

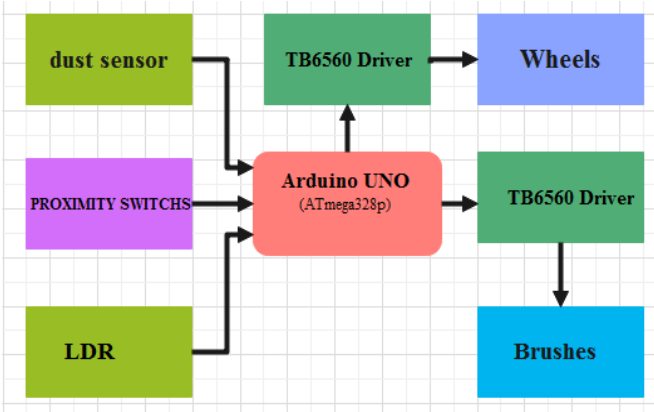

Fig -1: shows the block diagram of the proposed

2.2 Discussion and Calculation

The projected outcomes of energy production with and without the usage of a solar panel cleaning system are displayed in the following table:

Table -1 The following table shows the expected results of power generation without using the PV panel cleaning system:

Days	Before Cleaning Dust			After Cleaning Dust		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
Saturday	16.51	1.2	19.81	17.88	2.13	38.08
Sunday	16.89	1.33	22.46	18.06	2.2	39.73
Monday	17.16	1.4	24.02	18.14	2.25	40.82
Tuesday	17.58	1.7	30.69	18.28	2.44	45.34
Wednesday	18.05	1.66	29.96	18.58	2.38	43.51
Tuesday	*17.94*	*1.6*	*28.88*	*18.43*	*2.41*	*44.42*

There is a 10% energy drop when the PV panels are tilted. Additionally, the loss increases to roughly 40% when the plate cannot be addressed. We can completely comprehend that everyday cleaning is very significant by looking at the schedule

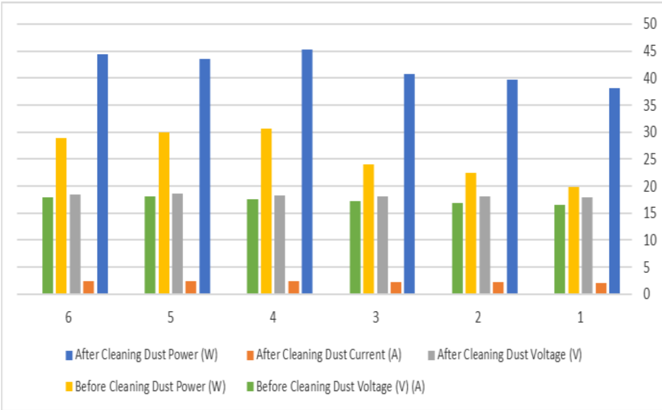

Chart -1. Solar panel I-V characteristic

Characteristics of solar panels

Several experiments have been carried out on cleaning dusty PV panels to evaluate the effectiveness of the proposed PV panel cleaning robot. In these tests, the flour was used to simulate the dusting of the photovoltaic panels. The PV panels under test were tested by measuring their voltage and current under different conditions: initially before cleaning (in a dusty condition), and after the dust cleaning process.

Fig -2: Selected design for PV cleaning system

Figure 2 shows the complete setup of the robot for dry cleaning of PV panels. The robot moves forward at 250 revolutions per minute when the light sensor is activated. In addition, the dust sensor is triggered and starts reading the dust density. The robot starts moving and continues to move forward if the dust density is greater than 40 micrograms. The microcontroller receives a signal from Limit Switch 1, which causes the robot to reverse the rotation so that it moves backward. After reaching the other end of Limit Switch 2, the robot stops its reverse motion and resumes moving forward. Until the robot is turned off, this process is repeated.

3. CONCLUSIONS

In this paper, a robot for cleaning solar panels has been constructed in its entirety. It emphasizes how the effectiveness of the PV systems is impacted by dust, filth, pollen, sea salt, and bird droppings. The performance and efficiency of solar panels are significantly impacted by dust. Peak power generation may be reduced by up to 20% to

40%. Power loss was noticed as a result of dust buildup on the panels, and robotic cleaning techniques can help. The solar panels' ability to generate electricity has grown as a result. A few benefits of this method include simplicity of maintenance, affordability, and reduced power consumption.

Finally, this cleaning robot can help to overcome the decrease in peak power generation.

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