ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)

Vol. 8, Issue 7, July 2022

SolarPanel Dual Management System

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***Abstract*—Solar Energy is a renewable source of energy and it is easy to extract electric energy from it. But many factors such as dust deposition, size of solar panels, affect the efficiency. Mainly, the deposition of dust on the surface of the panel reduces the output power. At present, regular manual checking is required to monitor the accumulation of dust on the solar panel that causes a drop in output voltage. Current theft prevention system has limitations like alerting the consumer even when insignificant objects pass through the mechanism installed. This inefficient performance may lead to theft and loss in investment. If above-mentioned problems are given proper attention, we can avoid theft and prevent loss of power generated from solar panels. This paper gives a detailed review on Solar Panel Dual Management System which can detect unauthorised activities and automates the detection of dust deposition on solar panel.**

Keywords: solar panel cleaning, dust deposition, yield increase, theft prevention.

I. INTRODUCTION

About 2% of the world's power necessity is satisfied by solar power generated using solar panel. The usage of solar panels is found increasing, since it is a renewable resource and it is a non-polluting power generating mechanism. Many organizations, companies and industries use solar panel since it can save a big part of expenditure for electricity. Nowadays, not only organizations and industries use solar panel, but also many individuals use solar power.

The solar power is generated from the solar cells which is present in the solar panel. The solar panel has a lot of these photo-electric cells, so that the output power generated is high enough. A lot of money is invested in the process of installation of solar panel. Since it is costly, it wouldn't be pleasant to hear that it got stolen. This not only results in loss of investment but also results in loss of one's source of power.

The pollution level is increasing many folds day by day. The solar panel needs to be kept in well sun-light-exposed area. There are many chances of dust storm, air pollution or fog to occur in those areas, where solar panel is kept. Hence, the solar panels are prone to deposition of dust particles on their surfaces. These dust particles have the nature of reflecting the light falling on them. If those dust particles accumulate on the solar panel, they reflect the sunlight which stops the light from reaching the photo-electric cells. This results in loss of output power.

Solar Panel Dual Management System helps in notifying the user when there is an unauthorized activity and also notifies the user about the right time to clean the solar panel. The movement of the solar panel is constantly monitored, and the user is notified when there is an unauthorized activity. The dust deposited on the solar panel is calculated in terms of concentration and the output power is also calculated. With these values, the user can be notified to clean the surface of the solar panel whenever necessary.

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ISSN (PRINT): 2454-9762
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II. LITERATURE SURVEY

Abhishek Rao and his team [1] had conducted a study on the effect of dust on the solar panel performance by plotting the I-V characteristics graph for the identical panels subjected to the same condition of isolation and ambient temperature. One of the panels had its surface covered with dust while the other had a clean dustless surface. It was found that the panel that had dust on its surface had shown a drop in the output current which is reflected to the output power of the panel.

Rohit Pillai and Monto Mani [2] had done some more study on the I-V characteristics graph with different types of particles and declared that the installation of solar panels is primarily influenced by the geographic location and installation design to maximize solar exposure. They concluded that the output power reduces with increase in dust deposition.

Neil S.Beattie and Nicola M.Pearsall had done laboratory investigation on dust deposition on glass surface. When light is incident on the dust deposited glass surface, the intensity of light that comes out at the other side is decreased. The same phenomenon is applicable to solar panels.

Motasem Saide and his team [4] had done experiments about the accumulation of dust on the solar panel. Under different experimental conditions, they conducted the experiments and found that the dust particles scatter the light falling on them. This reduces the efficiency of solar panels.

B.S.Panwar and his team [5] studied the performance of the PV module using I-V characteristics curve. They have installed PV modules in Noida (India) which is a Tropical Savanna Region which has three main seasons: Summer, Winter and Monsoon, for nearly one year. They have calculated different parameters of the PV module such as Power, before cleaning and after cleaning the PV module's surface and found that the PV modules after cleaning produced high efficiency in the output when compared to before cleaning.

Athar Hussain and his team had studied the effect of dust deposition on solar panel with different dust samples. They had used artificial light sources with different intensities and different dust samples to study the effect of dust on the output power. They plotted power vs weight of dust sample graphs and calculated the power loss.

BrahimAïssa and his team [7] investigated different dust particles that deposit on the Solar Panels and their influence on photovoltaic performance. They installed PV modules of different materials in their Solar Test Facility Centre located at city of Doha (Qatar). They have plotted the I-V characteristics curve and concluded that there is a reduction in the output power produced caused by accumulation of dust.

Merola A proposed a method of using the GPS. The GPS module runs periodically and checks the user-set coordinates with the current coordinates. When there is any change in the coordinates, the microcontroller deactivates the PV module and stops the further power production.

Wasif Ali Khan and his team [9] proposed a low power auto shut-off and non-destructive system for photovoltaic (PV) modules for security of the module. The position of PV module is stored in microcontroller as initial reference value and microcontroller uses this value to control the power supply. Power generation of PV module will be auto shut off and cannot be reactivated by unauthorized person when the position of it changes. On recovering authorized person can reset the value and can restore the module to old working condition.

Andreas Schneider [10] proposed a method using transponder and transceiver. The transponder is fixed near the PV modules which transmit the data about the presence of the PV module while the transceiver reads and decodes the data sent by the transponder. When transceiver did not receive any signal from the transponder, the anti-theft alert system activates.

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Yotham Andrea and the team [11] studied the effect of dust and temperature on the polycrystalline PV module in an industrial environment in a tropical region, Tanzania. Different dust particles from different types of environments such as fertilizer, gypsum and coal mine industries are used under different solar intensities. The results indicated that dust accumulation on the silicon photovoltaic module negatively affected output power.

Weiping Zhao and his team had studied the dust accumulation and its effect on solar PV performance. Their study concluded that dust of 4g/m2 can decrease output power by 40%. [12] analyzed that the reason that every family member will be employed and busy, the health monitoring of elderly people and patients has become very crucial. In the proposed methodology caretakers can get the information of the temperature and the pulse rate of the people being monitored at home.

Katarzyna Styszkol and his team [13] conducted a study for evaluating the effects of dust deposition on the PV module during non-heating season in one of the most polluted European cities, Kroków. They correlated the particle deposition on the PV module with the air pollution and concluded that pollution also causes the deposition of dust on the PV module which in turn can result in decreased output power.

Buvaneshwari and her team [14] investigated the effect of dust settlement on the efficiency of photovoltaic modules. To gain deeper insight into the problem, physical properties of the collected dust were examined by scanning under an electronic microscope. The results show a constant power loss between 3% to 4% for the optimal tilt angle and regular rainfall and rainfall is effective on only cleaning large dust particles.

Marek Jaszczur and his team [15] conducted an experiment where solar photovoltaic panels tilted at angles 15° and 35° were exposed to atmospheric conditions for the period of eighteen months. It was observed lower tilt angles promote dust accumulation on the surface and wind and rainfall usually promote the removal of dust particles from the surface. However, rainfall not always aids the cleaning of panels. It was only rainfall whose intensity was at least 38 mm/hr that was sufficient to remove dust particles from the panels.

Rashid Ahmed Khan and his team [16] studied about dust particles size and their effect on solar panel performance. They observed that particles of diameter less than 1um are more likely to accumulate quickly on surface when compared to particles of diameter greater than 5µm. They concluded that smaller particles lead to a considerable drop in output power as they merge to form a single large particle and larger diameter particles are porous and would permit sunlight partially and deflect partially resulting in less efficiency. [6] brought out present disclosure which provides an electrocardiogram remote monitoring system based on artificial intelligence including a patient 5 monitoring unit with a sensor system and a microcontroller .

It is found that the dust particles scatter the sunlight that is incident on them and the intensity of light photon available for solar energy conversion is low and hence the output power is decreased. We can finally conclude that the decrease in efficiency can be prevented by scheduled cleaning and suitable methods to prevent the clustering of dust on the surface of the solar panels. The existing theft prevention methods utilize more power and needs high investments.

III. PROPOSED SYSTEM

The proposed system consists of mainly two parts i.e., in the first part we monitor the position of the solar panel and directly send the data to web server. In the second part we measure the concentration of dust deposited on the solar panel and the output power. If the output power is gone below a threshold, the system alerts the consumer to clean the solar panel using the web server in the form an e-mail.

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A. Architecture

The Various Devices that are connected and interfaced with each other can be referred from the Architecture diagram from Fig. 1.

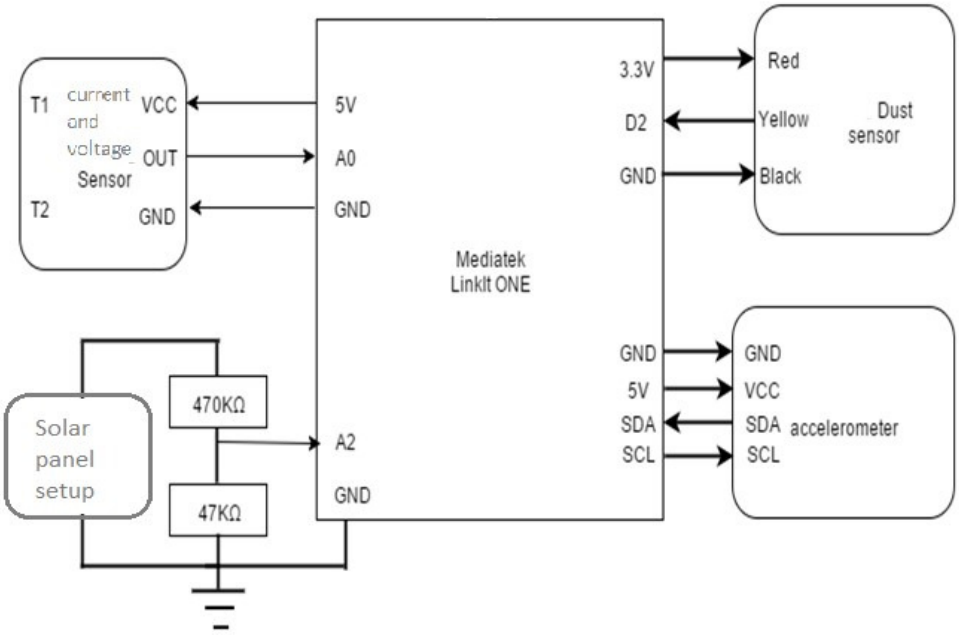

Fig. 1. Sensor Interfacing with LinkIt One

The LinkIt One Board acts as an interface between all the hardware components i.e., Solar Panel, Grove Dust sensor, Grove Accelerometer, Current sensor, Voltage sensor. This LinkIt One Board is then connected to Ubidots Web Server via Wi-Fi and the board transmits the readings from these devices to the Server continuously. The user can check the recorded information frequently in the Ubidots Web Server.

B. Theft Prevention

A Grove Accelerometer is attached to the solar panel. The Accelerometer is then interfaced with LinkIt One Board, which is linked to the Ubidots web server. The Accelerometer is used to measure acceleration of the solar panel with respect to acceleration due to gravity (g=9.8 m/s2). At first, the initial reading of the accelerometer in all three axes is noted. At an instance, the reading of the accelerometer is noted. This value is compared with the initial reading. If no one tries to move the solar panel, it will have no acceleration and accelerometer would not detect any change in any of the three axes. Hence the comparison with the initial reading returns false. This result is sent to the web server to which the LinkIt One Board is linked. Since the result of comparison is false, the web server identifies no unauthorized activity and hence continues to carry on its job.

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If there is any unauthorized activity, the solar panel is subjected to acceleration. This acceleration is reflected in accelerometer with a change in the values of three axes. Then these values are compared with the initial values. The result of comparison yields true which indicates the acceleration of solar panel. This result is sent to the web server. The web server detects that there is an unauthorized activity and sends the user an alert message.

C. Dust Maintenance

The Grove Dust Sensor, Current Sensor and the Voltage Sensors are attached to the Solar Panel. These are interfaced with the LinkIt One Board which is linked to the Ubidots web server. The dust sensor calculates Low Pulse Occupancy (LPO) time which means the time for which the dust passes through the dust sensor. From the Low Pulse Occupancy time, we indirectly calculate the concentration of dust in pcs/0.01cf (particles per hundred cubic feet). Simultaneously, the current and voltage sensors calculate the output power of the solar panel. These values are sent to the web server to which the LinkIt One Board is linked. When the concentration of dust rises above a threshold value (say 1500 pcs/0.01cf), and when the generated power drops beyond the threshold value (say 1.5 W), the user will be notified about cleaning the surface of the solar panel. [3] brought out an invention which discloses a system and method of representing health data of a patient. The invention comprises of a device 100 including a display module 102, a three dimensional sensor camera 101, a processor 107, a temperature sensor, a plurality of modules configured in the device including a template module 103, a healthcare provider module 104, a patient module 105, a processor 107, a server 108 connected to the device 100. [8] brought out present disclosure which provides a system for monitoring and controlling farming using drone technology comprising a drone system for monitoring the farm and transmitting information and a ground control system for controlling the drone system and receiving the information.

D. Experiments and Results

We conducted a couple experiments to show the degrading effect of dust and sand on the overall performance of a solar panel from which the need for the proposed SPDMS system can be realized.

(i) Voltage vs Dust Concentration Graph

In this experiment, we are measuring the concentration values of dust deposited on a 12V solar panel for 7 consecutive days and the respective output voltage produced, tabulated in Table 1. The dust concentration values are plotted against the corresponding output voltage on the graph. The percentage of voltage drop is calculated for each day using the formula:

$$\text{Percentage of voltage drop} = ((12-V)/12) \times 100$$

where, V is the output voltage produced on each day

TABLE I: VOLTAGE GENERATED DURING DIFFERENT CONCENTRATIONS OF DUST

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Day	Dust concentration (pcs/0.01cf)	Output voltage V (V)	Voltage Drop %
1	112.784	9.7	19.6
2	225.42	9.5	20.8
3	338.353	9.35	22
4	451.13	9.26	22.8
5	565.92	9	25
6	676.73	8.8	26
7	920.32	8.2	31

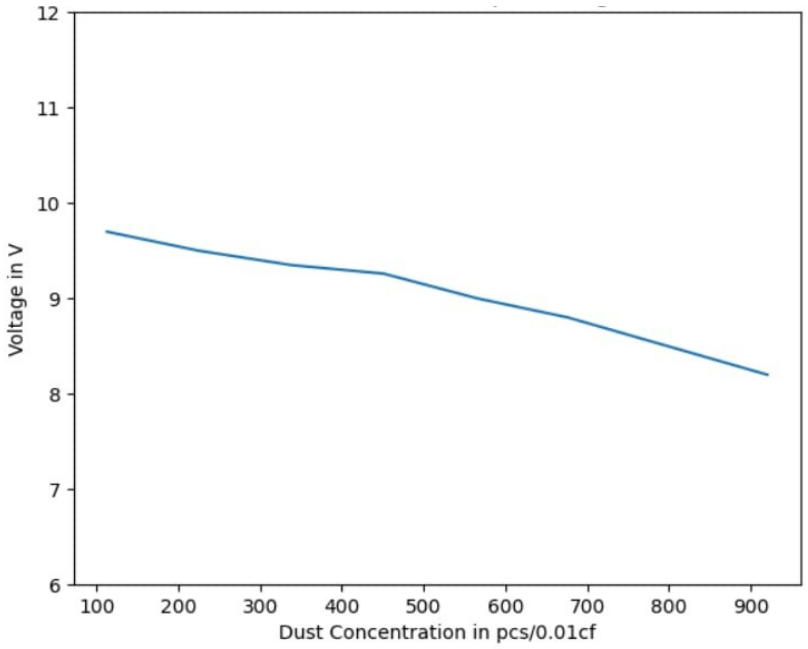

Fig. 2. Effect of Dust on Output Voltage

(ii) I-V curve

In this Experiment, an external load is connected in the form of a resistance to the solar panel. The resistance is varied to obtain different current and voltage values to display proper working of the system. For each resistance

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value, the current and voltage values of the clean solar panel is noted. Now a measured amount of dust is spread over the surface and then the current and voltage values are noted. The recorded values are given in Table 2.

TABLE II: CURRENT & VOLTAGE MEASURED DURING DIFFERENT CONCENTRATIONS OF DUST

Dust Concentration	Clean Panel		0.048g/cm^2		0.071g/cm^2	
Resistance Ohm	Current A	Voltage V	Current A	Voltage V	Current A	Voltage V
2	0.45	0.9	0.4	0.8	0.38	0.76
4	0.39	1.56	0.35	1.4	0.33	1.32
6	0.33	2	0.31	1.86	0.28	1.68
8	0.3	2.4	0.26	2.08	0.23	1.84
10	0.27	2.7	0.21	2.1	0.17	1.99
12	0.23	2.8	0.19	2.28	0.11	2.17
15	0.19	3	0.16	2.4	0.1	2.32
18	0.18	3.3	0.13	3.11	0.09	3.04
25	0.16	4.1	0.1	4.02	0.07	3.89
43	0.11	4.8	0.08	4.7	0.06	4.63

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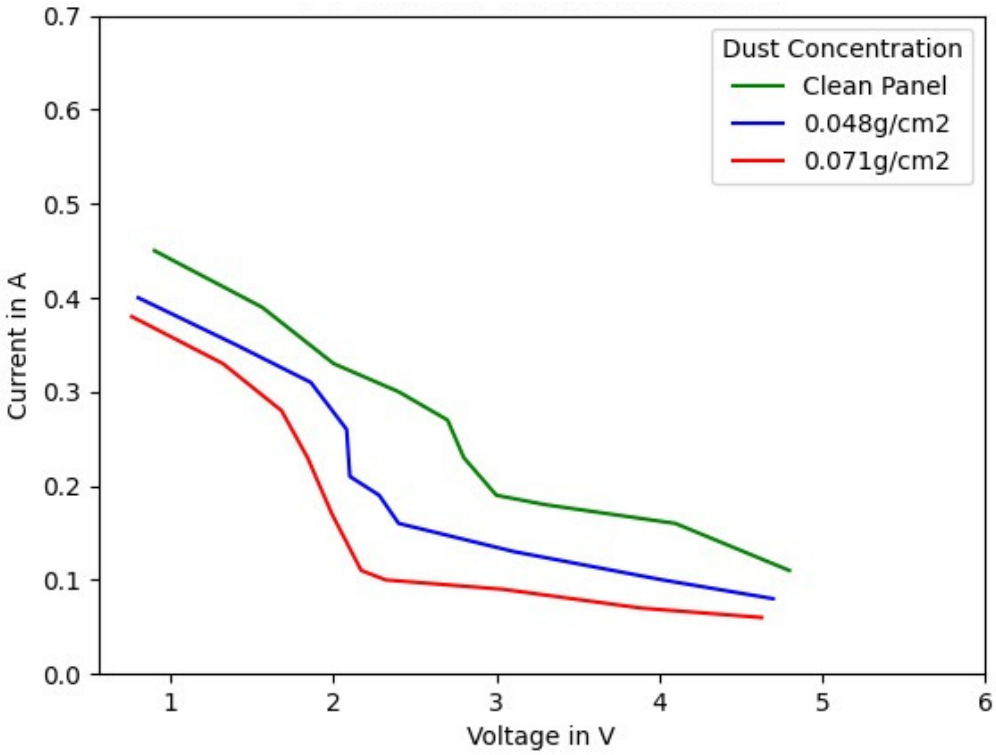

Fig. 3. I-V Curve for Variable resistance

From experiment 1, we infer that the concentration of dust increases day-by-day, and the respective output voltage decreases accordingly. This decrease in output voltage causes increase in the calculated voltage drop percentage. The decreasing slope in Fig. 2. proves the above discussion.

In the experiment 2, the current and voltage values of dust exposed panels are low when compared to that of clean panels. We may also infer that increase in concentration of deposited dust, decreases output current and voltage values, resulting in output power loss. This has been proved in Fig. 3., where each curve reflects the output current and voltage values of clean and dust exposed panels. The I-V curve of dust deposited panels are below the I-V curve of clean panel. From this, we can conclude that the dust deposited on the surface of the solar panel will result in the loss of power and the loss in power increases as the dust deposition increases.

IV. CONCLUSION

Our proposed project aims to design and implement a system for theft prevention and maintenance of solar panel. As the utilization of solar energy is increasing day by day, there should be an efficient benefit for it. Due to pollution, there is wastage of energy because of deposition of sand and dust on solar panel. So, there is always a need to clean the solar panel over a period. And theft cases of solar panel are also increasing day by day. So, our project provides a solution for theft prevention for Solar Panel and indicates the time for maintenance of the same.

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ISSN (ONLINE): 2454-9762
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