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AUTONOMOUS LOW POWER IoT BASED SOLAR PANEL CLEANING SYSTEM

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ABSTRACT

In a world of increasing population, and increased usage of devices, factories, electric cars, the rise of electric power consumption is inevitable. Currently, the energy industry is heading towards a more environmental friendly means of producing electricity. Solar power plants can have installed powers from tens of kilowatts up to hundreds of Megawatts. It is shown that based on the irradiate power of the sun, on the efficiency of solar cells (of 10-20%) and on the efficiency of conversion of DC to AC, it takes on average about 1.5-4 hectares (dependent on the geographical and meteorological position and conditions) for producing 1MW of electrical power. Although their wide availability and ease of use, solar panels are affected by one of the most common environmental factors: dust. Dust accumulation has a considerable effect on the power production, reducing power output down to 50% or even less. To overcome the effect of particle accumulation on solar panels, different kind of cleaning methods are used, depending on the dimensions of the solar plant. Cleaning by using human operator, semi-automated cleaning system (that requires the intervention of human operators but the operation itself is done automatically) or fully automated cleaning systems (that automatically asses the conditions and the necessity of the cleaning procedure). In this paper, an autonomous solar panel cleaning system is developed which can be controlled through wireless communication. The system uses several sensors to analyze the working of solar panel and rolling brushes are used to clean the panel.

KEYWORDS: Solar power, Autonomous, Solar panel, Wireless- communication.

I. INTRODUCTION

In a world of increasing population, and increased usage of devices, factories, electric cars, the rise of electric power consumption is inevitable. Currently, the energy industry is heading towards a more environmental friendly means of producing electricity. The most common types of eco power plants are photovoltaic power plants, wind turbine power plants and micro-hydro power plants or tide power plants. Micro hydro power plants depend on river flows flow rate, falling distance, volume rate, wind power plants depend on wind speed, duration and frequency of winds, and tide plants depend on the tides.

Fig. 1 PV Plant

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The opposite of the condition dependent power generation methods mentioned earlier solar power plants require light, a condition that can be satisfied in many use cases. Solar plants can be operated on-grid, off grid, with or without storing the produced energy and can serve applications that are ran during the day (factories) or they can just compensate the consumption of large energy consumers, reducing costs with electricity. They are widely used for home appliances or as power production stations for energetic power systems. To overcome the effect of particle accumulation on solar panels, different kind of cleaning methods are used, depending on the dimensions of the solar plant. Cleaning by using human operator, semi-automated cleaning system (that requires the intervention of human operators but the operation itself is done automatically) or fully automated cleaning systems (that automatically asses the conditions and the necessity of the cleaning procedure). In this paper, an autonomous solar panel cleaning system is developed which can be controlled through wireless communication. The system uses several sensors to analyze the working of solar panel and rolling brushes are used to clean the panel.

In chapter II we will present existing solutions and current research in the field of solar panel cleaning. Chapter III will present the proposed system block diagram and its working. Chapter IV is dedicated for the testing and result of the cleaning system. Future scope for the work will be presented in chapter V and in Chapter VI we will conclude the most relevant aspects regarding our solution.

II. LITERATURE SURVEY

A number of methods for dirt and dust removal from PV panels and other optical devices have been developed and tested. These are passive self-cleaning, active (manual or automated), and electrical (electrostatic and electrodynamics).

In a review of self-cleaning methods of solar PV cells, classified cleaning methods into four categories: natural means, mechanical means, self-cleaning nano-film and electrostatic means. Natural removal of dust includes wind, gravity, rain, and dew. To effectively utilize gravity, PV arrays have to be turned vertically or inclined at high angle during the night time, rain-fall, or during dust storms. This requires powered (and possibly automated) turning mechanisms. Mechanical means include brushing (as in windscreen wipers), blowing, vibration, and ultrasonic driving.

The first robotic system for cleaning photovoltaic panel arrays for large scale solar PV plants was developed envision that such devices could be equipped with sensors to inspect the PV panels and call for maintenance when needed. The vibration and ultrasonic methods have been investigated but still very little results were reported.

The self-cleaning Nano-film coatings are made of super-hydrophobicity (TiO_2) or super-hydrophobic materials. Because of its nature, the former film material is not applicable to desert conditions. It did work, though, in Singapore where, over 12 weeks outdoor tests conducted on solar cells showed that super-hydrophilic glass exhibits self-cleaning and antireflective effects, leading to only 1.39% drop in PV cell efficiency compared with super-hydrophobic film for which a 2.62% drop in efficiency was recorded. The super-hydrophobic film material increases the contact angle of the water droplets such that their wettability is reduced and they roll off the surface taking with them the dust.

Electric technique has been developed in connection with protection of PV panels used in space vehicles for exploration missions to the Moon and Mars. The method is based on the action of the electrostatic and electrophoretic forces produced by travel-wave electric curtain. The frequency of cleaning should be determined based on economic and operation factors such as the cost of cleaning, cost of adding more PV modules needed to compensate for loss in power during the periods in between cleaning operations. In this paper a portable automated system for solar panel cleaning is proposed, in which a robot is fixed to the solar panel and moves on the panel while cleaning it. This robot utilizes a dry system of brushes to clean the solar panels, and no water is wasted in the process. A more detailed discussion about the proposed robot cleaning system is discussed in the following sections.

III. OVERVIEW OF THE SYSTEM

The cleaning system design main aim is its ability to clean multiple panels in a solar farm using a single robot. Such a system is considerably much efficient than having multiple robots in the same farm working simultaneously. In order to facilitate the robot transfer from one panel to another, the system consists of two main parts; the first is the cleaning robot and the second is the full frame.

The autonomous solar panel cleaning system is working based on several sensor outputs. To detect the output power difference from the solar panel, a digital voltage sensor is used. When the output decreases below a threshold level, the digital ambient light sensor value will be measured to determine whether its night or day. Then digital rain sensor value is measured to deter- mine whether it's raining or not. If its day time and not raining, then there is a chance for something is blocking the solar panel from sun light. So the roller will start to work for cleaning. Here DC motors are used to control the system and brush movements, two motors for each, and an Arduino UNO unit with ESP8266 (Wi-Fi module) is used to control the motors. The sensor outputs and cleaning progress are reported to user website through internet. There will be switches in website to control the cleaning system remotely.

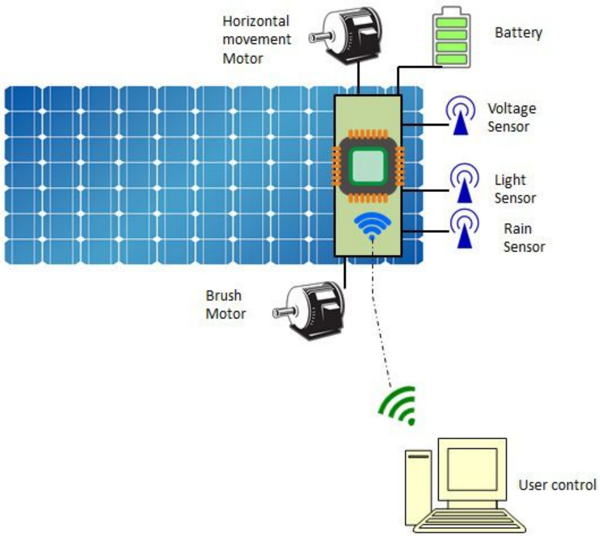

Fig. 2 Block diagram of the system

The cleaning robot, as shown in figure 3, travels the entire length of a solar panel while cleaning the panel in the process.

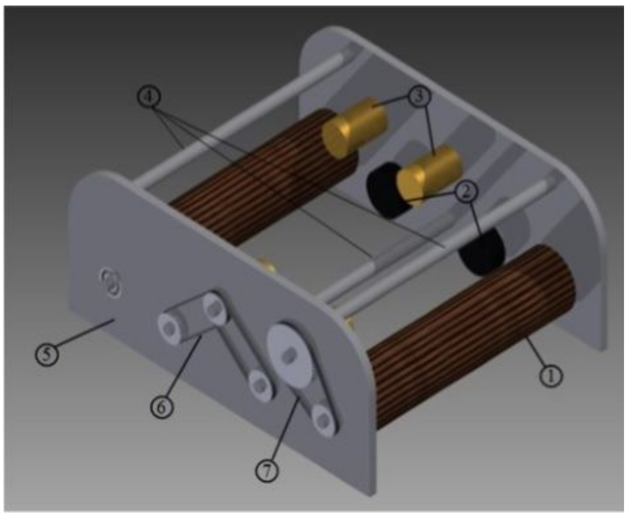

Fig. 3 The cleaning robot system (1. brush, 2. wheels, 3. motors, 4. connecting aluminum rods, 5.side panel, 6. wheel driving system, 7. brush driving system)

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The main advantage of this symmetrical design is that it can be easily modified to handle wider solar panels as illustrated in fig 4. The connecting rods and brushes can be modified with the same driving system.

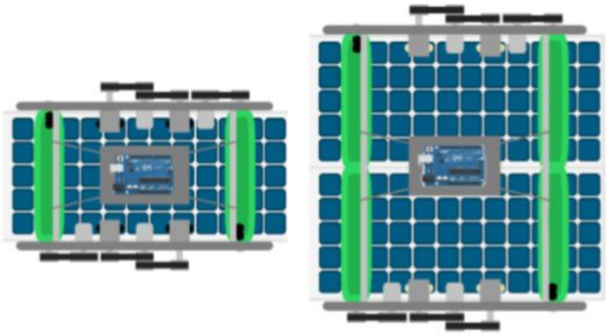

Fig. 4 Adapting the system for different solar panels

IV. EXPERIMENTAL TESTING AND RESULT

The fully integrated robot cleaning system is shown in Figures 5 and 6. During cleaning, the robot moves along the panel length while covering the whole panel width. The box in the middle contains the micro-controller to control the motors and sensors. Sensors(Limit switches) installed at both sides of the robot, signal the reach of panel edge at which point the robot returns back to the starting position.

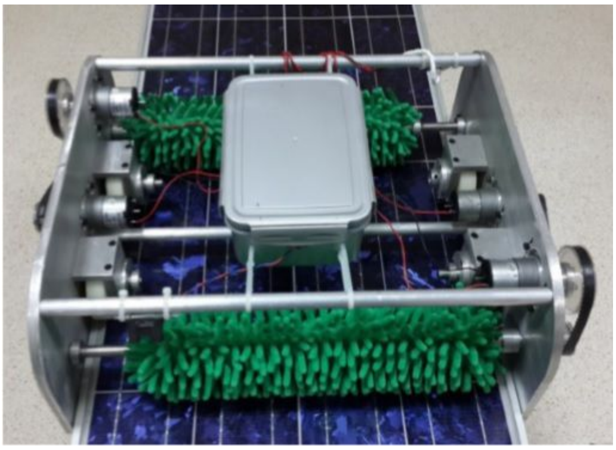

Fig. 5 Panel integrated cleaning system

To validate the robot designed operating capabilities, several experimental testing scenarios were carried out focusing on the effectiveness of the robot in both static and dynamic modes. First, the solar panel was covered with some amount of sand (see figure 7) to simulate dust accumulation process. Then, the robot was launched to clean the panel surface as shown in figure 8. It should be noted that after two passes, the robot was able to clear more than 80% of the surface and repeated tests show the same results.

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Fig. 6 Direction of cleaning system.

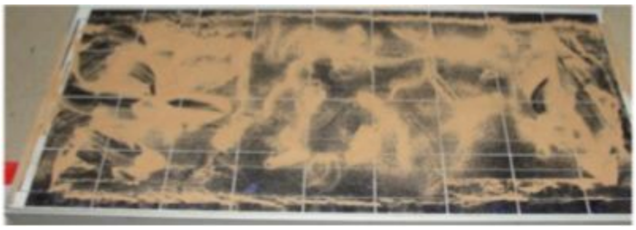

Fig. 7 Sand depositions

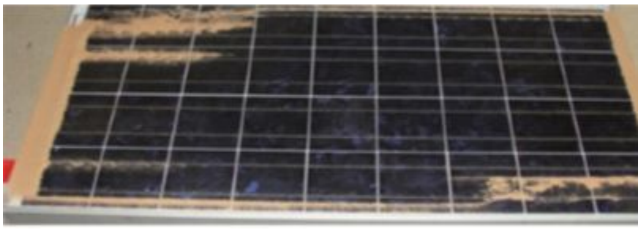

Fig. 8 Cleaned panel

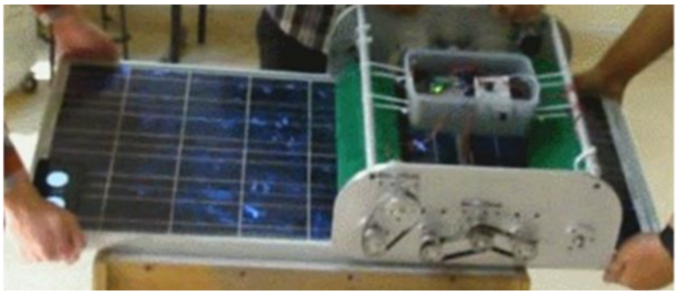

Fig. 9 Functionality test

V. RECOMMENDATIONS FOR FUTURE WORKS

Although the test results show the robot PV panel cleaning, it is believed that there are a few ways in which the design can be improved to achieve its autonomous state. It is proposed that future work should concentrate on replacing the automated cart system by a flying mechanism such as quad rotor. A quad rotor can be mounted onto the robot cleaning subsystem so that it can fly from one solar panel to another. This system can then be controlled remotely or fully programmed for outdoor environment, as illustrated in figure 10. The rotors may be arranged such that their downwash will enhance the system cleaning operations.

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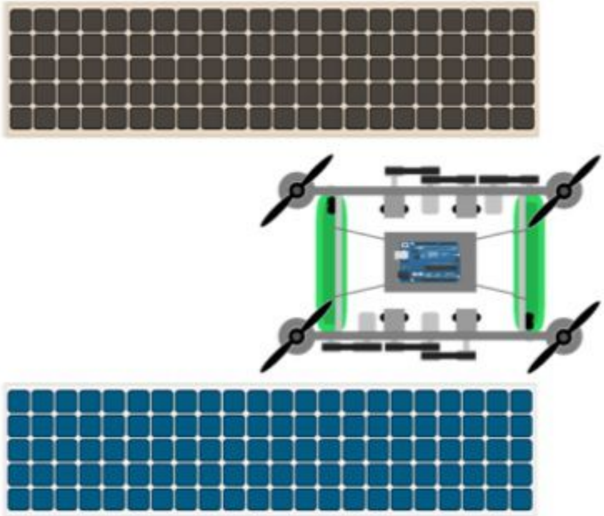

Fig. 10 Autonomous flying solar panel cleaning system.

VI. CONCLUSION

Dust accumulation on solar panels can significantly reduce their power output. The robotic system paper is a simple way to avoid this problem effectively. Although promising results were obtained from the prototype, further improvements and testing are required in order to create a more robust and autonomous cleaning solution.

VII.ACKNOWLEDGMENT

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