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Development of an Automatic Cleaning System for Photovoltaic Plants

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***Abstract*—This paper aims at developing a low-cost automation system to maintain the efficiency of solar panels connected in an array by providing an on demand cleaning. Wireless Sensor networks has been implemented to collect the data from individual panels. Monitoring data and information trends then will be used to trigger a robotic system to clean the surface of unclean panels.**

Keywords: PV panel, cleaning, Monitoring PV panels

I. Introduction

The power output generated by PV arrays is known to suffer power efficiency losses over time due to accumulation of dust and other dirt. In the Middle East, India and Australia, PV power output is significantly affected by the accumulation of dust on the surfaces of PV arrays.

Solar energy generation needs to be maintained to reduce the power loss from the PV panels. The lack of maintenance of the PV panels can reduce the amount of energy generated by each panel. The energy reduction due to dust can be very serious. Lack of maintenance in dusty environment reduced the efficiency of the solar panels by 32% to 45% [1, 2]. Bird dropping and tree leaves may cause an obstacle in surfaces of panels. These phenomena usually will not be noticed in high scaled power generation sites unless the obstacle cause a major output shortage in the site. Continuous monitoring the energy output for individual PV panels will improve the awareness from the situation of panels and hence increase the overall efficiency of the system. Monitoring the output of individual panels helps reduce the power loss from an individual panel in an array which only can be seen by a slight change of power generation that can be mistaken by influence of the climate change.

Often multiple PV panels feed into an array. Therefore it is not easy to determine the individual efficiency of a single PV panel attached to an array and note the amount of power that is generated.

There are several methods proposed and applied to clean surface of solar panels.

Heliotex is proposed an automatic cleaning system that washes and rinses solar panel surfaces by splashing water and soap on panels. The cleaning system can be programmed whenever it is necessary depending on the environment [3]. The system is very effective however it requires continues and reliable supply of water which is not applicable for most cases.

Electrostatics cleaning (Harvesting electricity) is first developed by scientists to solve the problem of dust deposits on the surfaces of PVs located on Mars. This technology can also be used in dry dusty areas on Earth. Electrostatic charge material is used on a transparent plastic sheet or glass that covers the solar panels. Sensors monitor dust levels and activate the cleaning mode [3].

The dust is shaken off the solar panels when an electrically charged wave breaks over the surface material. The system is capable of cleaning 90 percent of accumulated dust in less than two minutes. Safety is a major concern that limits applications of this method to nonresidential area.

The other method is using robotized brushing systems. These systems are usually fixed and cover parts of the surface of solar panels. SunBrush is one of these method which is primarily designed for cleaning snow on PV panels. Utilizing this system has led to a 15-18% increase in solar panel efficiency. [4]. The disadvantages of using these fixed robotic systems are that they are expensive, and difficult to install over a large PV area.

This paper is aimed at designing a low cost automation system to clean multiple solar panel with one mobile. The system will be low cost and flexible and easy to implement for different size Photovoltaic power generators.

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II. DESIGN AND IMPLIMENTATION

The cleaning system has two modules. A monitoring system to determine unclean panels and a robotic device to perform the cleaning. The monitoring systems triggers the robotic device to start the process of cleaning.

A. *Monitoring System*

Output current of each PV panel has been monitored to evaluate the efficiency of individual panels in the array. Multiple PV panels are arranged in an array, usually in parallel connection. In order to monitor the performance of individual PV panels, a current sensor is dedicated for each unit. The current data then will be transmitted to the receiving unit for further investigations. Figure 1 is showing the schematic of monitoring system.

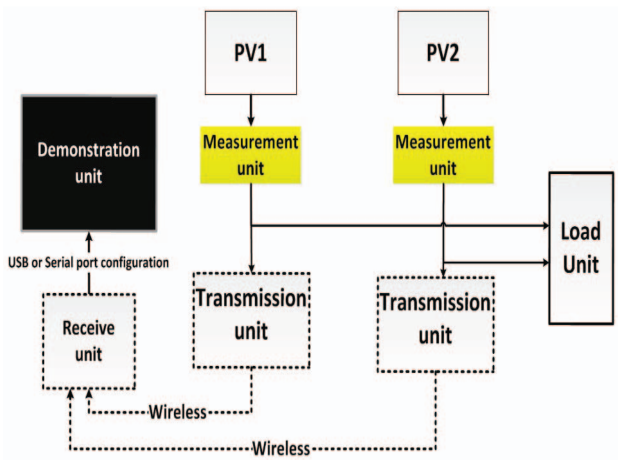

Figure 1 Schematic of the monitoring system

An Ardunino UNO micro controller has been utilized to pre-process the information using a current sensor. Details of the transmission and measurement system for PV measurement units is shown in Figure 2.

Current of the transmission each PV is processed initially using the Mico controller to verify whether it is higher than the threshold set-point value or not. If the current generated remains below the expectation for an hour, a warning signal will be transmitted to the receiving unit using the Zigbee boards. The data then will be transmitted to the central unit to trigger the cleaning robot. The threshold set-point varies to refract the change of daytime and also consider the solar profile of the site. The plan reduces the data transmission between measurement units and the receiver to absolutely necessary situation; and hence affectedly reduces the energy consumption of the monitoring system.

The central unit then may decide whether to trigger the cleaning request of affected panels. The triggering time is a function of number of affected panels and a minimum interval between cleaning operations.

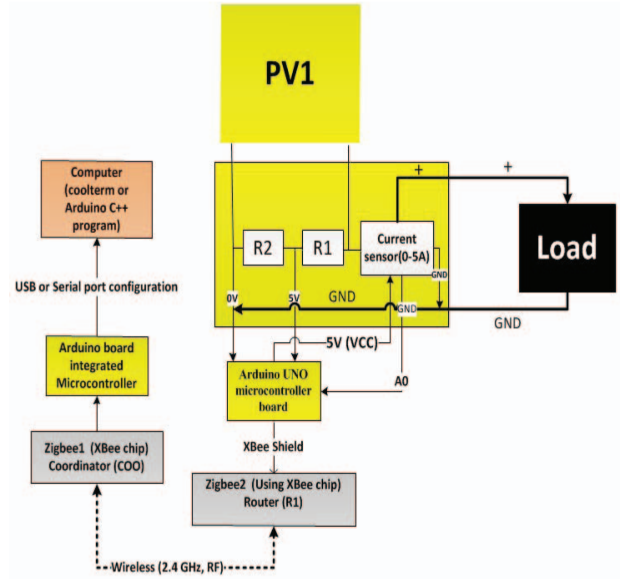

Figure 2 Schematic diagram of transmission and measurement unit for each single PV unit

Figure 3 is showing the current reading of a given PV.

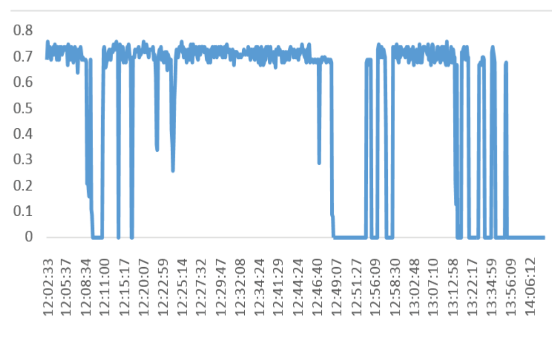

Figure 3 Output current of a given PV panel

B. *Robotic cleaning system*

A commercialized cleaning robot has been used to perform the mechanical cleaning tasks. The programme then has been modified to facilitate cleaning the sloppy surface of solar panels.

The system is set to start from the left bottom corner and end on the right side of the panel as shown in Figure 4. When the robot detected the end of the panel it returned to the starting point. It was either on the top right side of the panel or on the bottom right side when it finished. The robot then stopped and waited to restart to do the next run of cleaning.

The algorithm is designed to facilitate the movement of the robot as shown in Figure 4.

Figure 4 Cleaning pattern for the mobile robot

The cleaning algorithm of the Robot is shown in Figure 5. The PV cleaning system have used the original features of the cleaning robot for automatic charging and returning to the original location. The movement pattern of the robot has been manipulated to ensure the stability of the system while cleaning sloppy PV panels.

As shown in Figure 5, the moving pattern of robot changes as the touch sensors engage. Initially, when all the sensors are low the robot will drive straight. Then when the left sensor detects an edge, it will stop then turn to the right side for four centimeters or until the left sensor goes low. If the right edge engaged, the robot will do the same as explained for the left one. If the robot drives backward in three circumstances and the front sensor and the right sensor are high the robot will stop and drives back for 10cm and change to the left direction. And if the all three sensors are high the robot will stop drives back for 10cm and find a new route. Other situations have been shown in detailed in Figure 5. An example of maneuver of the cleaning robot while moving at edges is shown in figure 6.

The robot then find its way to the next panel and continue the process until reaching the edge of the last panel in the array.

In order to have a continuous operation, a physical path is required between PV panels. Otherwise the robot is only approach one panel and will go back to the central point after completing the cleaning operation of the panel. Locations of panels and the return path is given to a database to initiate the movement. The robot then follows a random pattern as illustrated in Figure 5.

III. Conclusion

A novel cleaning scheme for PV panels has been demonstrated. The cleaning system is operate whenever required and clean affected panels. A single robot should be able to cover good number of arrays. This scenario is cheaper than alternative methods as permanent instating is not required. In addition the system contributes the overall efficiency of the generation system as can addresses the affected panel immediately after generated current reduces below the threshold due to accumulation of dirt, dust and birds droppings.

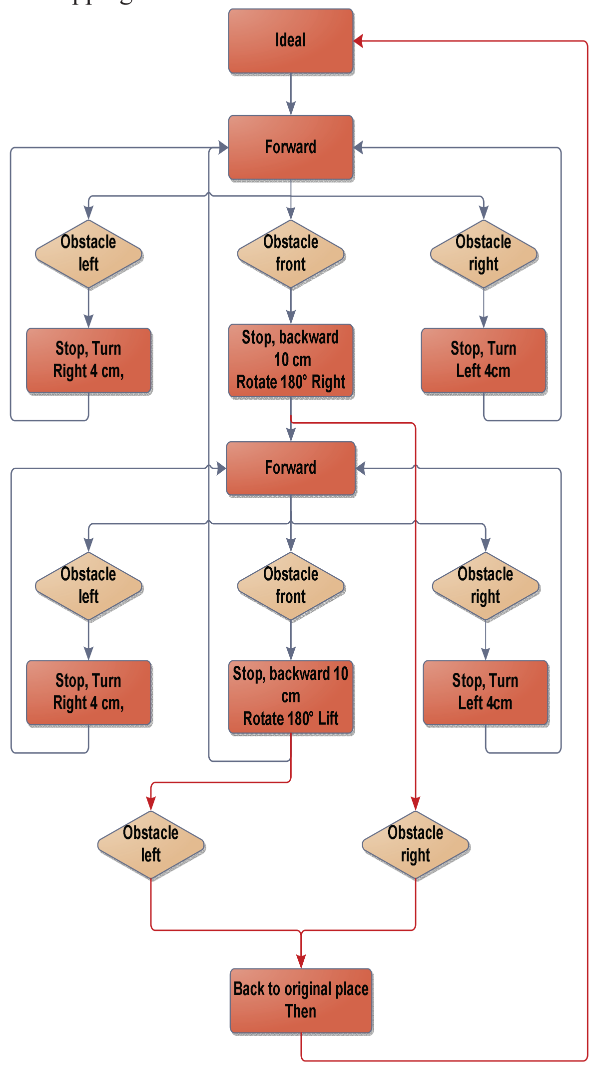

Figure 5 The searching path of the robot.

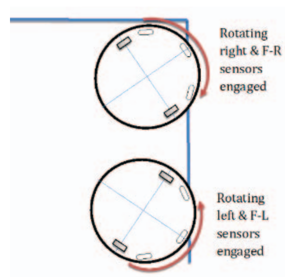

Figure 6 Operation of the cleaning robot on the edge of the solar panel

IV. Refrences

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