Microcontroller Based Automatic Cleaning of Solar Panel

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Abstract: The solar PV modules are generally employed in dusty environments which is the case in tropical countries like India. The dust gets accumulated on the front surface of the module and blocks the incident light from the sun. It reduces the power generation capacity of the module. The power output reduces as much as by 50% if the module is not cleaned for a month. In order to regularly clean the dust, a automatic cleaning system has been designed, which senses the dust on the solar panel and also cleans the module automatically. This automated system is implemented using 8051 microcontroller which controls the DC gear motor. This mechanism consists of a sensor (LDR). While for cleaning the PV modules, a mechanism consists of a sliding brushes has been developed. In terms of daily energy generation, the presented automatic-cleaning scheme provides about 30% more energy output when compared to the dust accumulated PV module (module kept stationary on ground).

Key words: Self-cleaning, Solar Panel, Transmittance, Dust Affects.

I. INTRODUCTION

Most of the applications nowadays like heating water, agriculture and industrial applications use the solar panels as an electrical power source instead of relying on the generators or the ordinary sources for electricity. The most important part of these systems is the solar panel where the solar energy is converted to heat for water heating or converted to electricity for the others. There are many types of the solar panels.

In the countries those have dusty environment accumulation of dust on the solar panels leads to reduction of the transmittance of the panel. Solar desalination plants in some of the middle-east countries like the solar desalination plant of Abu Dhabi suffers from the deposition of dust on its solar plates. The effect of the accumulated dust will be reduced with the increasing of tilt angle, since the tilt angle will affect the exposure time to the sunlight also. But the best way to eliminate the effect of the accumulated dust on the solar panels is to clean the panels.

Cleaning the solar panels is normally by washing which is tedious and cumbersome and also expensive in terms of the labour involved and time. In practice cleaning of solar panels should be frequently done which makes the process more laborious and expensive [2].

Hence in this paper an innovative method of automatic cleaning of solar panel has been proposed

II. METHODOLOGY

In this paper the effects of accumulated dust on the performance of the solar panels are investigated by referring the results obtained by experimentation in dusty atmosphere of different levels[1]. Also, an auto cleaning robot to work as the auto cleaner which is equipped on the flat solar panel is proposed. The design of the auto cleaning robot will have flexibility in order fix on different sizes of flat solar panels. In accordance with the dimensions of the flat plate panel, the robot consists of brushes driven by DC-motors through belt system. The movement of the brushes is controlled by signal generated by a microcontroller in accordance with the dust sensor LDR. The DC-motor will

produce a rotational motion which is converted in to linear motion through belt. The electrical power which is needed to drive the DC-motor is supplied from the solar plate itself. [5]
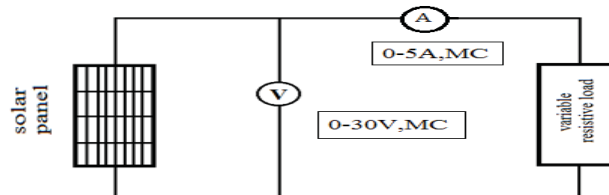
Following steps are involved in the methodology-

a) Collecting and studying more extra details regarding the effects of accumulated dust on the flat solar panels.
b) Designing the basic prototype of the auto cleaning system.
c) Choosing the proper microcontroller to control the auto cleaning robot and sensor to sense the amount of dust on the solar panel.
d) Designing the microcontroller's algorithm such that the microcontroller can control the robot in the right direction.

III. ANALYSIS OF DUST ON PANEL

The accumulation of dust on the surface of a photovoltaic module decreases the radiation reaching the solar cell and produces losses in the generated voltage and power. Dust not only reduces the radiation on the solar cell, but also changes the dependence on the angle of incidence of such radiation. According to the research, the daily energy loss along a year caused by dust deposited on the surface of the PV module is around 4.4%. In long periods without rain, daily energy losses can be higher than 20%. In addition, the irradiance losses are not constant throughout the day and are strongly dependent on the sunlight incident angle and the ratio between diffuse and direct radiations. When studied as a function of solar time, the irradiance losses are symmetric with respect noon, where they reach the minimum value.

The PV module performance has been tested under the deposition of different pollutants (red soil, ash, sand, calcium carbonate, and silica). According to the obtained results, a drop of PV module's voltage and output power is observed when dust particles are deposited on the PV module depending on the mass accumulated, and the type of pollutant. Moreover, larger reduction occurs when the PV module's temperature is increased. In addition to that, keeping the PV modules clean and cool, results efficient system performance. Power generation in the solar panel with dust and without dust with varying load resistance is determined experimentally. [4]
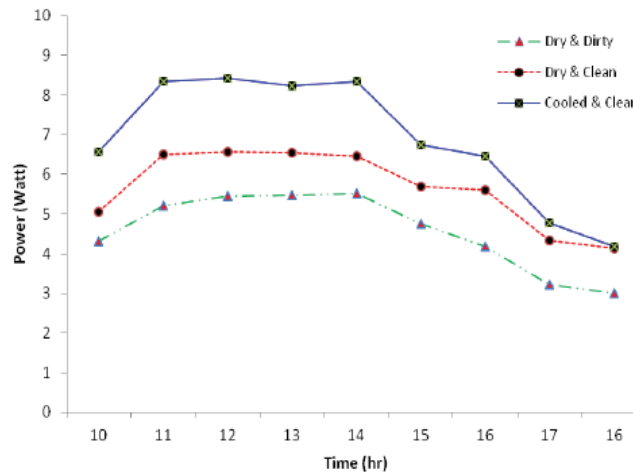

Block Diagram of Experimental Setup

Observation Table:

LOAD RESISTANCE in Ohms	VOLTAGE in Volts	CURRENT in Amps	POWER in Watts
1	1.69	1.43	2.4167
5	7.17	1.44	10.3248
10	14.79	1.35	19.9665
15	17.06	1.1	18.766
20	17.68	0.93	16.4424
30	18.54	0.6	11.124
50	18.99	0.36	6.8364
100	19.26	0.18	3.4668
150	19.31	0.12	2.3172
200	19.33	0.09	1.7397
250	19.44	0.07	1.3608
300	19.39	0.06	1.1634
Open circuit	19.4	0	0
Short circuit	0	1.45	0

LOAD RESISTANCE in Ohms	VOLTAGE in Volts	CURRENT in Amps	POWER in Watts
1	0.96	0.76	0.7296
5	3.94	0.75	2.955
10	8.11	0.73	5.9203
15	11.21	0.72	8.0712
20	14.30	0.7	10.01
30	17.64	0.56	9.8784
50	18.44	0.35	6.454
100	18.93	0.18	3.4074
150	19.05	0.12	2.286
200	19.07	0.09	1.7163
250	19.08	0.07	1.3356
300	19.06	0.06	1.1436
Open circuit	19.19	0	0
Short circuit	0	0.74	0

Table 4.1:Angle,Temperature, Without Dust   Table 4.2:Angle, Temperature, With Dust

Effect of dust on power production of a PV module

III. WORKING OF THE SYSTEM

In the automatic cleaning system, when the dust accumulates on the solar panel, the resistance of the LDR increases due to which more than 0.7V is supplied to the base and current starts flowing from collector to emitter. The LED which is in series with the resistor indicate the presence of dust on the panel. The continuous glowing of LED indicates, that the current is flowing from collector to emitter, this is taken as input pulse for the rotating the motor in both the directions for specified time, until the panel is free from the dust. Port pins P1.0 and P1.1 are connected to the corresponding input pins of the L293 motor driver. The motor is connected across output pins 3 and 6 of the L293. The software is so written that the logic combinations of P1.0 and P1.1 control the direction of the motor. Initially when power is switched ON, P1.0 will be high and P1.1 will be low. This condition is maintained for a
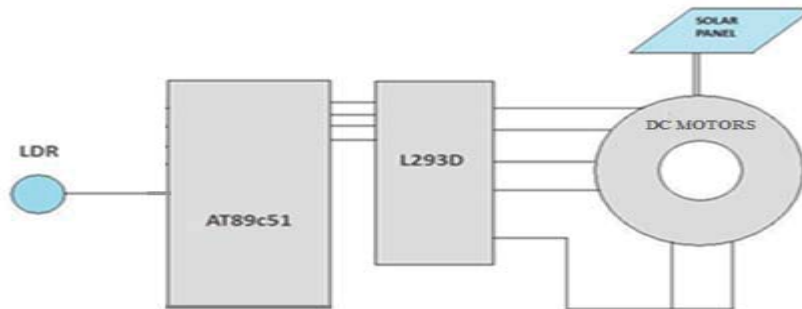

Fig.7.1 Block diagram of a Automatic cleaning of a solar panel

preset amount of time (around 1S) and for this time the motor will be running in the clockwise direction (refers the function table of L293). Then the logic of P1.0 and P1.1 are swapped and this condition is also maintained for the same duration. This makes the motor to run in the anti-clockwise direction for the same duration and the entire cycle is repeated .Depending on the dimension of the solar panel the sweep of the brush can be altered by changing the delay in the microcontroller program to keep the motor excited. The power required operating the DC motor and the microcontroller is taken from the solar panel output itself. Hence no external power supply required.

In this paper Dry dust cleaning system is proposed. Wet dust cleaning system may be designed by incorporating

automatic water sprinklers driven by the signal generated by microcontroller in accordance with the dust conditions.

IV. COMPONENTS OF AUTO - CLEANING SYSTEM

In this section we illustrated the components that used to build the auto cleaner system:
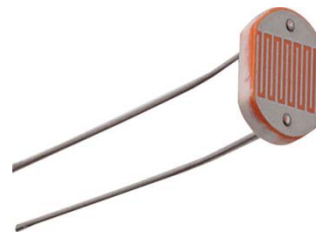
1-Brushes driven by DC-motor

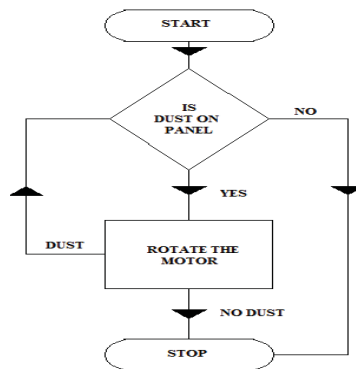2-Microcontroller used to control the Brushes movement

3-Conveyor Belt use to convert the rotational motion

of DC- motor to linear motion

4-Sensors use to give Information to Microcontroller

V. FLOWCHART OF C-CODE

VI. PERFORMANCE ANALYSIS

The main conclusions can be summarized as: The losses of the output power of the fixed solar panel at a tilt angle (35) is about 25% of the rated yield and can be higher depending on the dust form. The dirt and bird drop make a hot spot in the panel, and it can make temporary fail in the panel. Dry cleaning can' not remove all the dirt on the surface of the solar panel, but it is able to remove the outer layers of the dust. Cleaning solar panel with water increases the cleaning efficiency by removing majority of the dirt deposited on the panel. No external powers are required as the self- cleaning system takes its power from the battery of the solar panel. The device has lightweight because most material is made of aluminum. Comparing the costs of cleaning by Manual operation and Automatic operation the cost for automatic cleaning is proved to be more economic and significantly less cumbersome particularly in systems having large number of solar panels. Also frequent periodic cleaning ensures that the solar panel works with a good transmittance consistently at all times. [5]

REFERENCES

[1] J. Zorrilla-Casanova, M. Piliougine, J. Carretero, P. Bernaola, P. Carpena, L. Mora-Lopez, M. Sidrach-de-Cardona. "Analysis of dust losses in photovoltaic modules" world renewable Energy Congress 2011.Sweden, 8-13 May 2011.
[2] Ravi Tejwani, Chetan S Solanki. "360° Sun Tracking with Automated Cleaning System for PV" Department of Energy Science and Engineering, Indian Institute of Technology Bombay.

[3] A. Ibrahim "Analysis of Electrical Characteristics of Photovoltaic Single Crystal Silicon Solar Cells at Outdoor Measurements", . *Smart Grid and Renewable Energy*, 2011, 2, 169-175 doi: 10.4236/sgre.2011.22020 Published Online May 2011 (http://www.SciRP.org/journal/sgre).

[4] Shaharin Anwar Sulaimana, Atul Kumar Singh, MiorMaar of Mior Mokhtara, Mohammed A. Bou-Rabee, "Influence of Dirt Accumulation on Performance of PV Panels" http://docseurope.electrocomponents.com/webdocs/0030/0900766b80030030.pdf.

[5] http://users.ece.utexas.edu/~valvano/Datasheets/L293d.pdf

[6] http://www.biltek.tubitak.gov.tr/gelisim/elektronik/dosyalar/40/LDR_NSL19_M51.pdf

[7] Solar panels- Tata power solar systems limited, http://tatapowersolar.com.

[8] "Effect of Dust on Solar Panels". Katz. G. (2008, 27 April 2011). Available: www.gregorybkatz.com/Home/effect-of-dust-on-solar-panels.