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DESIGN AND IMPLEMENTATION OF MICROCONTROLLER BASED AUTOMATIC DUST CLEANING SYSTEM FOR SOLAR PANEL

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ABSTRACT

The aim of this paper is to give an innovative concept to handle energy demand around the world is increasing rapidly for many applications. Renewable sources of energy are solar, wind and geothermal which are inexhaustible. Solar energy is abundant in nature and is proving its existence for many applications like street lighting, house hold appliances, water heating, agricultural and industrial purpose. One of the way to harness solar energy is done by using solar panels. Limitation of solar energy is its efficiency for any application due to the factors like dust, humidity, temperature etc. Electrical parameters of solar panel are sensitive to accumulated dust density and will affect the transmittance of the solar panel thereby reduce its efficiency. In order to overcome this problem, it is necessary to clean the solar panels regularly. One of the method is to increase the efficiency of solar panel is by removing the dust accumulated on solar panel. Cleaning of solar panels is difficult task. The normal way to clean the solar panels is washing them manually but it is not reliable and economical. In this regard a work is taken up to design and implement the automatic dust cleaning mechanism for solar panel. The designed automatic cleaning mechanism consists of IR LED, Photo diode arrangement in order to sense the dust accumulated on solar panel. The efficiency of solar panel is determined by taking the readings of voltage and current of particular panel with and without dust for various days, weeks and months. By the recorded values efficiency comparison of solar panel with dust and without dust is made. The designed automatic cleaning system produces an effective, non-abrasive cleaning and avoids irregularities in the generation of power due to the deposition of dust on the solar panel. From the study it is proved that average efficiency of solar panel increases about 1.6% to 2.2% by regular cleaning. Thus developed model maximizes the efficiency.

1. INTRODUCTION

The sun emits energy at an extremely large rate hence there is abundant availability of solar energy in the nature. If all solar energy could be converted into usable forms, it would be more enough to supply the world's energy demand [1]. However, this is not possible because of conditions in the atmosphere such as effect of clouds, dust and temperature. Solar energy can be converted to more usable energy forms through solar panel. There is unprecedented interest in renewable energy, particularly solar energy, which provides electricity without giving rise to any carbon dioxide emission. Of the many alternatives, photovoltaic method of extracting power from solar energy have been considered has promising toward meeting the continuously increasing demand for energy [2]. The efficiency of solar panel is limited due natural conditions so it is very much essential to take care of parameters like dust, humidity and temperature. In this regard the work has been taken up to study the efficiency of solar panel with and without dust collected on it. The developed project includes design and implementation of microcontroller based dust cleaning system. The main aim of the project is to provide automatic dust cleaning mechanism for solar panel. In order to sense the dust IR LED, Photo diode arrangement is used [3]. The arrangement keeps the modules clean and thereby improving its efficiency. Traditionally cleaning system was done manually. The manual cleaning has disadvantages like risk of staff accidents and damage of the panels, movement difficulties, poor maintenance etc. The automatic dust cleaning system of solar panels has taken to overcome the difficulties arise in the traditional cleaning and also produces an effective, non-abrasive cleaning and avoids the irregularities in the productivity due to the deposition of dust [4]. The studies carried out to evaluate the efficiency of solar panel for dust collected on it for one day, one week and a month. The efficiency of solar panel also calculated after cleaning the surface for one day, one week and a month. And finally comparing both the efficiencies it is proved that solar panel efficiency increases considerably. Thus the developed model enhances the solar panel performance [5].

Fig.1.1: Manual cleaning process

1.1 OBJECTIVES

- To record the measured voltage and current for efficiency calculation of SPV panel with and without dust.

(a) Different days (b) Different months

- To compare the calculated efficiency of SPV panel with and without dust.
- To design and implement the microcontroller based dust cleaning system.
- To maximize the efficiency.

1.2FUNCTIONAL BLOCK DIAGRAM

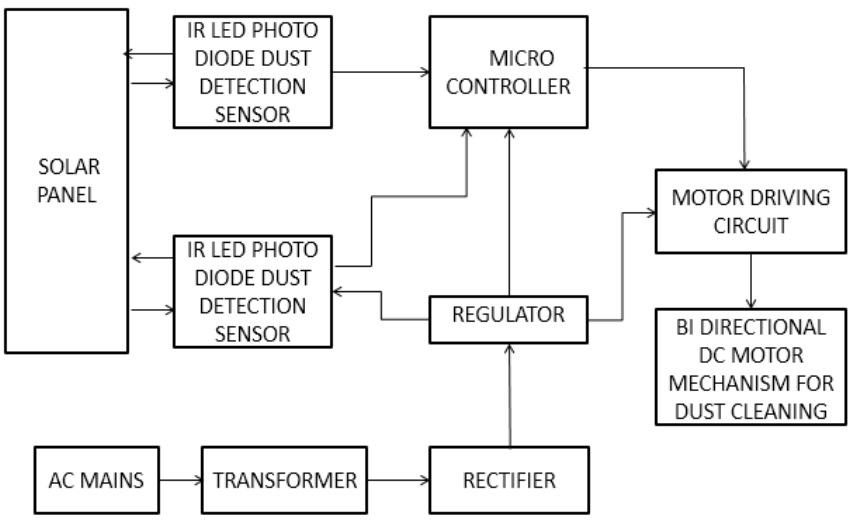

Fig.1.2: Functional block diagram of automatic dust mitigation system.

The functions of each block are described below:

Solar panel: Solar photovoltaic cell is a semiconductor device which converts sunlight directly into electricity. Therefore, solar PV panel when exposed to sunlight generates voltage and current at its output terminal. The specifications of the solar panel are given in Table-2.1.

Table-1.2: Specifications of solar panels

Model No	EMMVEE-D1
Maximum power	10 watt +/- 3%
Open circuit voltage Voc	21.6V
Short circuit current Isc	0.85A
Peak voltage Vpm	17.61V
Peak current Ipm	0.72A

Model No	KOTAK
PV array capacity	900 watt
Power rating of each panel	150 watt
Open circuit voltage Voc	38 V
Short circuit current Isc	24A
Voltage at maximum power	32.3V
Current at maximum power	20.7A

Sensor circuit (dust detection circuit): A dust Sensing circuit is designed with IR LED, OP_AMP (IC 741), Photodiode and Transistor, Photo Diode which is connected in the reverse bias condition. Here the OP_AMP is used as a voltage comparator. The IR LED and Photo diode are arranged in such a way that the IR LED rays emitted are continuously reflected back to the photo diode. When dust detected the light beams emitted by the IR LED reflection for Photo Diode is very less and thus Photo Diode goes to saturate. Now at this instant the potential difference between two inputs at comparator also changes and the output of the comparator is at its high state. Hence the NPN transistor (BC 548) turn activate (Saturate) the transistor. This signal is given to the microcontroller.

MicrocontrollerP89C51: The 89C51 is an 8-bit flash Microcontroller. It has 4 I/O ports and all ports are general I/O Ports. It receives the signals from sensor circuit and these signals act as input to the microcontroller, and then it compares those signals with pre-programmed data.

Motor Driving Circuit: This circuit makes use of Microcontroller L293**,** which has special characteristics to run the motors. It runs the motor for the input of 01 and 10

Transformer: Transformer (centre tapped step down) is connected to AC mains and fed to the rectifier (convert AC to DC) circuit which further provides the signal to the voltage regulator which provides the constant voltage for all the circuits.

Regulator (7805): A DC power supply system, which maintains constant voltage irrespective of fluctuations in the main supply or variation in the load, is known as Regulated Power supply. The 7805 IC referred to fixed positive voltage regulator, which provides fixed voltage 5 volts. The 7805 regulator is known as fixed voltage regulator.

1.3 WORKING PRINCIPLE

The main aim of this project is automatic dust cleaning mechanism of solar panel surface. In order to sense the dust infrared(IR) LED, Photo diode arrangement is used. Infrared (IR) rays continuously fall on the panel and reflected back to photo diode. If there is any dust on the panel, IR rays continuously falling on the panel reflect back to the photo diode is less thus the output of sensor goes high and these signals are fed to microcontroller. Depending upon input signal the controller compares those signals with preprogrammed data for motor movement and drives the motor driving circuit to rotate the motor in clock wise, anti-clock wise direction as per requirement. Wiper is connected to motor wiper which rotates in clockwise and anti-clockwise direction. Thus the cleaning is carried.

Transformer (centre tapped step down) which is connected to AC mains and fed to the rectifier (convert AC to DC) circuit which further provides the signal to the voltage regulator which provides the constant voltage for all the circuits.

- **Efficiency of SPV panels**

The data of solar radiation is obtained from the weather station installed in Energy Park, BEC. Considering the SPV powered irrigation pump of 1 hp as the load, the voltage and current generated by six parallel panels are measured from morning 8am till evening 6pm. The total power generated is calculated and the efficiency of SPV panels is estimated for different radiations.

Efficiency = output power/Input power

Output power = voltage*current

Input power = Solar rad.*area of panel

Where, Area of a panel installed in Energy park is 1.276 m^2

- **Power generated by SPV panels**

The total power generated by six SPV panels installed in main building is obtained by the equation

Power generated by SPV panels = (Input power *Efficiency*6) W

Input power = Solar rad. * area of solar panel W

Where,

Area of a panel installed in main building is 1.14 $m^{2.}$

Average solar radiation (W/m2) of all months

The Solar radiation intensity data is collected for one year from the weather station installed in the Energy park of BEC, Bagalkot. The data is collected from morning 9a.m. till evening 5p.m. at an interval of 15 minutes. Solar radiation helps to calculation of solar panel efficiency for different radiations.

1.4 RESULTS AND DISCUSSIONS

The data obtained for Solar Radiation versus Time characteristics, Panel efficiency versus Time analysis, voltage and current versus Time with and without dust curve for the solar panel under investigation shown in the Fig 3.3, 3.4, 3.5, and 3.6 respectively. In the summer, the sun appears brighter in the sky, which increases the duration of sunlight seen in a day than it appears in the winter. The sun is the highest in sky on the summer solstice. The minimum and maximum temperature was found to be 22.6 ºC to 41.8 ºC. The maximum and minimum solar radiation intensity was found to vary between 985 and 210 W/m2. The performance of a solar panel is necessary to describe the electrical parameters of the cell like Voc, Isc, fill factor, efficiency (η) estimate. The effect of the deposition of dust on the solar panel is considerable due to the fact that power is a complex phenomenon that is influenced by different environmental and weather conditions. From the study so for conducted that by cleaning the solar PVs regularly can maximize the amount of radiations received and increases output power up to the maximum limit.

A brief schematic representation of the factors that determines the settling of dust on the PV panels is shown in setup of experiment. A detailed analysis of the influence of dust on the PV modules performance is proposed in this project. During the study of the performance of solar panel with and without dust, then the following factors have been considered:

- Voltage versus days with and without dust
- Current versus Time with and without dust
- Panel efficiency versus Time analysis with and without dust.

1. Voltages and current values of 10w solar panel with and without dust

The experiment is conducted by using the two 10w solar panels mounted on a stand. The electrical parameters like voltage and current have been measured to study the effect of environmental dust effect. The average voltage and current generated by the panels noted down for different days and timings by considering with dust and without dust. The parameters measured are depicted in the table as shown:

1.4.1 Graph of voltage v/s days

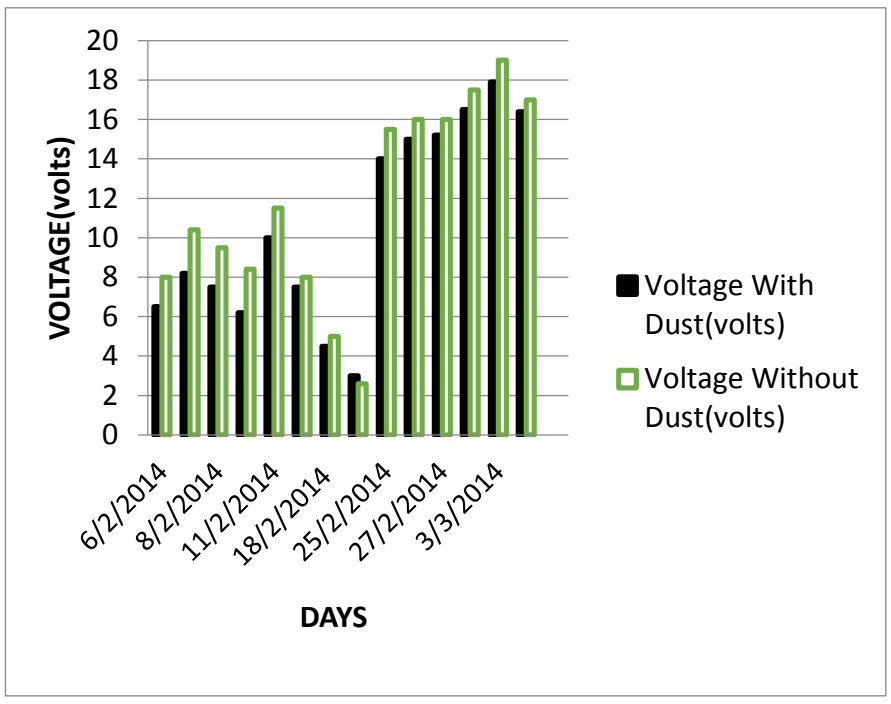

Fig: 1.4.1 Graph of voltage variation for days (6/2/14-6/3/14)

Inference: The graph shows that the variation of voltage with respect to different days. It shows that shorter the period of re-cleaning better will be the voltage value. Inferred from graph that voltage increases with regular cleaning.

1.4.2 Graph of Current V/s Time

The data collected on the date 18/3/14 is shown in figure

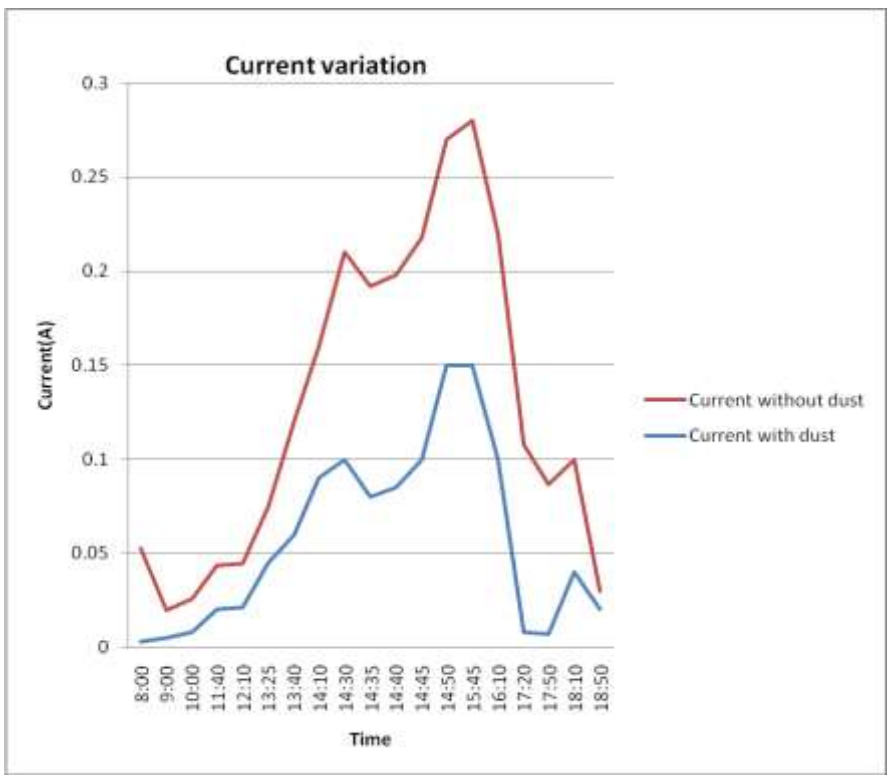

Fig: 1.4.2 plot of current v/s Time

Inference: The plot shows current variation with respect to time. It compares the values of the current noted for cleaned panel and unclean panel with same rating. It shows that the current increases

after cleaning the solar panel. The value of current is improved by regular cleaning.

2. Comparison of efficiency with and without dust for 900w solar panel

- **Graph (Efficiency v/s Time) for the date 14/4/14 and 15/4/14**

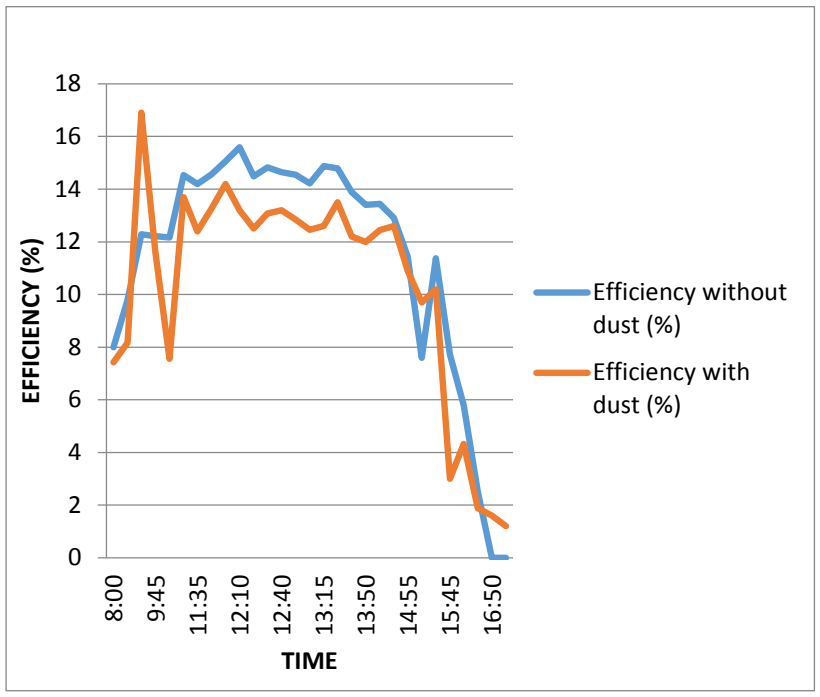

Fig: 1.4.3 Plot of Efficiency v/s Time for date of 14/4/14 and 15/4/14

Inference: The plot of efficiency v/s time for the date 14/4/14 and 15/4/14 describes about the small efficiency variation. It shows the variation of efficiency with dust and without dust with respect to change in time for SPV panel. The calculated average efficiency increases about 2.2% after cleaning the panel. Inferred from the graph that the efficiency increases with the regular cleaning.

Increased efficiency = (avg. efficiency without dust)-(avg. efficiency with dust)

= (9.87-7.65)

= 2.2%

1.5 CONCLUSION

The project describes the performance of solar photovoltaic panel subjected to environmental dust collect. The experimentally study is done. Tests are conducted for solar panel powered DC pump installed at Energy Park in BEC Bagalkot. The effect of dust on the power reduction and efficiency reduction of PV module was quantified. From the analysis it is observed that average efficiency increases about 1.6%-2.2% by regular cleaning. Hence implemented automatic cleaning system maximizes the efficiency.

1.6 FUTURE SCOPE

- The designed project is more reliable. As it doesn't need human interference in operation hence it reduces maintenance cost.
- The implemented project reduces the man work for cleaning purpose. As it can be used in solar power plants as well their services would be further required at homes when homes will be lightened by Solar Panels. Thus gives a very good scope in future.

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