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Solar Panel Cleaner Using Vibrator and Air Blower for Desert Location

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Abstract: *Solar panel is vulnerable to accumulated dust on its surface. The efficiency of the solar panel gradually decreases because of dust accumulation. Accumulation of dust and debris on even one panel in an array reduces their efficiency in energy generation considerably and emphasizes the need to keep the panel's surface as clean as possible. In this paper, a smart panel cleaning system for PV that provides a cost-effective and scalable solution for the removal of soil and dirt. It will automatically and remotely remove the dirt at a fraction of the cost of manual cleaning. In this paper, an Arduino based solar panel cleaning system is designed and implemented for dust removal. The proposed solar panel cleaner is waterless, economical and automatic. Two-step mechanism used in this system consists of an exhaust fan which works as an air blower and a vibration to detached the dust from the panel surface. Since, the system does not need water to clean solar panel, it avoids the wastage of water and effective in desert areas. 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.*

Keywords: Solar panel, Cleaning, Efficiency, Dust, Air blower, etc.

I. INTRODUCTION

To ensure sustainable environment, solar energy can play a vital role because it is an enormous, inexhaustible and green source of energy. In commercial level, 10 to 13% conversion can take place in solar cell. Efficiency of outdoor installed PV modules is reducing by 10 to 25% [1]. Efficiency of solar panel is decreases due to the dust. Dust is nothing but particulate matters. Dust consists of substance which present in air and includes smoke, fog. Inorganic and organic substances. Such substances are collected and dust can be formed. Also, dust can be included volcanoes vapors, forest fires, smoke, bacteria, storms, pollen and sand. For long period, dust can be present in air; atmospheric particles which are suspended solid can be included here. Through the wind movements, dust particles can be move and transfer to long distances. Atmospheric condition such as clouds, dust and temperature is affected to solar panel efficiency. Due to the atmospheric condition, all solar energy we can't be use. The mechanism primarily consists of air blower and vibration motion for cleaning on a glassy surface. In our project power loss can be less in amount. Our project is also self-reliant and for use it is very easy.[2]

A water-free automated cleaning service unit, comprising two DC geared motors, a lead screw, supporting shaft, rack and pinion mechanism, and the cleaning task is completed using blower and vibrator. These are hybrid actuators that provide rotary-to-linear motion through suitable mechanical transmission arrangements.[3]

Efficiency of solar panel is depending on the natural condition. So, it is necessary to take care parameters like dust, humidity and temperature. We used Atmega328 board for cleaning of solar panel. Our project includes design and implementation of solar panel cleaner. The actual goal is developed automatic solar panel cleaner. Manually solar panel can be clean but big disadvantage is risk of staff accidents, hard work and man power can be required. To overcome this all disadvantages, we can make automatic solar panel cleaner. It is more effective, smooth cleaning, and avoids the irregularities in the productivity due to the deposition of dust. Our system is work very smoothly.[4]

In recent years, photovoltaic technology has advanced fast for power generation from sunlight. There are mainly three cleaning methods, i.e., mechanical cleaning [5], nano-film based self-cleaning [6] and electrostatic cleaning [7,8]. Compared with other methods, mechanical method has a large dust removal force, rapid operation, good environmental adaptability and control performance.

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However, the mechanical cleaning system usually has a bulky and heavy structure owing to its driving components. There are mainly three cleaning methods, i.e., mechanical cleaning [5], nano-film based self-cleaning [6] and electrostatic cleaning [7,8]. Compared with other methods, mechanical method has a large dust removal force, rapid operation, good environmental adaptability and control performance. However, the mechanical cleaning system usually has a bulky and heavy structure owing to its driving components. [9,10]

II. BLOCK DIAGRAM

Figure below shows the block Diagram of Solar panel cleaner. For cleaning solar panel, we design and develop the system. The system works in vertical direction. For cleaning the dust, we are going to use two techniques. One is by using a blower and other is by using the vibrator the dust is cleaned. We can use a DC air blower for this purpose. The vibration motion is generated by the series of high-speed DC motors. There will be off-centered loads connected to the motor shafts which will cause the vibrations. There Whole system is controlled using microcontroller. The logic supply and motor supply are designed differently to avoid damage of the controller. The microcontroller used is Atmega328. The cleaning process is repeated twice a day; for that purpose, we will use a RTC IC module which will keep track of the time. RTC is a real time clock.

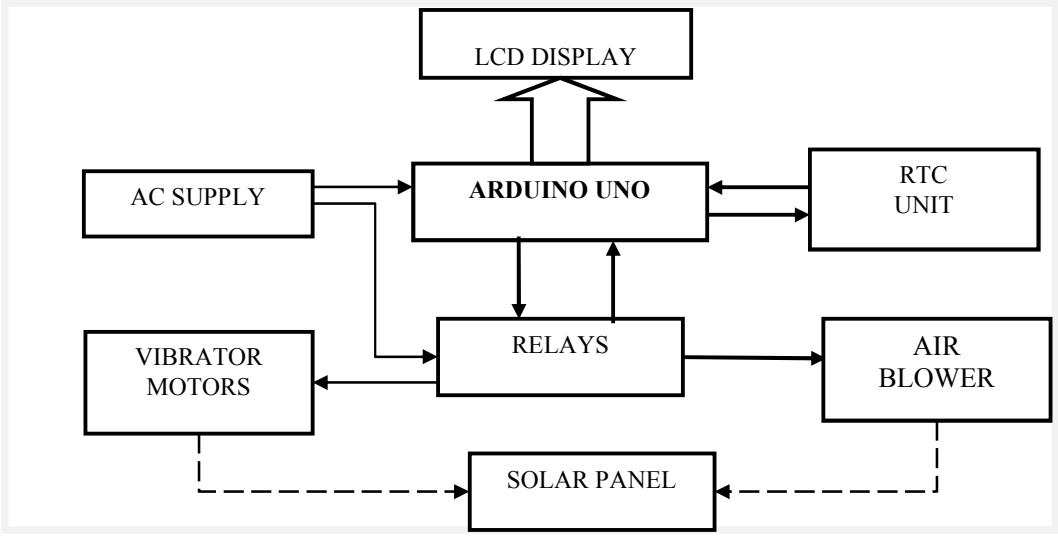

Figure 1: Block Diagram

III. METHODOLOGY AND DESIGN

The proposed solar panel cleaning system uses two-step cleaning techniques. First, vibration is start for deatched the dust from the surface of the panel, vibration purpose we used dc motors. Then air blower removes dust from surface of the panel using up-down structure as much as possible. For up-down mechanism we used two dc motors. This system is time based system. Therefore, no water is needed for the system for cleaning. This feature keeps the solar panel safe from scratch. The proposed solar panel cleaning system is fabricated with easily accessible components. The prime units are solar panel, microcontroller (Arduino Uno), DC motors, Air blower, Relays, LCD, Real time clock. The specifications and motive of some major components used in the proposed cleaning method are presented in Table I.

TABLE I: PROPERTIES OF MAJOR COMPONENTS

Name	Purpose and Rating
Solar panel	A 40W solar panel is used in this system. Its output voltage and current are 18.20V and 2.20 A, respectively.
Arduino UNO	We used ATmega328 microcontroller, its input voltage is 7-12v.
Air blower	Air blower is used for cleaning to blow out the sand on the surface of the solar panel.
Dc Motor	Dc motor is used for vibration, blower and up-down mechanism.

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Relay	We used 4voltage relays for vibration, blower, up & down mechanism
Real time clock	The DS1307 serial real time clock is a low power, full binary-coded decimal (BCD) clock/calendar plus 56 bytes of NV SRAM.

Some other components are used in this system as supporting components. We were marked the air blower with the help of cpu exhaust fan, dc motor using pvc pipe. This blower sucks the outside air and blow towards the panel surface to move out the dust from surface. The vibration motion is generated by the series of high-speed DC motors. There will be off-centered loads connected to the motor shafts which will cause the vibrations. Push button is also utilized here to set the limit of the movement of the cleaning Mechanism. Blower is used to remove the dust from the surface of the solar panel. The complete circuit diagram of the proposed solar panel cleaner is shown in Figure 1.

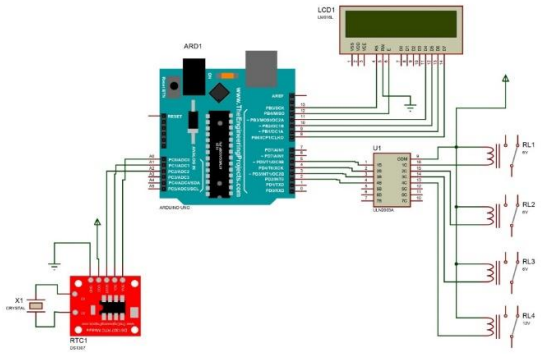

Figure 2: Complete Circuit Diagram of Proposed System

The Arduino uno are shown in the middle of the diagram which has 6 pins connected to the LCD (LM016L), 4 pin connected to IC (ULN20034) & 3 pins connected to RTC(DS1307). We give the supply to the Arduino and relay is 12V & 9V respectively. Ic connection goes to voltage relays which is parallely connected.

IV. HARDWARE IMPLEMENTATION

The proposed solar panel cleaning system is automatic and handmade. Simple architectural design is seen in this system including solar panel, cleaning mechanism. A 40W solar panel module is used here which provides an output voltage of 18.20V (open circuit voltage). The output of the solar panel depends on the sunlight. If we start with the body structure of the system. We designed the cleaner with a body that is made from iron.

A. Air Blower

In this system we have used a pvc pipe of 63.5 mm and two end caps to seal it's ending, a combination of exhaust fan and motor to suck in the air and then release it through the holes that are provided in the pvc pipe and this mechanism acts as a blower which is used to blow away the dust/sand that has accumulated on the solar panel.

Figure 3: Air Blower

B. Frame

The frame which is made by iron to support our system, underneath it we have connected a motor of 35000 RPM and off-centered load is connected to the shaft of the motor so due to which it provides vibration to our solar panel so that the larger partical of sand/dust slides down without damaging the solar panel. We have also used a rack and pinion to hold and provide linear moment of blower by using two motors of 30 RPM, they are rotated clockwise and anti-clockwise for the up and down moment of the blower.

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Figure 4: Frame

C. Electronic Circuit

To make the time based system we have used an ArduinoUNO which has 16 pins, D7(8th pin) - RS(13th pin) is connected to LCD display (LM016L), 5th pin- 2nd pin is connected to ULN2003 pin 1st pin-4th pin which is a used to amplify current cause relay can't be directly connected to Arduino, ULN2003 pin 9th pin- 16th pin is given to relay 1 [vibration], 9th pin -15th pin for relay 2 [blower], 9th pin - 14th pin for relay 3 [up moment], 9th pin - 13th pin for relay 4[down moment]. This system does clean twice a day to save energy we have used real time clock (RTC) to determine the timing of cleaning, VCC to RST is connected to A0 to A2. For better control of our blower, we have taken out two push buttons for UP and down moment.

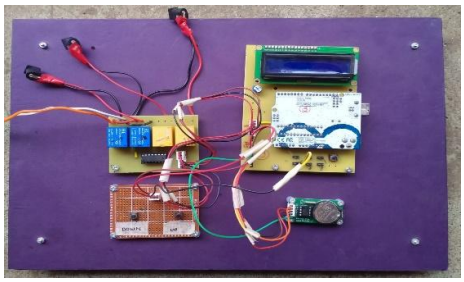

Figure 5: Electronic Circuit

D. Proposed System

Figure 6: Proposed System

This time-based system is controlled by Arduino which is connected to LCD display which shows us the time at which cleaning is supposed to be done. RTC is used for the time management and to let Arduino know when the cleaning has to be done, four voltage relays are used respectively for blower, vibrator and for up and down moment. When the time of cleaning that's given to Arduino occurs the motor used as vibrator starts and the frame of solar panels starts to vibrates so the larger partials of dust/sand slides down, when blower starts to move downwards the small particals are blowen away due to forced air.

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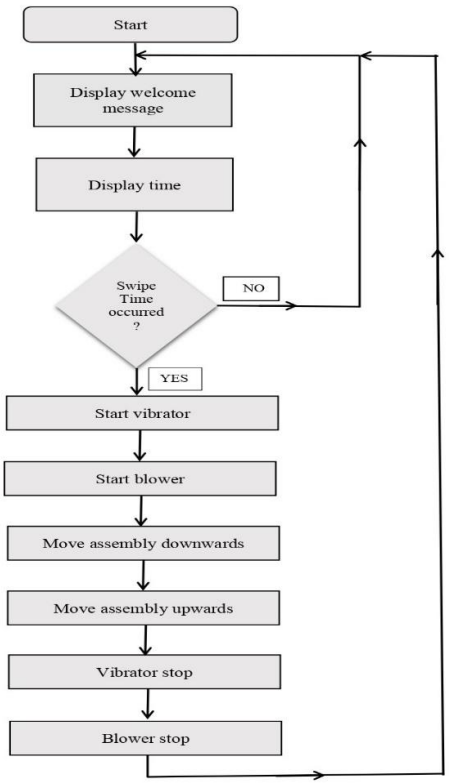
TABLE II: COST ESTIMATION OF THE PROPOSED SYSTEM

Components	Price
DC Motor (35000 rpm)	500
DC Gear Motor (30 rpm)	500
Arduino Uno	600
DC Voltage Relay	100
LCD display	170
RTC (real time clock)	150
Rack & pinino	500
PVC pipe	40
End Cap	40
Total cost	2600

Flow diagram



Flowchart 1: Flow Chart of the Program Used for Solar Panel Cleaner

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V. RESULTS

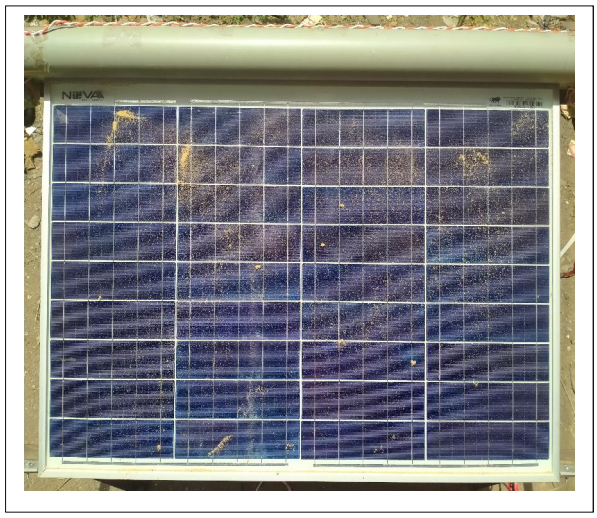

Figure 7: Before Cleaning

Figure 8: After Cleaning

Before cleaning the dusty solar panel, it's observed that due the dust particles there's decrease in the output of solar panel as dust tents to reduce the solar radiance that's trapped by solar cells and if left without cleaning it might also damage the solar panel. Shading due to dust particles is a huge issue as accumulation of dust on panel as it leads to formation of hot spot on the panel, if a solar cell is shaded due to dust particle no radiation is trapped and the current that needs to be passed doesn't pass and then that current tries to flow through over cell and the load on that single cell increases and it forms a hot spot, it also causes huge damage to solar panel. After cleaning there's increment in the output of solar panel, maximum amount of radiation is captured and later converted to energy which can be utilized in various fields

TABLE III: RESULTS

Day	Time	Voltage before cleaning (volt)	Current before cleaning (amp)	Voltage after cleaning (volt)	Current after cleaning (amp)	Calculated power before cleaning (watt)	Calculated power after cleaning (watt)	Efficiency increased (%)
1	10.00 AM	19.5	0.55	20.0	0.54	10.725	10.8	0.6
	2.00 PM	19.4	0.53	19.8	0.536	10.282	10.6128	3.21
2	10.00 AM	19.3	0.53	19.76	0.53	10.229	10.47	2.35
	2.00 PM	19.5	0.54	19.9	0.54	10.335	10.746	3.91
3	10.00 AM	19.4	0.53	19.8	0.53	10.282	10.494	2.02
	2.00 PM	19.55	0.54	20.0	0.54	10.557	10.8	2.30
4	10.00 AM	19.3	0.535	19.4	0.54	10.32	10.47	1.45
	2.00 PM	19.5	0.54	20.0	0.54	10.53	10.8	2.56

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Result Analysis

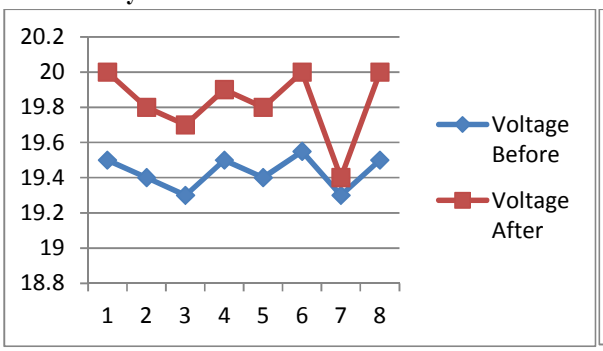

Figure 9: Voltage

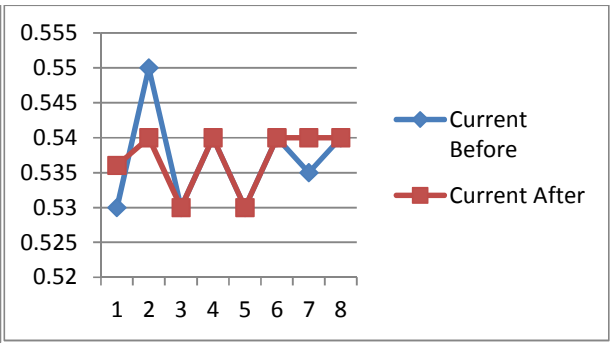

Figure 10: Current

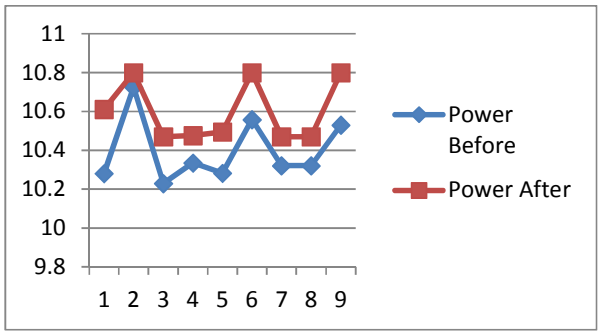

Figure 11: Power

VI. CONCLUSION

To ensure complete use of the radiated solar energy, one needs to ensure that the solar panel is cleaned. Cleaning the solar panel everyday seems difficult and overrated. Hence automatic solar cleaning finds application which also ensures the increased production of energy. Our system can be installed on single solar panel. The cleaning action of blower and vibrator nicely works in vertically direction. After using our system, we can conclude that there is 2 % of increment in the efficiency. Our system becomes benefited for smaller solar panel located in desert and dusty areas.

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