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Solar Panel Cleaning Robot

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Abstract. Now-a-days Photo Voltaic (PV) module solar panels are increasingly used for generation of electrical energy. This helps in decrease in the consumption of non-renewable fossil fuels and decrease in global warming, which has become very essential to save this world. The PV module solar panels suffer from dirt deposition with consequent decrease in efficiency. If the panels are clean, it can absorb more energy and charge the batteries during the peak hours of the day. So, several automatic, semi-automatic and manual cleaning methods are being invented to solve the issue of cleaning the solar panels and thereby increasing the efficiency. In this work a novel method of automatic cleaning of solar panels using a robot is designed, which has a dust density sensor. The cleaning robot can move freely and roam around the panel after every 4 hours (or any time which may be optimized and set by the user) during the off-peak hours of the sunlight and thereby cleans the portions of the solar panel, where the dust density value increases beyond a threshold. An alternative of water cleaning system in the robot also operates based upon signal received from the dust sensor, to clean any sticky dust on the panel.

Keywords — Solar Panel, Robot, Dust Sensor, Arduino Uno, Dust Density, Cleaning brush, Relay module, Ultrasonic Sensor

I. INTRODUCTION

The demand of solar energy is increasing globally in response to the production of photovoltaic's. The solar energy is renewable and its harness reduces use of fossil-fuels and hence helps in reducing production of harmful greenhouse gases. The PV module solar panels are invented to harness solar energy and convert it to electrical energy. Various factors that are affecting solar power efficiency \such as bird droppings, sand dust and snow which reduces its efficiency to 50 percent [1]. After a quite research and information gathered from literature review and deciding the requirements to design a robot by avoiding faults of previous designs.

The project Solar Panel Cleaning Robot (SPCR) has a very common relationship between environment and renewable energy and the SPCR provides cleaning to theses panels with water as alternative. This project will benefit a lot of families who are using solar panels in their houses as it will clean the panels without any damages caused to the panels or to themselves. Also, SPCR will save time of people and efforts especially in large place where there are hundreds of solar panels.

A. Methods of Dust Removal from Solar Panel

In [1] various methods were designed and suggested for automatic cleaning of panels such as piezo-ceramic actuation cleaning, electrostatic cleaning, motorized wiper and sprayer cleaning and robotic cleaning. In [2] the author defines the solar panel cleaning methods as follows:

- Rainfalls Cleaning Method [2]: Despite it does not cost anything, it is seasonally volatile. This will impact the condition and reliability of solar panels from this method as rainfall is shortage in many areas.
- Manual Cleaning Method [2]: This method depends on laborer to clean the PV surface the laborer needs to use brushes to remove the soil off the surface.
- Mobile Cleaners Method [2][9]: This method sends signal through GSM module which doesn't work accordingly due to bad weather and less signal connection.

These disadvantages are required to overcome and so an effective cleaning method should be performed when required with minimum requirements such as water or brushes.

B. Performance of Solar Panel

The work of the photovoltaic's are calculated from the (I-V) curve i.e. current and voltage curve, as there are polychromatic solar panel and monochromatic solar panel [3]. The solar panel parameters like voltage open circuit (Voc) and current short circuit (Isc) can be obtained from (I-V) curve. The power curve of the photovoltaic's power is obtained from the values of current and voltage. The point of the maximum power that is delivered (Pmpp) represents the maximal power point in the curve. From the aforementioned parameters, the conversion efficiency (η) and fill factor device (FF) can be obtained [4]. The performance of the studied panel is measured by the favor of energy that is produced over time period in (kWh) unit. Finally the panel performance can be represented by Yield (Ys) factor (kWh/kWp) which is the energy generated normalized by the installed capacity in (Wp).

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C. Block Diagram

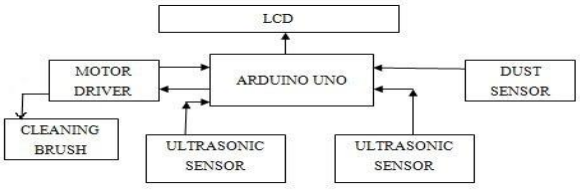

Figure.1. Solar panel dust cleaning system

II. SYSTEM IMPLEMENTATION

The implementation of the proposed system consists of the following devices:

A. Solar Panel Efficiency

Efficiency in photovoltaic solar panels is measured by the ability of a panel to convert sunlight into usable energy for human consumption [8].

Maximum efficiency= {max power output (Pmax)/(incident radiation flux (ES)*area of collector (AC))}*100

Now if Pmax=400W, ES=1000W/m2 and Ac=2.79 m2, you put the values into the efficiency equation where all units will cancel out and then multiply the value by 100% to give you your efficiency percentage of 14.3%.

B. Arduino Uno Microcontroller

[5]This microcontroller kit is a board that is based on ATMEGA328P and is used to store data and programs and give output to measure dust density and calculate solar plate output power. [2]The specifications of employed Arduino microcontroller are described in table 1.

Sl.no	Microcontroller	ATmega328
1	Required Voltage	5V
2	Usual Input Voltage	7-12V
3	Limited Input Voltage	6-20V
4	I/O digital pins	14 (6 PWM output)
5	Analog Input Pins	6
6	I/O Pin DC current	40 mA
7	3.3V Pin DC current	50 mA
8	Flash Memory used	32 KB
9	SRAM	2 KB
10	EEPROM	1 KB
11	Clock Frequency	16 MHz

Table.1. Arduino Uno Specifications

The microcontroller is connected to personal computer (PC) via Universal Serial Bus cable (USB) in order to upload the software.

Figure.2. Arduino Uno Microcontroller

C. GP2Y1010AU Dust Sensor

The dust sensor is device, which detects floor dust, cigarette smoke in air etc and it is designed as a sensor for spontaneous running application such as air conditioner with air purifier action and the light from the LED is spot with a sensor lens inside. When the detector identifies any dust remains inside the device, the reflected light from the dust. The device makes a voltage output, which is analog in nature when the current is in proportion to the amount of detected light, which comes out of the detector after the amplifier circuit amplifies the current from the detector.

Figure.3. Dust Sensor

D. HC-SR04 Ultrasonic Sensor

The Ultrasonic sensor is a device that is used in robotics and other test equipment projects. This sensor is used to measure distance between nearest solid object and itself which can also avoids driving into a wall. This sensor can be directly connected to an Arduino Uno board or any other devices which operate on 5V and are capable of measuring distances between 2cm to 400 cm. [5]It can be operated on battery as it is a low current device. It is a wall-e film where similar robot eyes were seen for latest robotic invention and it resembles a cool device in looks.

Figure.4. HC-SR04 Ultrasonic Sensor

E. REES52 Relay Module

The relay consists of three pins normally open pin (NO), normally closed pin (NC), common pin (COM) and coil. When a coil is powered ON, the magnetic field is generated and the contacts connect to each and every one which depend on magnetic field generated from the coil. Since power isolation takes place between switching pins and the coil, the coil is easily powered from Arduino by connecting VCC and GND pins from Arduino kit to the relay module kit. After that the Arduino output pins is designed and set depending upon the no of relays required. These pins are connected to output pin which makes the output pin high i.e.

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5V to control the coil that also allows controlling of switching process.

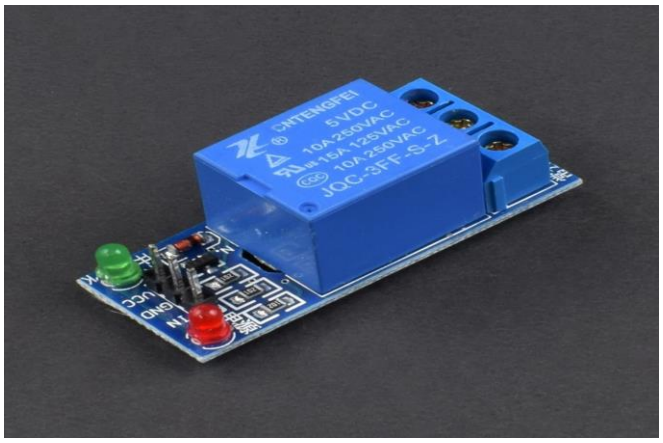

Figure.5. Relay Module

F. Submersible micro water pump

This device is a low cost, small size Submersible Pump Motor which can be operated from a 2.5 -6V power supply. Its maximum capacity is 120 liters/hour and consumes current of 220mA. The tube pipe of the device must be connected to the motor outlet and submerge it in water and power should be turned ON. The level of water is always higher than the motor as it should be looked into. If the device is not in contact of water and kept dry, the motor may be damaged due to heating and it will also produce weird noise.

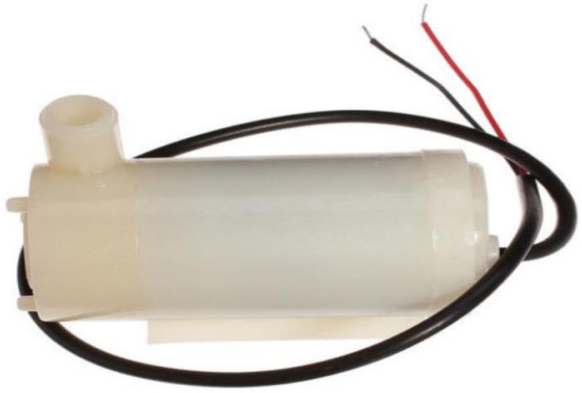

Figure.6. Micro water pump

III. WORKING OF THE PROJECT

In this project, after connecting all the devices together, then the power is switched ON. When the dust accumulates in panel is found, microprocessor sends a signal to actuate the system. The dust sensor will sense the dust and it would trigger the Arduino Uno to drive the wheel motor to move through the panel and move to that particular place to clean the dust accumulated in the panel which also cut down the efficiency of the solar panel and return back to the original position. The robot moves to that particular place and starts cleaning through DC motor. After around 4 hours time of the day it repeats the process. The robot also contains a water system to clean which acts as an alternative when required. In dry day, it's most useful as the shortage of rainfalls occurs. The ultrasonic sensors detect the distance so that the robots do not flow out of the panel and the cleaning process is done smoothly.

IV. EVALUATION

1. Impact on Global Context

SPCR is a technological way of solar panel cleaning which will be more beneficial to implement in large arrays of panels and can be used in any place that uses solar panels as a source of generating electricity. Example, it can be implemented in hospitals, companies, school and homes.

2. Impact on Economic Context

SPCR will be great in case of economic as it cost very less and moreover the water system implemented as a alternate when required and hence huge water wasted in cleaning is saved.

3. Impact on Social Context

SPCR will save time and effort as it is automatic and less chance of damage of the robot and the panel. Moreover the user will not need to check if solar panel is uncleaned or not as it will remove dust time to time.

4. Impact on Environmental Context

SPCR is an environment-friendly project because it is related to renewable energy and also it will help the solar panels to absorb maximum sunlight and secure the solar panel from dust and dirt spots.

V. PROJECT AUDIT

The following table represents the cost of all hardware components, which are purchased for achieving the project. The table contains all the components used and it resembles cost effective which is affordable.

Sl.no	Item Name	Qty	Cost(Rs)
1	Arduino Uno Board	1	450
2	Geared Motor(12V)	2	1000
3	L293D Motor Driver	2	280
4	Batteries(9V)	1	30
5	Adapter(12V)	1	200
6	Optical Dust Sensor	1	450
7	Ultrasonic Sensor	1	350
8	Relay Module	1	120
9	Submersible water pump	1	250
10	Wires and connectors	50	500
11	DC motor(5v)	1	60
12	Solar brush	1	30
13	Chassis with tyres	1 & 4	500
14	Solar Panel	1	800
	Total cost		5020

Table.2. Cost of components

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VI. FLOW CHART

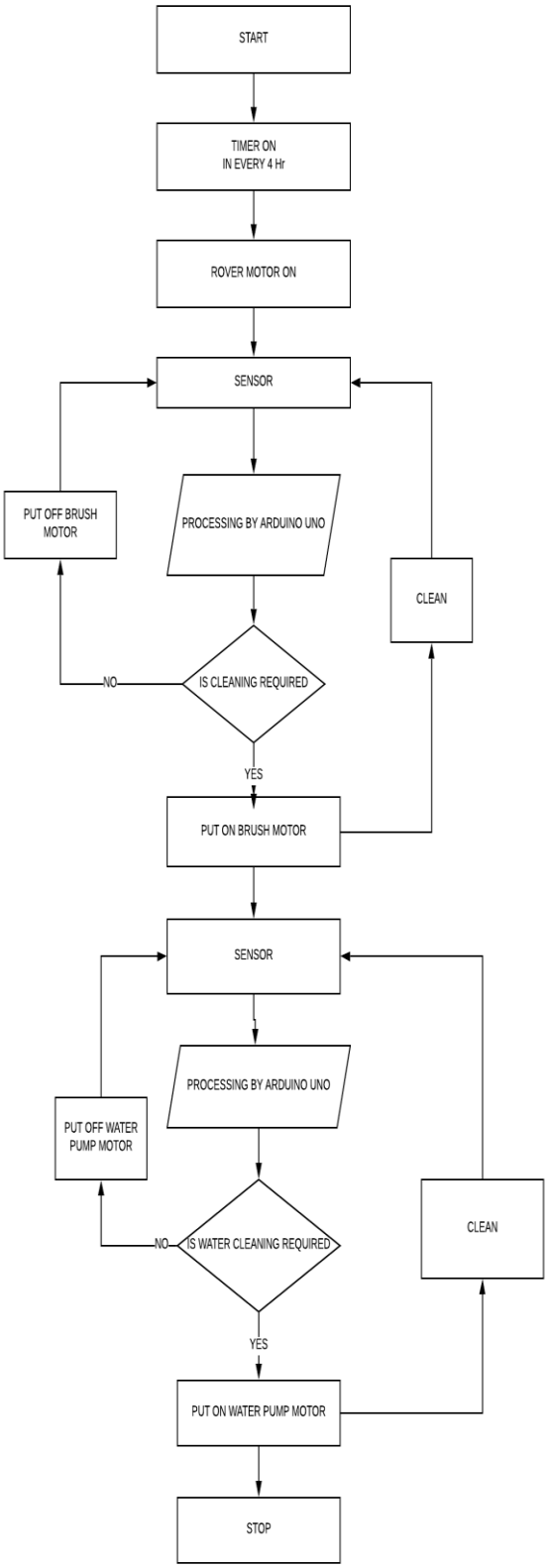

Figure.7. Flow chart of the process

VII. RESULTS

A. *Hardware Implementation*

The connections were done properly and it has been implemented and found the detection of dust. The robot roams in the solar panel every 4 hours to make it clean and allow the panel to grab more energy from the sun.

Figure.8. Hardware part of the project

B. *Serial Monitor output*

The serial monitor output defines the raw signal received by the device as well as voltage and dust density value, which helps in detecting dust. The dust density value varies from 0.08 to 0.20 which means whenever dust is detected the value of dust density increases and ultrasonic sensor value varies as the distance increases in moving the robot as shown in the monitor as 29.30 cm to 6.31cm.. If the dust density value increases more than 0.25, it will give signal to the microcontroller to switch on the water system, as it will imply sticky dust in that case.

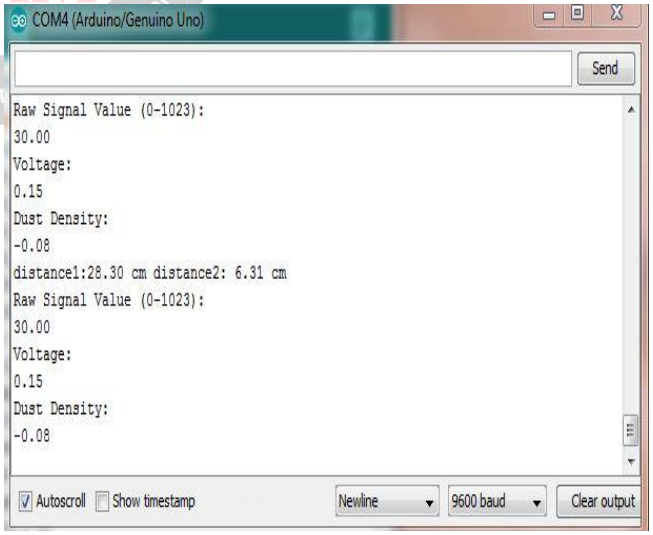

Figure.9. Output result

VIII. CONCLUSION

A reliable, cost-effective, and automatic cleaning robot was designed and implemented. [6]Its main purpose is to clean solar panels from dust and perform a physical inspection. Dust accumulation can significantly reduce the power output on the solar panels. The robotic system proposed in

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this research is a simple way to effectively tackle the challenges[7]. This project will also include a water system which when required to use when it comes through hard dust when it is unable to clear by simple brush. Finally, the research intentions are not only to solve solar panels dust accumulation issues, but also through this robot, the quality and performance of solar cells are improved[10]. As it is a free running robot, it reduces mechanical effort of rails to clean with huge machinery. Thus the system helps to cut down labor cost and high water usage in this dry environment.

IX. ACKNOWLEDGMENT

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