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An Automated Solar Panel Cleaning System based on Arduino's Dust Elimination Technology

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Abstract: *The solar panel is vulnerable to accumulate dust on its surface. The efficiency of the solar panel gradually decreases because of dust accumulation. Hence, cleaning the PV panels is a problem of great practical engineering interest in a solar PV power generation. In this project, the problem is reviewed and methods for dust removal are discussed. In this project Arduino based electromechanicalsystem is proposed to use as a cleaning mechanism and it will try to clean the solar panel and increase the efficiency of solar panel. In the previous system to clean the solar panel, we are using the manual operated system. In that there are various errors are come sometimes due to manual error, improper cleaning of the solar panels is taking place also due to bird waste and dust and dirt has accumulated on the surface of the solar panel due to which the efficiency of the solar panel is reduced. The time to time cleaning of the solar panel is not taking place due to which it harms the solar panels. If we want to clean the solar panel mechanically, then there is wear and tear are created due to which losses of the system are increasing. And the system efficiency decreases so this system is also not energy efficient. Hence, we are implementing this system automatic solar panel cleaning system. In this system, all the automation is taking place by using Arduino board and timer control. By which without human interference solar panel cleaning system will be automatically turned on and automatically turn off. Experimental results show that the proposed cleaning system can operate with an efficiency of 60- 70% for different types of sands.*

Keywords: Solar Panel, Arduino-Uno, solar energy, Dust Accumulation, photovoltaic, inexhaustible, Light Dependent Resistor.

I. INTRODUCTION

Solar energy can play a vital role in ensuring a sustainable environment because it is an immense, inexhaustible, and green source of energy. Solar energy is directly used for electrical power generation for a variety of applications which includes residential, commercial and industrial uses.It can provide the necessary amount of electricity without any threat to the environmental and health issues because no harmful gasses are emitted at the time of energy conversion. Moreover, the total sunlight that hits the surface of the earth in an hour and a half, according to the US department of energy, is adequate to manage the yearly energy consumption of the whole world. It is estimated that, the total amount of fossil fuel which is stored in the earth is equivalent to the energy produced from the sunshine on earth of around 18 days. In a solar energy system, photovoltaic (PV) solar panel provides DC electricity from the continuous flow of energy from the sun. MPPT method based on Fuzzy logic controller is presented in to produce maximum energy from PV system. Once the installment of solar panels has been completed, the fuel is free. The operating cost of the system is very low when compared to other energy production methods. However, solar energy is CO2 free renewable energy source, the routine maintenance of solar panel is required. The particles of dust on the solar panel come mainly from urban and industrial products. SiO2, Al2O3, Fe2O3, CaMg(CO3)2, Ca(OH)2, CaO and CaCO3 are some sorts of dust particles found on the solar panel. Dust Accumulation on the surface of solar panel has serious impact on the system's efficiency. It is estimated that, about 50% of system's efficiency can be reduced and almost 15% power losses can be occurred in dry areas. Therefore, it is essential to keep solar panel's surface clean as much as possible. Nowadays, different electrostatic cleaning methods and water-based methods are available and widely used as solar panel cleaner. A semiautomatic wiper control system-based cleaning method is presented in. A maximum efficiency of86.7% is achievable by this cleaning mechanism. Multiple cleaning systems which includeair and water vibration is presented in

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for the harsh desert environment. The output power of the system is increased by 27% by using a water jet spray. A self-cleaning method is proposed in which is automatic. To design the system, a 050 Wp solar panel is used which can generate 26-50% more electricity with the proposed cleaning method than a normal solar panel. The whole system is controlled by a microcontroller. Another wiper control method-based two steps cleaning system is developed in where water is first applied on the panel surface and then the wiper is triggered. The system's efficiency becomes 17.55% after cleaning which is quite identical to the average efficiency of the system before dust accumulation. Electrostatic dust removal is another type of efficient method but it is not suitable for pole mounted PV installations. Electrostatic cleaning equipment is proposed in which are economical and suitable for the mega solar power plants in deserts. The proposed system shows better performance when the dust is less than 5 g/m2. A self-cleaning method based on electrostatic travelling wave is designed in where the system consists of transparent dielectric film and parallel electrodes. With this system, 90% of total dust is cleaned within 2 mins without any water and moving parts. An automatic robotic cleaning system is presented in where a silicon rubber brush is used with an aluminum core to clean the surface of solar panel. On the other hand, Surface acoustic wave is utilized in to remove the spoiling particles from the surface of solar panel. Cleaning effects of surface acoustic wave are also analyzed in this study where spoiled solar panels are used.

II. LITERATURE REVIEW

A. Chandramouli and V. Sivachidambaranatham [1] worked on Extract of maximum power from photo voltaic (PV) system employing with fuzzy logic controller (FLC) based MPPT technique is investigated in this article. Fuzzy is an expert supervisory control algorithm system, provides satisfied acceptable results from PV. Maximum/lower power point tracking (MPPT/LPPT) approaches are adopted to get maximum output power from the PV irrespective of variation in its input source (Solar irradiation and temperature). X.Liu and J.Li [2] worked on Scaling dust particles intensify dust pollution degree on PV panels. Metrological and environmental conditions induce dust scaling behaviours. An induction period exists to make dust particles from loose state to scaling state. Nano-, micro- and coarse particles with many pores are randomly deposited on panels. CaCO3 is the main scaling compound adhering to PV panels. J.Zorrilla-Casanova et al [3] worked on the accumulation of dust on the surface of a photovoltaic module decreases the radiation reaching the solar cell and produces losses in the generated power. Dust not only reduces the radiation on the solar cell; but also changes the dependence on the angle of incidence of such radiation. Our results show that the mean of 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. N.Sugiartha [4] worked on Solar panels are susceptible to dust accumulation on their surface for long term operation. Scheduled cleaning work is thus important to maintain the efficiency and reliability of the solar panel for producing electricity. The paper presents a preliminary design of the cleaning mechanism for the solar panel surface using a semiautomatic wiper control system. A DC motor is utilized to power the wiper. The manual switch buttons are used to control the rotation direction of the DC motor. The experimental tests are conducted to obtain the solar panel performance, namely output voltage, output current, output power, and panel efficiency under clean and dusty conditions. The comparison of both conditions has been made to determine the cleaning effectiveness of the proposed prototype. A.S.Alghamdi, A.S.Bahaj [5] worked on Dust accumulation on solar photovoltaic (PV) modules reduces light transmission from the outer surfaces to the solar cells reducing photon absorption and thus contributing to performance reduction of PV systems. In regions such as the Middle East where dust is prevalent and rainfall is scarce, remedial measures are needed to reduce such impacts. Currently, various techniques are being employed to address such sand soiling ranging from mechanical (brushing) to active and passive electrical interventions. K.P.Amber et al [6] worked on to develop automatic self-cleaning mechanism (SCM) for pole mounted solar installations and to evaluate its performance. Design and fabrication of device allows the SCM to start cleaning cycle after every 24 hours for a period of 20 seconds. It also restricts the SCM to continue the cleaning process during rain or when the battery voltage level is low. The experiments were done at two identical pairs of photovoltaic (PV) panels tilted at 33° angle, one with SCM and one without, for a period of six weeks in the climatic conditions of Pakistan. Irradiance, dust density and other performance parameters such as maximum power output, short circuit

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current, open circuit voltage, and fill factor and panel efficiency were recorded.M.Mazumder [7] worked on The direct solar energy conversion in gigawatt scales by photovoltaic, photothermal, and photoelectron chemical processes is of national and global importance in meeting energy needs. Dust depositions on solar panels and solar concentrators cause efficiency loss from 10% to 30% depending upon the surface mass concentration of dust requiring manual cleaning with water. S.Alagoz and Y.Apak [8] worked on Removal of spoiling materials from solar panel surface by applying surface acoustic waves. Surface acoustic wave (SAW) technologies have been widely utilized for sensitive surface cleaning and particle steering applications in micro-electro- mechanical system (MEMS). This study investigates application of SAWs for cleaning of solar PV panel surfaces. Spoiling of photovoltaic (PV) solar panel surfaces is one of major problems that can reduce energy efficiency of PV solar energy systems in outdoor conditions. Rough mechanical cleaningmethods can easily damage surface of panels and hence they can reduce efficient working life-span of panels.

III. METHODOLOGY AND PROPOSED SYSTEM

The proposed solar panel cleaning system uses two-step cleaning techniques. First, an exhaust fan removes dust from the surface of the panel as much as possible. Four different types of sands are used here as dust. Then a wiper made of soft clothes are used to swipe. 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), metallic dc gear motor, buck boost converter and motor drive module. The specifications and motive of some major components used in the proposed cleaning method.

- **Solar panel:** A 250W solar panel is used in this system. Its output voltage and current are 30.3Vand 8.27A, respectively
- **DC gear motor:** Metallic dc gear motor is connected to the cleaning shaft in order to operate it. The operating voltage, current and speed are 6V dc, 0.4A and 100 rpm.
- **LDR sensor:** A light dependent resistor (LDR) is used here to track the sunlight.
- **Wheel:** Four wheels are used in this system which moves the cleaning shaft upwards and Downwards.
- **Buck boostconverter:** A dc-dc buck boost converter is used here to supply constant voltage.

Some other components are used in this system as supporting components. A motor drive module is used to drive the motor and the motor operates with the solar dc power. Push button is also utilized hereto set the limit of the movement of the cleaning shaft. Exhaust fan is used to remove the dust from the surface of the solar panel. The complete circuit diagram of the proposed solar panel cleaner.

IV. BLOCK DIAGRAM

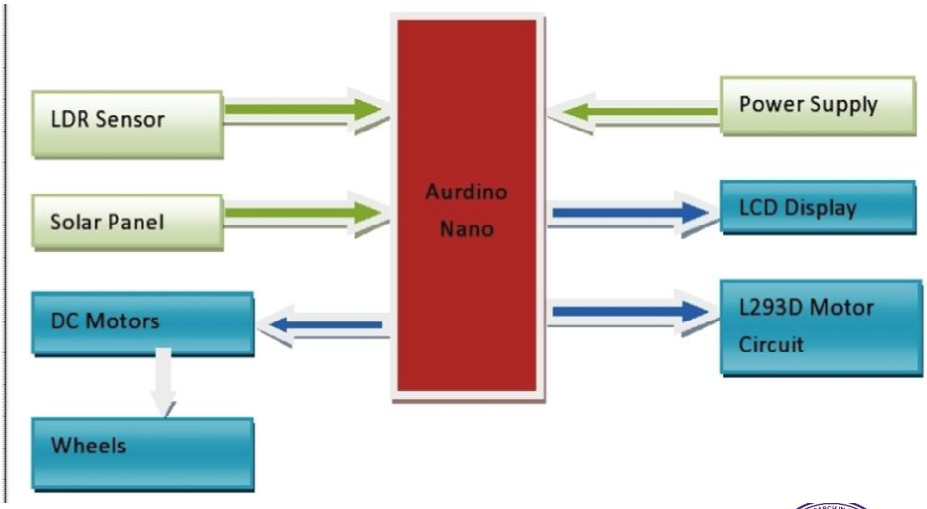

Fig 1: Proposed Block Diagram

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V. WORKING PROCEDURE

A solar panel is placed in the top left corner which produces dc electrical power. A microcontroller is seen just under the solar panel. A buck boost converter is shown in the right side of solar panel which takes input from the solar panel and maintains constant voltage supply. A LDR and 2 push buttons are placed in the right side of the diagram. Four motorsM1, M2, M3 and M4 are shown in the middle of thediagram along with the motor driver, L298N to drive the wheel. A voltage regulator of 7805 is usedhere to supply the required voltage.

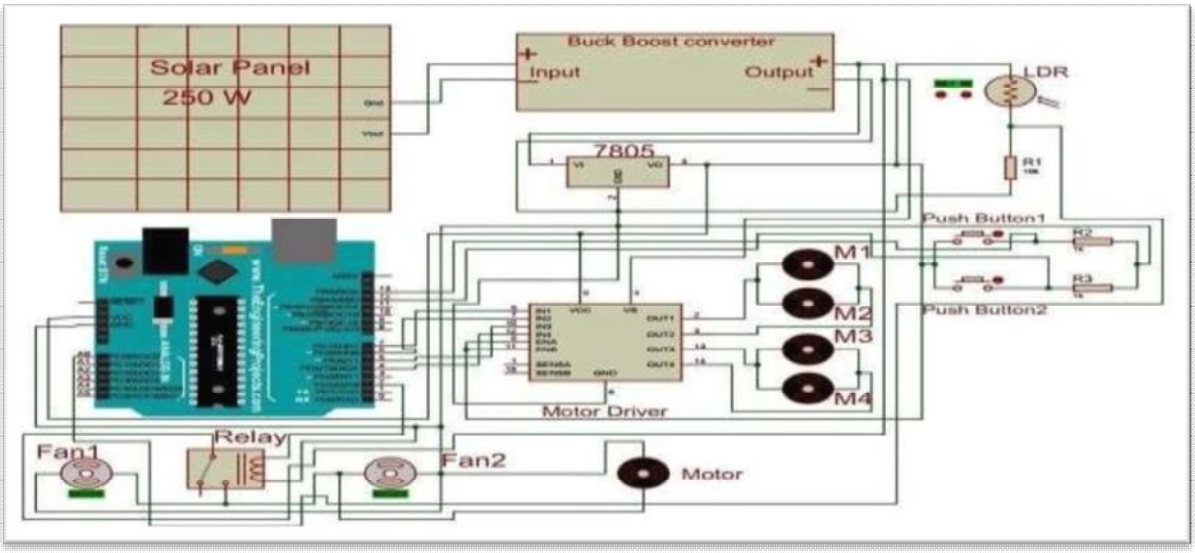

Fig 2: Arduino Interfacing design

The input of 7805 is 12V and it provides 6V as output. Another motor is used to operate the wiper and these are shown in the bottom of the diagram along with the relay switch.

VI. HARDWARE IMPLEMENTATION

The proposed solar panel cleaning system is automatic and handmade. Simple architectural design is seen in this system including solar panel, cleaning shaft. A 250W solar panel module is used here which provides an output voltage of 38V (open circuit voltage). The output of the solar panel depends onthe sunlight. A buck boost converter is used here to keep the output voltage constant. The output voltageof the converter is set at 12V dc. Therefore, the variation of the sunlight does not have any effect on the output voltage. Two reference lines are set for the movement of cleaning shaft/exhaust fan. Each line consists of 2 motors and wheels. When the sunlight comes out, microcontroller and LDR measure the value and the whole system is designed in such a way that the system will start its operation at the beginning of the day typically between 09-11 am. Every morning, the proposed system tracks the sunlight for starting its operation even though there is no dust on the panel surface. Therefore, the proposed system is effective for any types of dust. Fig. 2 shows the full experimental setup of the proposed solar panel cleaner.

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Fig 3: Solar panel

A handmade cleaning shaft is depicted in Fig. 3. Four types of sand are used to justify the efficiency of the proposed system.

Fig 4: Cleaning shaft of the proposed solar panel cleaner

Experimental results validate that the proposed solar panel cleaning system works efficiently at desiredlevel. System efficiency and number of swept vary depending on the type of sands. The efficiency ofthe proposed system is around 87%, 91%, 92% and 96% for sand 1, sand 2, sand 3 and sand 4,respectively. The number of swept for completing the operation is 3,4,6 and 8, respectively. Thisproposed system works without water. Therefore, it can be used effectively in the areas which do nothave a nearby water source. The proposed system is inexpensive and made with handy components.Performance comparison of the proposed solar panel during normal, dust and dust wiped condition.

VII. CONCLUSION

An automatic solar panel cleaning system is proposed and built with easily available components. The proposed system is inexpensive and does not require any water to do the cleaning operation. Thus, wastage of water is avoided here. And this feature makes this system applicable in the desert areas and where no water source is available. This proposed cleaning system is based on twosteps mechanism where exhaust fans do the first part which is remove dust from the surface though airblowing. The second part is done by wiper. This feature ensures the safety of the panel because any typeof scratch is not seen during the experimental tests. Experimentally the cleaning system is capable ofserving its purpose.

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