Intelligent Non Hydraulic Photovoltaic Cleaning Module For Industrial Applications

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***Abstract* — Now a days, Solar panel plays an important role in terms of observing energy from the promising energy source. This paper aims to increase the efficiency of solar power plants by solving the problem of dust accumulation on the surface of the solar panel, which leads to a reduction in plant output and overall plant efficiency. A solar panel cleaning system that could periodically remove dust accumulated on its surface and maintain the performance of the solar power plant. The system is a robotic system that can move autonomously on the surface of solar panels using cups with DC motors and a vacuum cleaning system. This paper also aims to reduce human involvement in the cleaning process of solar panels, as it is a very useful device for the environment.**

***Index Terms*— Cleaner Robot, Vacuum system, Efficiency, Solar panel**

I. INTRODUCTION

India is one of the few countries endowed with abundant solar energy and receives around 5 000trillion kWh/year, which is more than sufficient to satisfy the power requirement of the entire nation. With more than 300 million people without access to uninterrupted electricity and industries citing energy shortage as the key growth barrier in India, solar power has the potential to help the country address the shortage of power for economic growth. Although solar energy is a very promising source because it supports offshore power generation, it requires regular maintenance after installation. Dust accumulation on the surface of photovoltaic (PV) cells. Solar panel may reduce system efficiency a 50%. This underscores the need for care solar panel surface as clean as possible. Very of today's cleaning methods use water techniques (ex., washing directly from the water pump, soap solution?). It is not that much easy to afford to waste large quantities of water for cleaning solar panels. Photovoltaic modules are usually installed on relatively inaccessible areas such as rooftops or dry deserts that complicate manual cleaning operations and expensive. Most solar panels are normally cleaned early morning or late at night since cleaning during its main operation leads to power failure and reduced efficiency. With the increasing use of energy and climate change due to the use of fossil fuel sources, there is growing interest in renewable energy sources, including the direct use of solar radiation by photovoltaic cells (solar panels).

Fig: 1.1 Solar Panels

However, these are subject to degradation in efficiency due to factors such as location, environment and weather conditions. Other conditions include dust accumulation on the panels, shading from structures such as trees and buildings, seasonal changes, weather influences such as snow, rain, clouds, and animal (bird, etc.) migration routes in the vicinity of the production site. The pollution of the panels caused by these factors influences the output voltage of the panel and thus the energy production. The solar panel efficiency is reduced more by dusty environment as it

interferes the amount of direct sunlight received by PV panel. Since dust layer build up on solar collectors in these areas causes major energy- yield loss, there have been many efforts to maintain the optical surface of the solar collectors clean. To overcome above problems regular cleaning of panels is required which can be done by robot technology instead of humans. It increases the panel efficiency by cleaning uniformly. However, this advantage becomes a disadvantage of the automatic cleaning system, as it has to work on an inclined surface. This paper is to develop a robust and economically viable product that offers a simple and cost-effective solution for cleaning solar panels. The robot uses a cleaning process, to effectively remove dust from solar panels. The vacuum is placed at the front to disperse the dust from the solar panel.

II. RELATED WORKS

Qi zhang. A piezoelectric actuator linearly shifting on a manual is hired to pressure a wiper constant at the actuator. At a proper pressure force between the wiper and drive the wiper to effectively wipe a dust layer away from the solar panel's surface. Chassis Subsystem: consists of the main body of the machine. Mechanical Subsystem: responsible for moving the entire system. Control Subsystem: Controls the operation of cleaning subsystems [1]. Fuzzy logic is used to increase the efficiency and energy consumption also we can used in Solar panels [2]. Fatima I. A full design and implementation process of a low-cost system that is used to clean solar panels automatically without using liquids. The system utilizes two microfiber brushes driven by two separate DC motors to clean the panels [3]. Ramesh Jayaraman. This device allows the cleansing of floating water plants. This gadget enables the cleansing of floating water plants. Where a human cannot go there and clean them. The robotic vehicle works as manually controlled. Vehicle using internet communication. This robot can also be automated [4]. Arash Sayyah. Design, construction, and evaluation of self-cleaning Electrodynamic screen (EDS) films and their production through gravure offset printing as a transition from laboratory-scale to roll-to-roll printing process. Both transparent and reflecting EDS films are fabricated for their applications to self-cleaning solar panels and concentrating Mirrors, respectively [5]. Nitin R. The progress of the electro dynamic screen (EDS) film technology for frequent water-free cleaning with low energy requirements. Results offered here, primarily based totally on laboratory scale EDS-film-laminated sun panel cleaning, display that the output power can be restored higher than 95% of the initial power under clean conditions [6]. Shelving Joseph. Fully automated permanent setup solar panel cleaning system with/without water. It uses soft yet powerful nylon brushes to clean the panels and also has two squeegee on either sides of brush to wipe out water. The system can be retrofitted directly on to the panels in solar power plant, commercial, residential sectors. In this system, the water can be reused, vibration free, multiple row cleaning [7]. Prototype consists of two dc motors of 1000rpm for cleaning and 10rpm for tracking mechanism. The wiper which is placed on the panel is used for cleaning the dust particles which are deposited on that. These dc motors can be controlled by the microcontroller [8]. A.B. Afarulrazi. The tracking system of the robot will be controlled by two Light Dependent Resistors (LDRs) act as input signals, and a servo motor as an actuator to rotate the solar panel. Besides, the navigation of the robot most of the time will be controlled by using digital compass data to correct the error [9]. Yahiya Zatsarinnaya. In this paper, the authors cope with the pressing trouble of easy sun energy. This paper presents the results of a study of the selection of an engine, an electric drive for it and the software program surroundings of a self-sustaining and dependable tool for cleansing sun panels. A device characterized through low strength intake and the absence of the opportunity of panel shading [10]. Increasing efficiency goes on increasing tremendously in all kind of real-time applications. It includes security, computer networks, robotics, control systems, parallel processing, bio-medical engineering, data mining, power systems, mobile wireless sensor networks, agricultural application, production engineering, and Industrial automation [11]. Guangzhou Dai. This paper adopts the grid scanning set of rules primarily based totally on electric powered map recognize ground insurance task, and designs synthesis Detection device primarily based totally on sensor array locating approach era in step with set of rules characteristics, experimental outcomes for impediment detection by indicate that the designed Static locating imply that the designed detection gadget improves cleansing robot's surroundings belief and course seek capacity greatly [12]. A solar panel

cleaning system that has low-cost and efficient performance was designed and tested. An improvement on the maximum produced power of 16.7% was resulted from the comparison of the power generated from a typical PV panel before and after cleaning.

III. SYSTEM ARCHITECTURE

The main objective of the system is to detach the dust from the photovoltaic cell, increasing the efficiency of the module. The proposed solar panel cleaning system falls into the cleaning robot category but is designed for industrial cleaning in large solar power plants. It is an autonomous robot that moves along the inclined surface of the solar panels. In each cycle, the robot first moves forward to clean and returns to the solar panel after processing, and then the vacuum cleaner moves along with the device. Dust or other particles on the solar modules affect the optical efficiency of the systems. The accumulation of dirt or particles such as dust, water, and sand on the surface of the solar panel obstructs or deflects the light energy from reaching the solar cells and the result is a reduction in energy production. This solar panel cleaning system is operated via a mobile app. The solar panel cleaning system is powered by a battery (12 volts). The cleaning tool (vacuum cleaner) operated by geared motors. This cleaning tool moves forward horizontally; after cleaning that will move backward.

The configuration of the proposed system is to remove the dust from the surface of the solar panels, thus reducing the amount of radiation that reaches them. This leads to the loss of generated electrical energy and the formation of hot spots that can permanently damage the solar panel. This paper aims to develop an autonomous vacuum cleaning method that can be used regularly to maximize the lifespan and efficiency of a solar panel. Dust accumulated on solar panels forms a sticky layer that cannot be removed directly with portable vacuum cleaners. The vacuum cleaner is used to collect the dust scattered on the solar panel. The robot is controlled by the microcontroller. When the brightness decreases due to light obscuration caused by layers of dust on the panels. The cleaning system includes relays that control the movement of the device. The forward and backward movement is based entirely on the lighting level and the output voltage of the solar panel. The Figure 3.1 shows the block diagram of the proposed system which represents the complete cleaning system. The dust accumulated on solar panels forms a sticky layer which can be cleaned directly by using portable vacuum cleaners.

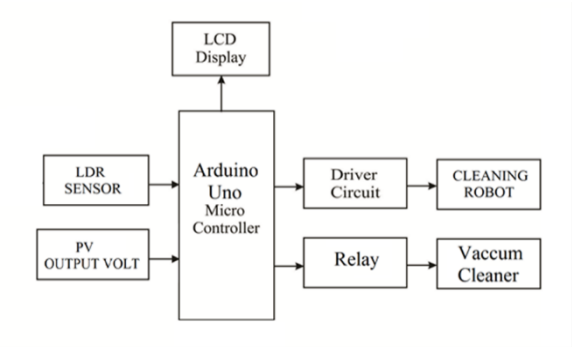


Fig 3.1 Proposed Block Diagram

LDR (Light Dependent Resistor) sensor used to measure light intensity and the change in the output voltage of the solar panel indicates dust deposits on the PV cells. When it detects that the output voltage is low for the right lighting level, the robot will automatically detect that dust is accumulating on the panel and will have completed the cleaning process automatically. LDR is a high resistance semiconductor photo resistor. If the light falling on the device is of high enough frequency, the photons absorbed through the semiconductor supply the sure electrons sufficient strength to leap into the conduction band. This is used to measure light intensity falling from the solar panel.

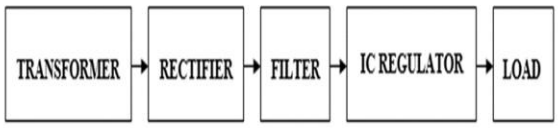


Fig 3.2 Power supply

The Figure 3.2 shows the Block diagram of Power Supply which describes the AC voltage, typically 220Vrms, is connected to a transformer which steps this AC voltage down to the level of the desired DC output. This resulting DC voltage will usually have some AC voltage fluctuation or variation. A control loop eliminates ripple and maintains the same DC value even if the input DC voltage varies or the load connected to the output DC voltage changes. This voltage regulation is usually achieved with one of the popular voltage regulator IC packages. The transformer reduces the voltage of the power supply (0-230 V) to the level (0-6 V). Then the secondary side

of the voltage converter is connected to the precision rectifier, which is built using an operational amplifier. The advantages of using a precision rectifier are that it outputs the peak voltage as DC; the rest of the circuits only output RMS.

The regulator IC packages contain the circuitry for the reference source, comparator amplifier, and controller and overload protection, all on a single IC. This circuit is used to control the motor in forward and reverse directions. The ON and OFF relay is controlled by the pair of switching transistors. A relay is nothing more than an electromagnetic switching device consisting of three pins. In the Figure 3, they are Common, Normally Closed (NC) and Normally Open (NO).The common pin of two relays is connected to the positive and negative terminals of the motor respectively through the overvoltage protection circuit. The relays are connected to the collector terminal of transistors T2 and T4. When a low pulse is applied to either the base of transistor T1 or transistor T3, the transistor turns off. Now 12V is given to the base of transistor T2 or T4, so the transistor conducts and the relay is switched on. The NO and NC pins of two relays are connected together, so only one relay can operate at a time. If the relay is switched on and off continuously, the back EMF in the relays can fail. When relay 1 is in ON state and relay 2 is in OFF state, the motor runs in the forward direction. When relay 2 is in ON state and relay 1 is in OFF state, the motor runs in reverse.

IV. HARDWARE DESIGN

The configuration of the proposed system is to clean the dust on the surface of solar panels. This leads to loss in generated electric power and formation of hotspots which can permanently damage the solar panel.

Table 4.1 Hardware Description

Hardware	Description
Arduino Uno R3	5V
LCD Display	4.7 – 5.3V
LDR sensor	3.3 – 5V
DC Motor	12VDC
Relay	5 V
IoT Module	3.3V

This project aims at developing an autonomous vacuum cleaning method which can be used on a regular basis to maximize the lifetime and efficiency of a solar panel. This system is implemented. A sun panel (photovoltaic module or photovoltaic module) is a packaged, interconnected array of sun cells, additionally known as photovoltaic cells. The sun panel is used as a thing of a bigger photovoltaic gadget to offer energy for industrial and home applications. Since a single solar panel can only generate a limited amount of electricity, many systems contain multiple modules. This is called a photovoltaic system. A photovoltaic system typically includes a row of solar modules, an inverter, batteries, and connection cables. Solar panels use mild energy (photons) from the solar to generate power via the photovoltaic effect. Crystalline silicon is commonly used in wafer form in photovoltaic (PV) modules and is derived from silicon, a commonly used semiconductor. The dust accumulated on solar panels forms a sticky layer which cannot be cleaned directly by using portable vacuum cleaners. Hence, a two stage cleaning process is implemented. The vacuum motor is used to create enough suction to collect the dust scattered on the solar panel. The presence of a sticky layer of dust on a smooth inclined surface adds to the problem of slipping. Therefore, to have better traction gripper wheels are used to traverse the solar panels. The robot is controlled using the Arduino Uno R3 microcontroller. It acts as the master control element of the robot. The robot is designed to minimize the total load in order to achieve higher efficiency and longer battery life. The maximum cleaning efficiency was almost 100%, when the initial loading of dust was 1 g/m2, which corresponds to the dust accumulated for three days.

The dust accumulation rate on the PV panels in the Middle East and North Africa regions is approximately 0.3 g/m2/day. One electrode is charged with a completely excessive terrible voltage, and the alternative electrodes are definitely charged, inflicting the dirt debris to be ejected from the panels. In an exceptional mechanism, dirt turned into eliminated with the aid of using an electric-powered curtain, with the distribution of the electrical discipline density. A control strategy is formulated to navigate the robot in the required path using an appropriate feedback mechanism. The battery voltage of the robot is determined periodically and if it goes below a set threshold, it returns to the docking station and charges

itself automatically using power drawn from the solar panels. The operation of the robotic vacuum cleaner has been verified and relevant results are presented. The DC charging circuit in the docking station is simulated in Proteus environment and is implemented in the hardware. An economical and robust Robotic Vacuum Cleaner which can clean arrays of solar panels.

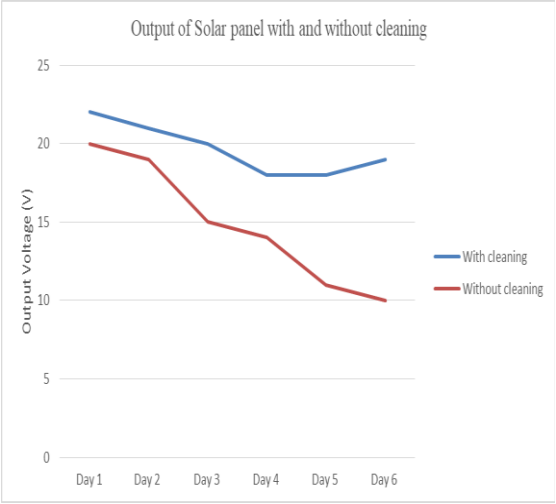
V. SOFTWARE DESIGN

SOFTWARE DESIGN Arduino Software (IDE): Arduino IDE is an open-source software mainly used for writing and compiling the code on the Arduino module. It's official Arduino software, making compiling the code so easy that even a non-technical layman can become familiar with the learning process. It is readily available for operating systems like MAC, Windows, and Linux and runs on the Java platform which has built-in functions and commands that play an important role in debugging, editing, and compiling code in the environment. A range of Arduino modules are available including Arduino UNO, Arduino Mega, and Arduino Leonardo. The main code created on the IDE platform, also called a sketch, ultimately generates a hexadecimal file, which is then transferred and loaded into the board driver. The IDE environment mainly consists of two basic parts: Editor and Compiler, where the first is used to write the required code and then to compile and upload the code to the given Arduino module. The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog. Beginning with version 1.0, files are saved with an .ino file extension. Previous versions use the .pde extension. You may still open .pde named files in version 1.0 and later, the software will automatically rename the extension to .ino.

VI. CONCLUSION

Finally, In the Figure 4, we can see that the system is working properly, and we can do a proper cleaning of the solar panel. In addition, this system works everywhere. By replacing the vacuum system, it can be designed for different types of solar panel installation such as residential rooftop, commercial rooftop, solar farm and carport in the future by using advanced technology. This also depends on the need for cleaning due to the continental climate and the type of soil. This model can be used on a small scale, e.g. as a solar pump, single plate cleaning, etc.

Fig 6.1 Proposed system



The above is the graphical representation of the proposed work, the solar panel with cleaning and without cleaning monitored by a week

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