AUTOMATIC SOLAR PANEL DRY CLEANING ROBOT

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Abstract**—**The dustiest places on Earth also happen to be some of the best places to capture solar energy. The amount of sunlight that reaches the solar cells is diminished by the dust that falls on solar panels as a result of neighbouring pollution and traffic. The effectiveness of solar panels reduces when dust particles are present. Experts agree that soiled solar panels do not produce as much energy as their pristine counterparts. When dust accumulates on a panel, its power output might decrease by as much as 50%. We propose a solar panel cleaning device to assure optimal power output from solar panels even when placed in dusty areas. This project makes use of an LDR sensor,
a relay, and a brush. If it's day or night outside, the LDR sensor can detect it. Depending on the sun's output, different levels of dust can be seen on the surface of the sun. When they detect dust, infrared sensors turn on an oscillating wiper to remove it. We are monitoring the PV voltage in this instance. The warning signal is transmitted by the GSM module and picmicrocontroller in this PV monitoring system.

Keywords—component, formatting, style, styling, insert (*key words****)***

I. INTRODUCTION

The global installation of solar panels has recently increased. Due to the 20–25 year lifespan of each solar park, it is essential to maximise power production while in regular operation. The amount of energy produced by solar photovoltaic modules is associated with the sun's available irradiance and spectrum content in addition to ambient, climatic, component performance, and intrinsic system parameters. Photovoltaic (PV) panels lose efficiency when dust and other debris collect on their surface. Commercial detergents are not only ineffective, but they may also harm the frames of dirty solar panels and take up valuable time. Regular solar panel cleaning is necessary to maintain maximum efficiency, which can be difficult for large solar panel arrays.An automated cleaning system (20,000 square metres) is needed for a sizable ground-based solar array, up to a functional park of 22,000 panels.
The production of electricity is a critical issue in many developing nations. The demand for power has grown as a result of the expansion of the manufacturing and retail industries. Since renewable energy sources produce clean energy and aid in meeting our overall energy needs, we should all be doing more to encourage their use. Long-term, this can assist society in reducing harmful emissions and protecting the ozone layer for future generations. The solar photovoltaic method is becoming more and more popular among them due to its wide availability, low cost, easy installation, and minimal maintenance needs.
When connected via a standard protocol and a cloud-based storage and processing system, ordinary devices have better functionality and usability, which is how the Internet of Things (IoT) works. Simple variables like pv voltage, temperature, and humidity all have an effect on the output of the solar panel. Therefore, a real-time solar monitoring system is essential for improving PV panel performance by comparing the results of experiments to initiate preventative action. The global installation of solar panels has recently increased. Due to the 20–25 year lifespan of each solar park, it is essential to maximise power production while in regular operation.
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II. LITERATURE SURVEY

[1] Manju B et.al "Automatic Solar Panel Cleaning System" International Journal of Advances in Scientific Research and Engineering (ijasre), July – 2018

Solar energy is now a source of renewable energy, and its use needs to be expanded. Typically, dusty settings, such those seen in tropical nations like India, are where solar PV modules are used. The dust builds up on the module's front surface and blocks the sun's incident light. It lowers the module's ability to generate power. If the module is not cleaned for a month, the power output can drop by up to 50%. The cleaning system was created to remove dust from the PV modules and clean the module by utilising Arduino programming to control it.

[2] Nurul F. Zainuddin et.al "Design and Development of Smart Self-Cleaning Solar Panel System" IEEE International Conference on Automatic Control and Intelligent Systems, 29 June 2019

A significant source of clean and renewable energy, solar power is essential in meeting future energy demands. However, accumulation of tiny dust, water droplets, and other airborne debris will hinder sunlight from reaching the solar cell's surface. This is a significant problem since the materials that block light act as an external impedance and reduce the performance of solar-powered photovoltaic systems. In this study, a flexible cleaning tool is created that travels the entire length of the solar panel.

The method described can also be used to monitor the amount of electricity produced by the solar cells, and when cleaning instructions are needed, Internet of Things (IOT) mobile applications can be used to activate them. The outcomes showed that the external resistance could decrease the solar panel's performance by up to 22%.

[3] Javad FarrokhiDerakhshandeh et.al " A comprehensive review of automatic cleaning systems of solar panels" Sustainable Energy Technologies and Assessments 47 (2021)

In order to address issues related to dust accumulation, this study covers the most modern and popular cleaning systems. The cleaning systems are often divided into two major categories: active and passive. There is a thorough analysis of the automatic cleaning systems. The characteristics of each system are described, and the benefits and drawbacks are carefully contrasted. When selecting the best cleaning system, factors such as cost, efficiency, water usage, cleaning time, and human intervention are taken into account. Both brushing and heliotex cleaning systems are efficient yet labor-intensive methods of cleaning. On the other hand, areas with a limited supply of water are advised to use electrostatic cleaning methods.Furthermore, robotic cleaning systems are not recommended for counties with windy climates due to their slow operation and high costs.

III. SYSTEM DESIGN

A.EXISTING SYSTEM

• Manual cleaning of solar panels was required with the previous system. Solar panels lose efficiency for a variety of reasons, such as human error, bird droppings, dust, and debris that builds up on the panels' surfaces.

• Additionally, since they are not routinely cleaned, solar panels suffer damage. Wear and tear brought on by mechanically cleaning the solar panels increases system losses as well.Additionally, the system efficiency is declining, making it less energy-efficient overall.

B.PROPOSED SYSTEM

A PIC microcontroller, a solar panel, a light-dependent resistor, a relay, an LCD display, and infrared (IR) technology are all components of the proposed system. This system's brain is the PIC microcontroller. To identify whether it is currently day or night in the atmosphere, an LDR is utilised. Data from the LDR and the solar panel are sent to the microcontroller using a voltage divider and an analogue to digital converter. A voltage divider is a passive linear circuit that generates an output value that is a percentage of its input voltage, as opposed to an ADC, which takes an analogue voltage and converts it to a digital number proportionate to its magnitude.

The system includes an infrared (IR) sensor that automates the cleaning process using appropriately designed wipers. During the wiper's sweep cycle, the action covers the surface of the panels. In a wiper system, a motor propels the wiper as it moves horizontally across the windscreen. The energy storage device, which is charged by the solar panel during the day, powers the motor at night.

The voltage sensors are used to determine the voltage of the panel. a solar PV module's effectiveness, The microcontroller is essential for processing and transmitting information to the user via the GSM module for real-time monitoring and decision-making.

By removing the dirt and dust that have been deposited on the solar panel, the suggested solar panel cleaning robot enables the solar panel to absorb the most energy possible. The cleaning robot and the carrier robot are the two key components of the suggested system.By travelling from one panel to another, the carrier robot performs the role of a carrier for a cleaning robot. Along with the carrier robot, the cleaning robot traverses the whole length of the panel.The cleaning robot's attached brush removes the dirt and dust from the panel.The robot's actions and movement from one panel to the next are controlled by software running on an Arduino and microcontroller.. The ability of the cleaning system to use a single robot to clean many solar farm panels serves as the primary design objective. A method like this is significantly simpler than having several robots operating simultaneously in the same farm. Since solar panels need to be cleaned regularly in practise, the procedure is more time-consuming and expensive.

BLOCK DIAGRAM

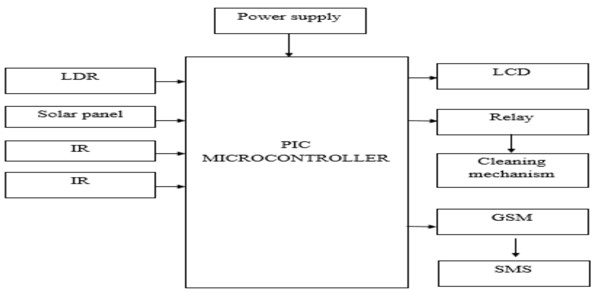


Fig 1.Block diagram of proposed system

IV. HARDWARE REQUIREMENTS

- Power supply
- PIC microcontroller
- LDR
- LCD
- Solar panel
- Relay board
- IR
- Voltage Divider

- DC Motor
- GSM module

A. DC MOTOR

As can be seen on the left, the relationship between torque, speed, and current is linear. As a motor's load increases, speed will decrease. The features of a typical motor are depicted in this graph. Long life and good performance can be anticipated if the motor is used in the high efficiency zone (shown by the darkened area). A motor in a locked rotor condition will quickly heat up and stop working if voltage is continuously provided to it. It is crucial that there be some sort of safeguard against sudden temperature increases. The fundamental rating point of a motor is a little less than the maximum efficiency point.

Fig 2. DC MOTOR

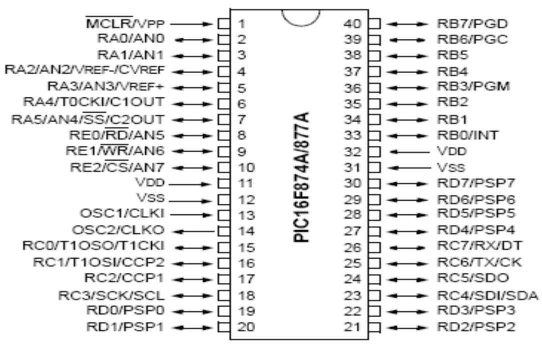
B.IR SENSOR

theInfrared light is produced by IR LED. The surface in front of LEDs is illuminated by this radiation. The amount of light reflected varies depending on the surface's reflectivity. The reverse biassed IR sensor is made to incidentally receive this reflected light. The quantity of electron-hole pairs produced is influenced by the strength of the incident IR radiation. So, when the strength of the incident ray changes, so will the voltage across the resistor.

Fig 3. IR SENSOR

C.PIC MICROCONTROLLER

The 16F877A PIC microcontroller is employed in this case. This plays a crucial function in processing the data that has been collected from the sensors and sending it to the Li-Fi module. Microcontrollers have advantages over traditional CPUs, including low power consumption and flexibility in connecting to other devices.



D.VOLTAGE DIVIDER

A voltage divider in electronics is a passive linear circuit that generates an output voltage (Vout) that is a portion of its input voltage (Vin). It is also referred to as a potential divider. The distribution of the input voltage among the divider's parts produces voltage division. Two resistors connected in series provide a straightforward voltage divider, with the input voltage applied across the pair and the output voltage arising from the connection between them.

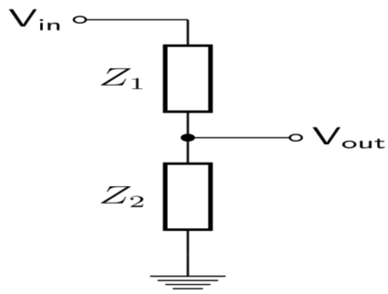


Fig 4.VOLTAGE DIVIDER

E.SOLAR PANEL

A solar panel really consists of a number of solar (or photovoltaic) cells that can produce power thanks to the photovoltaic effect. On the surface of solar panels, these cells are organised in a grid-like configuration. As a result, it might alternatively be described as a collection of photovoltaic modules put on a supporting framework. A 610 solar cell assembly that has been packaged and connected is known as a photovoltaic (PV) module.

Fig 5.SOLAR PANEL

F.RELAY BOARD

Relays are straightforward switches that can be controlled manually and electrically. Relays are made up of a collection of contacts and an electromagnet. The electromagnet is used to operate the switching mechanism. Relays are most commonly utilised in situations when a circuit can only be controlled by a low-power signal. It is also employed in situations when a limited number of circuits can be controlled by a single signal. They were utilised to change the signal's direction from one source to another. Relays used in high-end applications need to be operated by electric motors and other devices with high power. Contactors are the name for these relays.

Fig 6.RELAY BOARD

G.POWER SUPPLY

A power supply is a device or system that provides electrical or other types of energy to an output load or group of loads (also known as a power supply unit, or PSU). The phrase is most frequently used in reference to electrical energy sources, less frequently to mechanical ones, and infrequently to others.

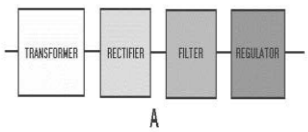


Fig 7. BLOCK DIAGRAM OF A BASIC POWER SUPPLY

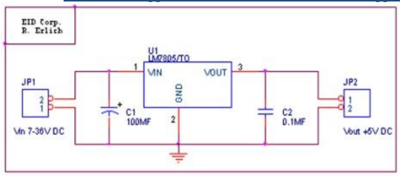


Fig 8. Circuit diagram of the power supply

H.16×2 LCD

Liquid crystal display is referred to as LCD. They come in a variety of sizes, including 8x1, 8x2, 10x2, 16x1, 16x2, 16x4, 24x2, 30x2, 32x2, and 40x2. To be employed in their products, numerous international corporations like Philips, Hitachi, and Panasonic manufacture their own unique type of LCDs. The same tasks are carried out by all LCDs, including displaying characters, numerals, special characters, ASCII characters, etc.They all have the same 14 pins (0–13) or 16 pins (0–15) and the same programming. Numerous devices, such as word processors, photocopiers, point-of-sale terminals, medical equipment, mobile phones, and palmtop computers all use alphanumeric displays.

Fig 9. LCD DISPLAY

I.GSM

The SIM Technology Group Ltd. (stock code: 2000. H.K) subsidiary SIMCom Wireless Solutions is a part of that company. It is a rapidly expanding wireless M2M company that creates and sells a range of wireless modules based on the technical platforms GSM/GPRS/EDGE, WCDMA/HSDPA, and TD-SCDMA. SIMCom Wireless offers specialised design solutions for M2M, WLL, mobile computing, GPS, and other applications through partnerships with third parties. Customers can also get ODM services from SIMCom Wireless. SIMCom Cellular Module, which acquired 20% of the global market share in 2008, was the world's second-largest provider of wireless modules, according to an ABI Insight research.

Fig 10. GSM

V. SOFTWARE REQUIREMENTS

- MPLAB-IDE.
- EMBEDDED C.

MP LAB

Microchip Technology created MPLAB, a proprietary freeware integrated development environment for creating embedded applications for PIC and dsPIC microcontrollers. Microchip's 8-bit PIC and AVR (including ATMEGA) microcontrollers, 16-bit PIC24 and dsPIC microcontrollers, 32-bit SAM (ARM) and PIC32 (MIPS) microcontrollers, and MPLAB and MPLAB X offer project management, code editing, debugging, and programming.The MPLAB ICD 3 and MPLAB REAL ICE are two examples of MPLAB-certified hardware that may be used to programme and debug PIC microcontrollers using a personal computer. MPLAB also offers assistance to PICKit programmers.With the MPLAB Code Configurator and MPLAB Harmony Configurator plugins, MPLAB X provides automatic code generation.For programme storage, early PIC models used read-only memory (ROM) or field-programmable EPROM, some of which featured features for memory erasure. All contemporary models store programmes in flash memory, and later models enable PIC self-reprogramming. Data memory is independent from programme memory. Data memory is 8-bit, 16-bit, and 32-bit wide in the most recent versions. Programme instructions can be 12, 14, 16, or 24 bits long, depending on the PIC family. Model-specific differences in the instruction set include the addition of instructions for digital signal processing in more powerful CPUs.The hardware of PIC devices includes discrete I/O pins, ADC and DAC modules, and communication ports like UART, I2C, CAN, and even USB. It also includes 6-pin SMD, 8-pin DIP, and 144-pin SMD chips. For several types, low-power and high-speed versions exist. Assemblers, C/C++ compilers, programmer/debugger hardware, MPLAB and PICKit series compilers, and MPLAB X development computer software are all offered by the manufacturer. There are also several open-source and third-party tools available. Some components can be programmed in-circuit; both high-production and low-cost development programmers are available.Due to its low price, widespread availability, broad user base, extensive library of application notes, accessibility to inexpensive or free development tools, serial programming ability, and reprogrammable Flash memory, PIC devices are well-liked by both industrial developers and amateurs.

EMBEDDED C

The C Standards Committee created Embedded C as a set of language extensions for the C programming language to solve issues of commonality between Cextensions for various embedded devices.

The C language has traditionally needed nonstandard extensions to implement exotic features like fixed-point arithmetic, many separate memory banks, and fundamental I/O operations. The C Standards Committee expanded the C language in 2008 to solve these problems by establishing a uniform standard that all implementations must follow. It offers a variety of features not found in standard C, such as named address spaces, fixed-point arithmetic, and fundamental I/O hardware addressing. The majority of the syntax and semantics found in standard C are used by embedded C, including the main() function, variable definition, data type declaration, conditional statements (if, switch case), loops (while, for), functions, arrays and strings, structures and unions, bit operations, macros, etc.

VI. CONCLUSION

In addition to producing biomass, wind, hydropower, and wave energy, solar energy represents a huge source of immediately usableenergy. The outcome demonstrates that the created solar panel cleaning robot can efficiently clean the panel and, after the dust on the PV panel is cleaned, boost back the output current as well as the maximum power of the panel by 50%. In order to gather and analyse solar energy characteristics for performance prediction and dependable power generation, this research suggests a solar energy monitoring system. This project makes use of an LDR sensor, a relay, and a brush. If it's day or night outside, the LDR sensor can detect it. Different levels of dust can be seen on the sun's surface, including.Depending on the sun's output, different levels of dust can be seen on the surface of the sun. When they detect dust, infrared sensors turn on an oscillating wiper to remove it.

VII.RESULT

The measured data is tabulated in Table 1. The calculated real power and efficienciesobtained from the measured voltage and current is provided in Table 2. Figure 2 provides the current versus voltage (I-V) characteristic of the undusted, dusty andcleaned solar panel. From the data given in Table 2, the current decreased by almost 20% when the solar panel was covered by dust. The real power provided by the solar panel also decreased linearly with the reduction of the current. Then the cleaning process was done by using the developed robot. After the dust cleaning process, the current increased back almost by 20%. From the data given in Table 2 fig 3 is created. It shows the improved efficiency of solar panel using robot. These conditions can be seen from the data provided in Table 1 and Table 2. The solar panel used is 180W 36 cell 12v nominal solar panel having specifications:

- Maximum Power Output = 180 Watt
- Maximum Voltage = 18.95 volt

Time	Before Dust		During Dust		After Cleaning	
	Voltage(v)	Current(A)	Voltage(v)	Current(A)	Voltage(v)	Current(A)
11.00 AM	17.80	4.80	14.24	3.84	17.44	4.70
12.00 PM	18.80	4.82	15.04	3.85	18.42	4.72
01.00 PM	18.00	4.70	14.04	3.76	17.64	4.60
02.00 PM	17.10	4.60	13.68	3.68	16.75	4.50

Table 1: Measured Voltage and Current of Tested Solar Panel

Time	Before Dust		During Dust		After Cleaning	
	Voltage(v)	Current(A)	Voltage(v)	Current(A)	Voltage(v)	Current(A)
11.00 AM	17.80	4.80	14.24	3.84	17.44	4.70
12.00 PM	18.80	4.82	15.04	3.85	18.42	4.72
01.00 PM	18.00	4.70	14.04	3.76	17.64	4.60
02.00 PM	17.10	4.60	13.68	3.68	16.75	4.50

Table 2: Calculated Real Power And Efficiency Of Tested Solar Panel.

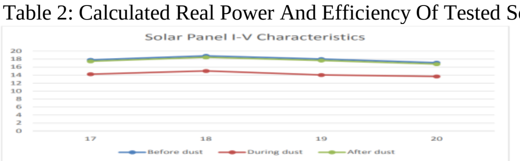


Fig 11. SOLAR PANEL V-I CHARACTERISTICS

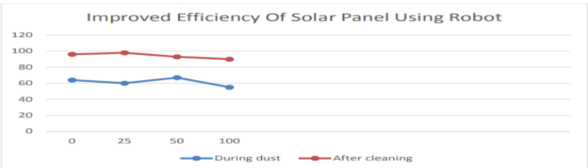


Fig12 IMPROVED EFFICIENCY OF SOLAR PANEL USING ROBOT

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