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# AUTOMATIC SOLAR PANEL CLEANING SYSTEM

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***Abstract:*** The adoption of solar energy is increasing rapidly worldwide due to its renewable and eco-friendly nature. However, the efficiency of solar panels can be significantly impacted by dust, debris, and other environmental factors. To address this issue, an automated solar panel cleaning system is proposed. This system utilizes a combination of sensors, actuators, and a control unit to autonomously detect the level of dirt on solar panels and initiate cleaning operations accordingly. The system employs techniques cleaning the system automatically when the voltage of the panel falls beyond certain limits of the threshold voltage by using different equipments which in term makes this automation successful.This cleaning mechanism that we are developing only allows the cleaning of the panel only for one time in a day because simultaneous cleaning of the system requires more energy which leads to losses. By automating the cleaning process, the system reduces manual labour, ensures consistent cleaning intervals, and maximizes the energy output of solar installations. Additionally, it contributes to prolonging the lifespan of solar panels and minimizing maintenance costs. This abstract highlights the significance of automated cleaning systems in enhancing the performance and longevity of solar energy systems, ultimately promoting the widespread adoption of renewable energy sources.

***Index Terms*** **-** Solar Panel, LDR Sensor, Voltage Sensing Module, Analog to Digital Converter, Micro-controller, L293D"H"Bridge, DC motors, Rack and Pinion Mechanism, Sliding Mechanism, Limit Switches, Cleaning Unit, Power Source.

## I. INTRODUCTION

This project sets out to develop a fully automated system for handling automatic solar panel cleaning mechanism by using the data provided by the voltage sensing circuit which in term converted in to the digital data by analog to digital converter.Where the data will be moved to micro controller where the movement of the cleaning unit depends the micro controller units output if the voltage falls beyond the levels of the threshold the cleaning is to be done otherwise the cleaning will not takes place . The cleaning system of the solar panel is done with help of H bridge IC where it controls the movement of the DC motor to move in clock wise or in anti clock wise direction to clean the panel. The movement of the cleaning system is controlled by the limiting switches ,these help to reverse t the direction of the motor by changing the input H bridge IC.The entire cleaning system takes or utilizes the energy from the stored solar energy and does not takes the energy from the outside power source. Ultimately, the project seeks to explore control theory applicable to micro-controller-based systems, underscoring the importance of fully utilizing the capabilities of such systems.

## II. FUNCTIONAL DESCRIPTION OF THE PROJECT

This section of the project aims to elucidate the functional operation of the system in a step-by-step manner, breaking it down into comprehensible blocks. Through a thorough examination of this explanation, readers can grasp the foundational aspects of the project. Let's delve into the essence of each block, illuminating the core concepts behind the project's functionality.

### 2.1 Solar Panel

The solar panel with a rating of 12v 22watts is considered this means this panel can produce maximum power output of 22watts when exposed to full sunlight and its voltage output is around 12volts.This type of panels are only used for small scale applications but not for the big applications as the ratings are very low. The physical dimensions varies with the manufactures but the common dimensions or the most used dimensions for this rating solar panel is around 435mm X 350mm(17.1 inches X 13.8 inches)with a thickness around 18mm(0.7 inches). It nearly weights up to 1.5- 2.0 Kilo grams. Solar panel is used for the power generation and generation of power depends on the various factors like light intensity, weather conditions, position of the sun etc. The energy generated by the panels is stored and used for various purposes.

### 2.2 LDR Sensor( Light Dependent Resistor)

This sensor stands for light dependent resistor it is called with different names one such name is photo resistor because the resistance of the sensor changes based on the amount of light that the sensor is receiving. It is made up of semiconductor devices like calcium sulphide or cadmium selenide and it is a passive component .LDR sensor works by converting the amount of light that fall on the sensor in to the value of the resistance. The amount of light fall on the LDR sensor is inversely proportional to the value of the resistance of the LDR sensor I.e the resistance of the decreases with the increase of light intensity on the LDR sensor. In this project we use this property of the LDR sensor for triggering the cleaning system. So, when no light falls on the LDR sensor there is no reading of the voltage in the system but when the light falls on the sensor then the voltage sensing unit reads the data which proceeds to the first step where micro controller unit decides whether to clean panel or not.

### 2.3 Voltage Sensing Module

The voltage sensing module is a device which is used to measure or to supervise the voltage levels in the circuit. It is used in the circuits for the smooth functioning of the circuit with proper voltage levels within the specified ranges. The output of the voltage sensor is analog this not only measures voltage levels it may also provide over voltage protection, under voltage protection etc . In this project we use voltage sensor in order to read the voltage of the solar panel. As the output of the voltage sensor is analog this is combined with ADC unit where it helps in conversion of the analog data in to digital data and this output of voltage sensing unit id fed to micro controller that monitors the voltage and performs the operation defined in the program.

In this we will set certain threshold voltage for the panel i.e as the rated voltage of the panel is 12v we will set the threshold voltage of the panel as the 10v. If the voltage falls below the 10v then the system is triggered or the system is allowed to perform the task.

### 2.4 Analog to Digital Converter

In this project the ADC is integrated with the voltage sensor the final output of the solar panel is measured by the voltage sensor and this measured voltage is in analog for , this analog data of the voltage sensor is comverted in to digital data by this ADC and this converted data will be fed to the micro controller unit. Conversion of analog data in to digital data is very important because micro controller will not accept the analog data. The A/D converter used in this project is having 8-channels,and out of 8 channels 1 channel is used in our application I.e measuring the panel voltage .This channel depends on the address selection sent by the micro controller.This ADC is having three address inputs to select one out of eight channels of the ADC.

### 2.5 Micro-Controller

In this project work 89C51 controller is used.The ATMEL AT89C51 is a popular micro controller developed by Intel. It belongs to the MCS-51 family of micro controllers and is widely used in various embedded systems and applications. The 89C51 features a 4 KB ROM for program storage, 128 bytes of RAM, and 32 I/O lines. It also includes on-chip timers, serial communication interfaces, and other peripherals, making it suitable for a wide range of tasks. The 89C51 is known for its simplicity, reliability, and ease of use, making it a preferred choice for many embedded projects, including automation, control systems, and sensor interfacing.

It consists of different units like memory unit, central processing unit, bus, input-output unit. The memory unit of the AT89C51 provides the necessary storage space for program code, data, and control registers required for embedded system operation.. The CPU of the AT89C51 provides the processing power and capabilities required to execute embedded software, control external peripherals, and respond to real-time events in embedded systems.The bus in micro controller refers to data bus and address bus which are crucial components

for communication between CPU, memory and peripherals. Together, the data bus and address bus form the main communication channels within the micro controller, enabling the CPU to execute instructions, access data, and communicate with external peripherals and memory devices.The input-output unit provides the necessary interfaces and functionality to communicate with external devices like sensors, actuators, displays and communication modules, enabling wide range of embedded applications and system integration.

The controller will be given input from the voltage sensing circuit of the panel, by which the controller will understand when the DC motor is to be operated . Which will be defined in the controller programming. The controller unit checks the panel voltage and controls the brush movement using limit switches.

### 2.6 L293D "H" Bridge IC

The L293D is a popular integrated circuit (IC) that is commonly used as an H-bridge driver. An H-bridge is a circuit configuration that allows control of the direction and speed of a DC motor. The L293D contains two H-bridge circuits, which means it can control two DC motors independently or one stepper motor. It can drive DC motors with voltages up to 36V and continuous current up to 600mA (per channel) and peak current up to 1.2A (per channel). The H-bridge configuration allows for bidirectional control of the motor's rotation, enabling forward, reverse, and braking operations.

In this project we use a 2 DC motors one motor for the movement of brush in forward and backward direction and other motor is used for controlling the direction of rotation of the brush that is clock-wise and anti-clock wise. This direction of the motor will be decides by the input given by the micro controller to the "H" bridge this in term decided by the limit switches.

### 2.7 DC Motor-30 RPM- 12 Volts

In this project the one DC motor we use of rating 30RPM and 12 Volts geared DC motor.It is a simple DC motor with a gearbox attached to it . Attaching a gear box to the dc motor provides versatility and flexibility in adapting the motor's output to meet the requirements of the application, including speed, torque, direction etc. This dc motor is used for the brush as it is attached to the brush it helps the brush to rotate in clock wise while moving forward and in anti clock wise while moving back wards.

### 2.8 DC Motor -10 RPM- 12 Volts

Another DC motor used in this project is geared DC motor whose RPM is 10 and voltage is of 12 volts. This dc motor is used to move the brush in forward and in backward direction . This movement is also controlled by the input given to the "H" bridge from the micro controller unit. Limit switches will also a play a key role in controlling the output of the micro controller unit as it decides the direction.

### 2.9 Rack and Pinion

A rack and pinion system is a type of linear motion mechanism commonly used for converting rotational motion into linear motion. It consists of two main components called Rack and Pinion. The rack is a linear gear with teeth along its length. It typically resembles a straight bar or rod with teeth cut into one side. The rack is stationary and provides a linear track for motion.The pinion is a gear with teeth that mesh with the teeth of the rack. It is mounted on a rotating shaft, such as a motor shaft. When the pinion rotates, it engages with the teeth of the rack, causing the rack to move linearly along its length.

In this project rack and pinion is used for conversion of rotational motor of 10 RPM DC motor in to linear motion which in term helps in movement of DC motor in forward direction and backward direction.

### 2.10 Sliding Mechanism

A sliding mechanism is a type of mechanical system that enables linear motion along fixed track guide. It allows objects to move smoothly back and forth ,side to side or in other linear directions.The combination of rack and pinion and sliding mechanism can be used to produce both rotational and linear motion in a single system. The combination of rack and pinion and sliding mechanism can be used in a system that requires linear motion for the movement of load and rotational motion to drive the brush . THe pinion gear is mounted on the rotary motor ,which drives the rack along the guide to produce linear motion, at the same time pinion gear can also engage with another gear to produce rotary motion for driving other components.

### 2.11 Limit Switches

In this project limit switches are used to control the direction of the DC motor by stopping its movement and reversing its movement when the switch is triggered .Actually these limit switches are connected at the both ends of the DC motor travel path .When motor reaches one of the limit switches, it stops and triggers the switch which interrupts the flow of current in the motor. The motor controller then reverses the polarity of the voltage applied to the motor, causing it to spin in the opposite direction.

### 2.12 Cleaning Unit

Cleaning unit is responsible for taking action for the cleaning of solar panel. Cleaning unit consists of two parts they are cleaning brush and linear actuator. Cleaning brush is responsible for swiping or cleaning away the dust present on the panel and this brush is attached to the v-slot gantry plate platform which moves in the linear actuator.The brush is rotated with the help of 12volts DC motor

### 2.13 Power Source

Power source consists of 4volts battery connected in series and of 2 Ah current , this energy is stored energy which was generated by the solar panel. It also consists of voltage regulator where it is used to maintain constant voltage level in the electrical circuit .the output voltage fed to all the components in the circuit is 5 volts but the output voltage fed to the DC motor is of 12volts .

### 2.14 Blue-Tooth Module

A Blue-tooth module is a small electronic device that enables wireless communication between electronic devices over short distances. It uses Blue-tooth technology to establish a connection and exchange data between devices such as smart phones, laptops, tablets, and other peripherals. Blue-tooth modules are commonly used in various applications, including wireless audio streaming, data transfer between devices, Internet of Things projects, and remote control systems.In this project we can able to see the status of the cleaning system using the blue-tooth module. It shows the current voltage of the panel and it show whether to initiate the cleaning or should not initiate the cleaning it also shows if the cleaning is completed.

## III. WORKING PROCESS

The Automatic solar panel cleaning system working process involves mutual interaction between all the components . The solar panels converts the solar energy in to electrical energy and this energy is stored in batteries and this stored energy is given as supply for cleaning system. At first when the light falls on the LDR sensor then the voltage sensing circuit senses the voltage this analog voltage value is converted in to digital value by A/D converter and this will be fed to micro controller initially certain threshold value of voltage will be set if the measured voltage is greater then the threshold voltage no cleaning takes place but if it less then the threshold voltage value then the cleaning of the panel takes place.If the value sent by the A/D converter is less than the threshold voltage value then the micro controller will send the signal to the “H” bridge IC the “H” bridge IC triggers the movement of the motor then the brush moves on the rack and pinion in sliding mechanism, and when the motor touches the limit switches the direction of the motion of the motor reverses in this way it comes back to its original position.If we want to see the values and working of this cleaning system we can connect our mobile to the blue-tooth modules check how the work goes. This cleaning is done only once in a day the next cleaning is done on the next day

## IV. APPLICATIONS

Automatic solar panel cleaning systems are increasingly being deployed across various applications to maximize the efficiency and longevity of solar energy installations. In commercial and industrial settings, where large-scale solar arrays are common, these systems play a crucial role in ensuring optimal energy production. By regularly removing dust, dirt, and debris from solar panels, automatic cleaning systems help maintain peak performance, thereby increasing energy output and reducing downtime. Moreover, in remote or hard-to-reach locations, where manual cleaning is impractical or costly, these automated systems offer a cost-effective solution. Additionally, for residential solar installations, automatic cleaning systems provide home-owners with peace of mind, knowing that their investment in renewable energy is being efficiently maintained. Overall, the applications of automatic solar panel cleaning systems span a wide range of sectors, contributing to enhanced energy generation, reduced maintenance costs, and greater sustainability in the renewable energy landscape.

## V. LIMITATONS

Despite their benefits, automatic solar panel cleaning systems also have limitations that need to be considered. Firstly, the initial cost of installing these systems can be relatively high, which may deter some users, especially for smaller-scale installations. Additionally, while automatic cleaning systems can effectively remove dust and debris, they may struggle to address more stubborn contaminants such as bird droppings or tree sap, requiring occasional manual intervention. Furthermore, the mechanical components of automatic cleaning systems are subject to wear and tear over time, necessitating regular maintenance and potentially increasing long-term operating costs. Finally, the energy consumption associated with operating these systems, particularly in off-grid or remote locations, should be taken into account, as it may offset some of the energy savings gained from improved panel efficiency. Despite these limitations, automatic solar panel cleaning systems remain a valuable tool for enhancing the performance and reliability of solar energy systems, especially in environments prone to dust and dirt accumulation.

## VI. FUTURE SCOPE

.The future development of automatic solar panel cleaning systems lies in their integration with renewable energy and smart grid technologies. As the energy landscape evolves towards decentralized and interconnected systems, there is potential for solar panel cleaning systems to become an integral part of smart energy management solutions. For example, these systems could be equipped with sensors and communication capabilities to not only monitor the cleanliness of solar panels but also to interact with other components of the energy system, such as energy storage systems and grid infrastructure. By leverage real-time data and predictive analytic, these integrated systems could optimize energy production, storage, and distribution, leading to improved overall system efficiency and reliability. Additionally, advancements in robotics and drone technology may enable the development of autonomous cleaning fleets capable of servicing large-scale solar installations more efficiently and cost-effectively. Furthermore, with the increasing focus on sustainability and circular economy principles, there is potential for the development of self-sustaining cleaning systems that utilize renewable energy sources, such as solar or wind power, to operate autonomously without relying on external resources. By exploring these interdisciplinary approaches, the future of automatic solar panel cleaning systems holds the promise of not only enhancing the performance of solar energy systems but also contributing to the transformation of the broader energy landscape towards a more sustainable and resilient future.

## VII. CONCLUSION

In conclusion, automatic solar panel cleaning systems represent a vital component in ensuring the efficiency, longevity, and sustainability of solar energy installations. While they face challenges such as initial costs, water usage, and maintenance requirements, ongoing advancements in technology offer promising solutions to overcome these limitations. As the demand for clean energy grows and the world transitions towards renewable sources, automatic cleaning systems will continue to play a pivotal role in maximizing the performance of solar panels. By leveraging innovations in materials science, robotics, and smart grid technologies, these systems hold the potential to further optimize energy production, reduce environmental impact, and contribute to a more resilient and sustainable energy future.

## REFERENCES

While designing and fabrication of this project work,we gathered information from websites & consulted experts in various fields. This information is gathered from yahoo.com search engine.Regarding automatic solar panel cleaning system using micro controller plenty of books are available, The following are the references made during design, development and fabrication of the project

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