

SMART IOT BASED SOLAR PANEL CLEANING SYSTEM

Abstract:

The power generation efficiency of solar panels is hampered by high dust build up and bird dropping, Since the output power in solar system is depending on the intensity of light falling on it, when these modules are utilized in dust environment, there occurs a tidy piece of dust on the solar panel which will try to reduce its efficiency and productivity. Manually cleaning a solar panel is time – consuming and difficult. So, this problem can be avoided by having suitable cleaning system for panel. This study suggests a brush –based programmed system using IOT technology for cleaning solar panels. The microcontroller and an android device are used to control the system. The proposed wor provides automatic tracking of solar light using light intensity diode and direct the panel according to it and if there is any dust and dirt present in the panel, automatic cleaning system is used for cleaning purpose. This technique will lead to increased output power. Suitable sensors are used for detecting the dust and this arrangement is connected to the controller. It offers a higher integrity, consistency, cost- effective and scalable solution for the elimination of dust and speck. The amount of labor required to clean solar panels is also reduced by this technology.

Keywords: Solar Panel, Microcontroller, IOT, Sensors, Cleaning, Automation.

1. INTRODUCITON

Traditional solar cleaning and monitoring system have some limitation, such as high cost ,complexity, and low accuracy compared to automated solar panel cleaning system is to achieve this target , there is a need for efficient and cost effective solution to enhancing the performance of solar panel and increase their output. Conventionally, the panels are cleaned with water and the process is labor intensive and is proven to be expensive in large scale solar panel system. a wiper and water spray are cleaning the solar panel .internet of things (IOT) emerges as a transformative technology, enhancing the functionality of everyday objects by networking them through a common protocol and utilizing cloud based storage and processing system .real time solar monitoring system , enabled by IOT, become essential in optimizing solar panel performance press monitoring

parameters such as voltage , temperature , and humidity in real time allows for data driven decision making and proactive measures to maintain peak efficiency contributing to the long term reduction of harmful emission and the preservation of ozone layer. we are developed automated solar panel cleaning system using IOT, providing transparency and control through a mobile application. The system included sensors for monitoring and predicting the suitable time for cleaning actions, offering in potential solution for large scale farms. Over all, these studies emphasize the importance of automated cleaning system in maintaining the efficiency of solar panels, particularly in regions with challenging environmental conditions. the integration of IOT and advanced technologies further enhances the monitoring and effectiveness of

the system. compared to manual cleaning has challenges such as risk of employees injuries and panel damage, movements difficulties, and poor maintenance, etc. the performance of solar panels is greatly impacted by dust collection.

processor of the autonomous unit. as renewable source like solar power become more integral to global energy strategies, the adoption of IOT-enabled automatic cleaning system become a crucial step towards sustainable and efficient energy production by harnessing the power of optimization techniques and IOT connectivity, solar panel cleaning can be streamlined, efficient and environmentally friendly, solidifying the place of solar energy as a key player in the transition to a greener and more sustainable future.

2. OBJECTIVES

- To design and develop the solar panel cleaning system
- To analysis the efficiency of IOT based solar panel.
- To analysis the energy conservation with dusted solar panel

2. LITERATURE REVIEW

Muhammad ahmad baballe et.al.,(2024) entitled as “implementation guidelines for an automated solar panel cleaning system”When compared to water-based cleaning, dry cleaning is less efficient. This is because dust particles are more able to be transported away from the modules by fluids like water. The robotic devices have a significant upfront cost. Consequently, it is not ideal for home system. The operation robotic cleaners requires electricity. The additional expense of this electricity mounts up. Since robotic technology is relatively new, there is still a great deal of research development (R&D) to be done in this field. Artificial intelligence and other sophisticated technologies are still needed for this machine.

Dhanashri ingole et.al.,(2023) entitled as "IOT based solar panel cleaning system” The design prototype is to clean the solar panel using an electrical mechanism, such that efficiency or quality of solar panel is not compromised. In Saudi Arabia are facing a lot of dust storms and the solar panels need to be cleaned frequently. If task is performed manually, it will be very costly and time consuming. Water sprinklers and a special wiping material shall be used in the conceived mechanism design to insure quality of cleaning. If the panel isn't wiped clean then 50% of the module performance might be reduced .The 8051 microcontroller is used to control the tools motors

and to implement the automated gadget. The mechanism consists of a sensor and also consist of the sliding brushes while cleansing the PV module. The analysis of the dust can be examined below the different conditions with the deposition of the unique pollutants like ash, sand, silica, calcium carbonate and crimson soil.

Satish A.patil et.al.,(2023) entitled as“ Design and analysis of automated solar panel cleaning system” The reduction in the peak power generation can be upto 10-30%.Power reduction was observed due to dust accumulation on the panels and this can be improved by using robotic cleaning method .It has increased power generation capacity of the solar panels. The issues varies based on the specific surrounding of the installation sites. Industrial areas might emit various particles such as fly ash and brick powder, whereas areas with low buildings and residential zones could face issues like bird droppings. Dry regions like deserts are susceptible to sand accumulation due to frequent sandstorms.

Nasib khadka et.al., (2020) entitled as “smart solar photovoltaic panel cleaning system” Solar photovoltaic energy is harnessed from solar radiation for a monocrystalline solar PV panel under standard test condition , its seen that only 15-18% of solar radiation is utilized to produce electricity Achieving maximum efficiency has been a challenge and this efficiency changes due to several factor like lower irradiance, higher air mass, higher temperature,regardless of this solar radiance is failed to be harnessed due to accumulation of foreign particles like dust, bird excrement ,snow and many other. Large scale PV system are immensely affected by dust deposition on solar panel .Conventionally, the panels are cleaned with water and the process is labor- intensive and is proven to be expensive in large scale PV systems.

3. PROBLEM IDENTIFICATION

- Reduce panel efficiency, especially in dry and desert areas.
- Using the wrong cleaning tools or excessive pressure can cause scratches or cracks.
- Traditional cleaning methods consume large amount of water.

4. METHODOLOGY

- Problem Identification
- Literature Review
- Design study
- Components Selection

- Fabrication Process
- Field testing & Analysis

5.DESIGN OF THE MACHINE

MANUFACTURING PROCESS

Manufacturing processes are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the creation of the materials from which the design is made. These materials are then modified through manufacturing processes to become the required part. Manufacturing processes can include treating (such as heat treating or coating), machining, or reshaping the material.

The manufacturing process also includes tests and checks for quality assurance during or after the manufacturing, and planning the production process prior to manufacturing.

CUTTING

Cutting the stand at the centre for solar panel fixing. The solar panel fixing at the centre of the stand. Stand is a crucial part of the fabrication process to ensure proper fit, alignment, and structural stability.

WELDING

The welding process for fixing a solar panel onto a stand primarily involves arc welding techniques such as MIG (Metal Inert Gas) welding or TIG (Tungsten Inert Gas) welding. These methods are used to fabricate and secure the metal mounting structure, ensuring durability and stability. The stand, usually made of galvanized steel or aluminum, is welded together to form a strong framework that can withstand environmental conditions like wind and rain. Spot welding may also be used to reinforce joints in pre-fabricated structures. After welding, anti-corrosion coatings are applied to prevent rusting. The solar panel is then fixed onto the welded stand using bolts and clamps, ensuring it is securely mounted without damaging the panel itself.

GRINDING

Grinding of a solar panel is not a standard process in its installation or maintenance, as solar panels are delicate and made of tempered glass, silicon cells,

and protective layers. However, in solar panel manufacturing, grinding is used in the edge trimming process to smooth and shape the glass, ensuring uniformity and preventing sharp edges that could lead to breakage. Special diamond grinding wheels or precision grinding machines are used to achieve smooth, polished edges without damaging the panel's structure.

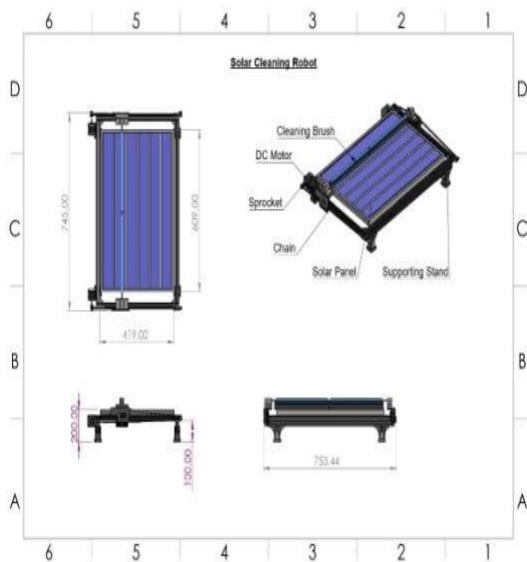
Additionally, in rare cases, grinding may be required to remove surface defects from the frame or mounting structures, but extreme caution is needed to avoid weakening the panel.

PAINTING

Painting the solar panel stand is an essential step to protect it from corrosion and enhance its durability. The stand, usually made of galvanized steel or aluminum, is first cleaned to remove dust, grease, or rust. A primer coat is applied to improve paint adhesion and provide an extra layer of protection against moisture. After the primer dries, a weather-resistant paint, such as epoxy or polyurethane-based paint, is used to coat the structure. This helps the stand withstand harsh environmental conditions, including rain, UV exposure, and humidity. In some cases, powder coating is preferred over traditional painting for better durability and a uniform finish. Properly painted stands ensure a longer lifespan and stable support for the solar panels.

IOT IMPLEMENTATION

It is an IOT server that provides free IOT App server facilities shows the IOT server monitoring interface from where the generated voltage status and connection status can be monitored. If the automated cleaning system does not work properly, then it can be handled manually by using the ON/OFF button of the interface displayed on the smartphone's screen. This screen shows the corresponding branch connection status. The red color circle represents the disconnection or short circuit condition of the branch, and the white color represents the normal connection of the branch.



6. COMPONENTS

- Temperature sensor
- Solar panel
- Arduino Uno
- Dc motor
- Dc water pump
- LCD display
- Relay
- Battery
- Cycle chain & sprocket
- Blower
- IOT
- Limit switch
- Humidity sensor
- LDR switch

7. WORKING PRINCIPLE

The potential transformer will step down the power supply voltage (0-230V) to (0-9V & 15-0-15V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op- amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corner. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B.

the positive potential at point A will forward bias D3 and reverse bias D4. The negative potential at point B will forward bias D1 and reverse D2. At this time D3 current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. this path is indicated by the solid arrows. Waveforms (1) and (2) can be observed across D1 and D3.

One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A.

fig.2 Solar Panel Tracking System Prototype with Mechanical Movement Mechanism



This path is indicated by the broken arrows. Waveforms (3) and (4) can be observed across D2 and D4. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5).

Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

8. RESULT AND DISCUSSION

The IOT-based solar panel cleaning system efficiently removes dust and debris, ensuring optimal energy generation and reducing manual maintenance efforts.

By integrating Arduino, sensors, a DC motor, a water pump, and IOT connectivity, the system enables automated operation and real-time monitoring. The LDR sensor detects day or night, while the voltage sensor monitors power output, triggering the cleaning mechanism when necessary. Additionally, temperature and humidity sensors provide environmental data to enhance system efficiency. The use of IoT allows remote monitoring through a mobile app, making the system user-friendly, cost effective, and sustainable. With optimized water usage and reduced human intervention, this smart cleaning solution enhances the lifespan and performance of solar panels, making it an ideal choice for residential, industrial, and large-scale solar farms. A considerable and encouraging outcome has been obtained from an automated solar panel cleaning initiative, the initiative decreased reliance on traditional energy sources by incorporating renewable energy sources. Customers saved a significant amount of money as a result, and by lowering carbon emissions, improved the energy supply chain. Furthermore, because PV system have a balanced energy flow. More clean solar electricity may be produced with less manpower working when real-time monitoring and precise values are used. The outcomes brought to light the significance of this scheme in promoting the use of renewable energy, reducing environmental impact, and creating a more robust and efficient energy infrastructure.

By introducing a more efficient logistic system, it will be possible to use the collected data more efficiently. As it is an IOT-based system, the platform is open and flexible and can be continuously upgraded to improve the system’s performance. By incorporating many more features, the system will help create various future opportunities. With more features, machine learning, deep learning, more updated dust detection sensors, and customized efficient cleaning brushes can build an efficient cleaning system to improve solar power generation.

9. COMPARISON OF DUSTED &CLEANED SOLAR PANEL



fig.3 Comparison of dusted solar panel VS cleaned solar panel

10. CALCULATION

day	Tym (hrs)	Voltage (v)	Current (amp)	Power output	Daily energy	W used
1	5	17.0	1.15	19.55	97.75	0.2lit
2	5	17.0	1.16	19.72	98.6	0.2lit
3	5	17.1	1.17	20.01	100.05	0.2lit
4	5	17.0	1.15	19.55	97.75	0.2lit
5	5	17.0	1.16	19.72	98.6	0.2lit
6	5	17.1	1.18	20.18	100.9	0.2lit
7	5	17.0	1.15	19.55	97.75	0.2lit

Average efficiency dirty panel = 70.07
 Average efficiency cleaned panel = 98.77%
 Total efficiency gain (98.77-70.77) = 20.7%

table 1: Daily Solar Energy Output and Consumption Data

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