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A Review on Photovoltaic Model Cleaning Robot

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Abstract: *The PV Sun oriented Board made a difference us tackle the control of the sun and change over it intoelectrical vitality with adequate productivity and comfort. Sun powered vitality is one of the most solid and maintainable sources of renewable vitality. But the productivity is unfavorably influenced by the collection of tidy, fog, winged creature droppings, and snow and in this manner it is the require of the hour to have normal cleaning of sun oriented boards. Along with the planned cleaning, it is moreover basic to have fitting and viable sun based board cleaning. Customarily, Sun powered boards are cleaned physically. The impediments of manual cleaning are non-uniform cleaning, detachment, harm to boards, hazard of human casualties (particularly in roof- top boards) and development troubles. The labour-hire is too a lumbering errand for PV board cleaning. The errand of PV board cleaning gets to be troublesome an exorbitant if work is contracted. The drawback can be overcome with the offer assistance of an robotized mechanical cleaning arrangement. This extend, we propose an programmed sun powered following framework with an programmed cleaning solar-based instrument to keep upthe effectiveness of sun powered boards. The plan, execution, and appraisal of a sun oriented following frameworkwith an programmed board cleaning component are secured in this venture. By expanding sun powered vitality retention and protecting the cleanliness of sun oriented boards, the framework looks for to increment the viabilityof control era.*

Keywords: Photovoltaic Panel, Solar Panel, Robot, Solar Energy, Laser Diode, Limit Switch

I. INTRODUCTION

Solar energy is emerging as the fastest-growing alternative source of energy due to its benefits to the environment, being a renewable form of energy, it is widely adopted in all sorts of environments, especially in regions of good annual insolation period. The solar power plant in India generates around 0.20 kWhper meter on a daily basis. The efficiency of the solar power plant decreases due to the accumulation of dust on solar panels. The efficiency reduces drastically in the presence of dust in surrounding environments. The particles of dust and soil spread in the atmosphere. The smoke, fog and other aerial particles come under the category of dust and these materials are responsible for the amount of dust in the atmosphere. Dust can be formed due to the accumulation of sand, unwanted particles from factories, remaining particles from forest fires etc. The dust formed from these substances. These particles which are foreign to solar panels gets depositedon PV panel and prevents the light to reach the solar panel. Due to this problem, the energy production from solarpanels reduces. Moreover, solar panels are positioned in such a way that they come directly in contact with bird droppings that get stuck to the panels so that even rainwater cannot clean them completely.

The study was done on dusty solar panels and cleaned solar panels and the study period was around 4 months. The efficiency of these panels which were left open for natural deposition of dust has shown a drastic decrease in efficiency as compared to cleaned solar panels which were cleaned on a daily basis. The above discussed problems can be easily overcome using regular cleaning of panels. Along with regular cleaning of PV panels, uniform cleaning is also required. Scheduled automatic robot tech-solution, without human intervention will solve this problem. The energy output increases if an automatic cleaning system is incorporated. It has been foundthat solar panel provides 29% more power output if it is compared with dusty solar panels. The automatic cleaning of solar panel is more effectiveas compared to dusty solar panels.

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II. LITERATURE SURVEY

Muhammad Ahmad Baballe (2023) focused on improving the effectiveness of solar panels in a variety ofapplications, including solar panels for homes and other sectors. An attempt was made to implement an automated robot cleaning system using a low power wide area network (LWAN) based on a network of ES8266 Node MCUs associated with a set of sensors under various configuration.

Mounir Bouzguenda (2023) looked up the factors that affect PV efficiency, and depending on the previous methods and techniques, the combination of water cleaning and nanospray automated cleaning system is the best method for cleaning dust accumulation.

Ali Omar Mohamed, Abdulazez Hasan(2022), Considered the southern area of Libya which usually carries the dust and sand in the period from February to May, which is also called as seasonal wind. So the small particles of the sand, trees, debris and droppings of birds are accumulated on the PV model surface, which yielda shading sunlight on the modules. Here the area of study divided as rural desert, where the amount of solar irradiance is large over the year. Thus it inspires to adopt the clean energy resource on desert region.

Santosh Kumar S (2020) they proposed solar PV panel cleaning robot aims to remove the dust on the panel byblowing the air. Using liquid to clean and wiped out by using the cylindrical brush. The prevention of manual shifting of robot from one row to another will be avoided.

III. SYSTEM DESIGN

This is the block diagram of Photovoltaic Model Cleaning Robot of how the components interact within the system. Here's an overview of the key elements:

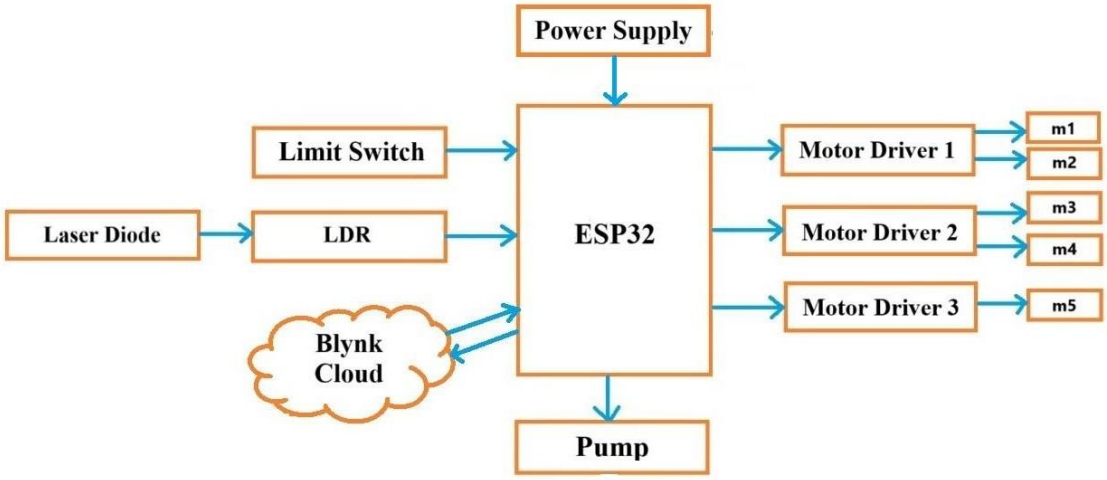

Fig 3.1 Block Diagram of Photovoltaic model cleaning robot

The diagram illustrates an ESP32-based system that combines sensor inputs, microcontroller processing, and actuator control. The system utilizes limit switches, laser diodes, and light-dependent resistors (LDRs) to gather data about the environment or user interactions. This information is then processed by the ESP32, which makes decisions and sends commands to motor drives and relays. The system can be further enhanced by integrating cloud-based connectivity through platforms like Blynk, enabling remote monitoring and control. This versatile setup finds applications in various domains, including automation, robotics, and IoT project

Components Specification:

[1] ESP32: The ESP32 is a low-cost, low-power system-on- chip (SoC) microcontroller that has Wi-Fi and Bluetooth connectivity. It's designed for use in embedded devices, such as mobile devices, wearable electronics, and IoT applications.

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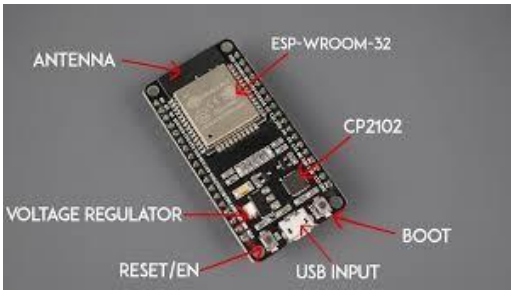
Specification:

• Processor: Dual-core Tensilica LX6
• Clock speed: Up to 240 MHz
• RAM: 520 KB SRAM
• Wireless: Wi-Fi (802.11 b/g/n), Bluetooth (v4.2 BR/EDR and BLE)GPIO Pins: 34



[2] Laser diode: Laser diodes are semiconductor devices that convert electrical current into a light beam. They are also known as injection laser diodes, semiconductor laser diodes, or diode laser.

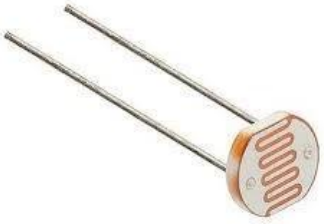
Specification:

• The laser diode operates at 650 nm (red) or 532 nm (green) with 5 mW to 100 mW power and a 3V to 5V voltage.
• Wavelength: Typically 650 nm (red) or 532 nm (green)
• Power output: 5 mW to 100 mW
• Operating Voltage: 3V to 5V

[3] LDR:LDRs are semiconductor-based electronic components that change resistance in response to light intensity. They are also known as photoresistors. LDR stands for Light Dependent Resistor, a type of sensor that detects light and changes its resistance based on the amount of light it receives.

Specification:

• The LDR changes resistance with light, ranging from ~1kΩ in light to ~1MΩ in darkness, operating at 3.3V to 5V.
• Resistance in Light: Low resistance (~1kΩ to 10kΩ)
• Resistance in Darkness: High resistance (~1MΩ)
• Voltage: Typically 3.3V to 5V



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[4] DC Motor: A direct current (DC) motor is an electric machine that converts electrical energy into mechanical energy. DC motors are made up of two main parts: the stator and the rotor.
The DC motor is an electrical motor that uses direct current (DC) to produce mechanical force.

Specification:

• The DC motor operates at 3V to 12V, with speeds between 1000 to 3000 RPM.
• Operating Voltage: 3V to 12VCurrent: 0.5A to 2ARPM: 1000 to 3000 RPM (varies with motor type)

[5] Limit Switch: A limit switch is an electromechanical device that detects the presence or absence of an object, and is used to control machinery or as a safety interlock. Specification:
• The limit switch detects mechanical movement, typically operating at 12V or 24V with up to 15A current.
• Type: Mechanical switch with lever/roller
• Operating Voltage: Typically 12V or 24VMax Current: 5A to 15A.

Technical Specification:

1. Wireless Connectivity: The ESP32 microcontroller features built-in Wi-Fi, which allows it to connect to the Blynk IoT platform, providing real-time control and monitoring over long distances.
2. Motor Control and Drive System: The robot uses DC motors for movement across the PV panels. A motor driver circuit is included to handle motor direction and speed control, ensuring smooth and precise operation for effective cleaning coverage.
3. Laser Diode for Obstacle Detection: The laser diode is configured to detect obstacles and panel edges, ensuring the robot's safe operation by halting movement when interruptions are detected. This sensor data is processed in real-time by the ESP32 to prevent falls or collisions.
4. Power Management: The robot is equipped with a rechargeable battery, monitored through the ESP32 to prevent power depletion during operation. Battery level information is displayed on the Blynk app, notifying the user when recharging is necessary.
5. Error Handling and Fault Tolerance: The software includes routines to handle sensor malfunctions or communication errors, ensuring the robot stops safely if a critical error occurs, thus preserving hardware integrity and user safety.
6. Pre-programmed Cleaning Path Algorithm: The ESP32 runs a pre-defined cleaning pattern, designed to maximize coverage with minimal movement overlap. This path algorithm can be optimized further based on different panel sizes or layouts.
7. Code Optimization and Libraries: The code for this project utilizes optimized libraries for motor control, real-time interrupt handling, and Wi-Fi communication, enabling efficient resource usage and smoother operation across varying conditions.

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IV. EXPECTED OUTCOME

[1] Increased Energy Efficiency: Cleaning robots remove dust, dirt, and other debris that accumulate on the solar panels, which can block sunlight and reduce energy production. Regular cleaning can boost the energy output of the PV system, sometimes by 10-30%.

[2] Reduced Maintenance Costs: Using an automated robot reduces the need for manual labor or specialized cleaning services, saving time and reducing long-term operational costs.

[3] Minimized Water Usage: Many PV cleaning robots are designed to operate with little to no water, especially in dry regions, making them an environmentally sustainable solution compared to traditional water-based cleaningmethods.

[4] Consistent Performance: Regular automated cleaning ensures that the panels are consistently maintained in optimal condition, preventing the long-term buildup of dirt that can permanently affect the panels' efficiency.

[5] Extended Lifespan: By keeping the panels free from debris, the cleaning robot helps prevent corrosion orother damage that might shorten the solar panels' operational life.

[6] Automated and Remote Operation: Many PV cleaning robots can operate autonomously and even be controlled remotely, allowing for minimal human intervention.

[7] Improved Return on Investment (ROI): Cleaner panels lead to higher energy production, which maximizes the financial returns on the solar investment over time.

In short, a PV model cleaning robot is designed to maximize energy output, reduce costs, and improve the overall efficiency and longevity of solar power systems.

V. CONCLUSION

The theoretical part and prototype development of PV Model Cleaning Robot offers the extremely improved the efficiency of power generation and enhanced panel durability. The dust, dirt and residue deposition minimizes the radiation falling on PV cells and in turn reduces the electricity generation. In this study, a cleaning robot system was developed and implemented. The cleaning robot was tested and achieves successful result. Both of produced current and of efficiency rating was improved by using the developed system.

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