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Automatic Solar Panel Cleaning by Voltage Sensing and Light Luminance

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ABSTRACT: "IOT Based Solar Panel Cleaning And Monitoring" presents an IoT-based solution for the monitoring and automatic cleaning of solar panels. The system employs sensors to detect dust and dirt accumulation, which can significantly reduce energy output. Using IoT technology and microcontrollers panel efficiency and environmental conditions real time generation data is collected and transmitted to the centralized platform. The cleaning mechanism is triggered based on the sensor data, ensuring optimal performance without manual intervention. Additionally, the system monitors various parameters such as voltage, current, temperature, humidity, and sunlight intensity, allowing for comprehensive performance analysis. This proactive approach not only enhances energy production but also extends the lifespan of solar panels. By integrating machine learning algorithms, the system can predict cleaning schedules and identify patterns in efficiency degradation, contributing to more sustainable energy management practices. Ultimately, this project aims to provide a scalable and efficient solution to maximize the solar energy utilization by minimizing maintenance costs. Overall circuitry is run by li-ion batery which is intigrated with battery management system.

KEYWORDS: Microcontrollers, Iot ,Battery Management System , Li-on Battery , Monitoring.

I. INTRODUCTION

In recent years, the introduction of solar energy has been increasing. This is due to the need for sustainable, renewable energy sources. Sun collectors are an important part of this energy transition, using sunlight to generate electricity. However, the efficiency of solar collectors can have a significant impact on the effects of dirt, dust and environmental pollutants that block sunlight and reduce energy power.

This project focuses on the development of IoT-based solar panel cleaning and monitoring. The main goal is to improve the operational efficiency of solar collectors and provide real data for performance. By integrating progressive cleaning mechanisms into IoT technology for IoT technology, we want to automate the cleaning process and ensure optimal energy generation with minimal human intervention.

The proposed system uses sensors to monitor the cleanliness and efficiency of solar panels. The collected data is transferred to a centralized platform, allowing users to pursue power metrics and receive notifications when cleaning is required. Additionally, the project will explore the possibilities of automated cleaning solutions that can be active based on sensor data that can reduce maintenance costs and improve energy yield.

II. LITERATURE SURVEY

In this paper titled "Solar Panel Cleaning System Based on the Arduino & Microcontroller" by the Mr. Yuliya Zatsarinnaya & others discussed that the Russia intends to raise the proportion of renewable energy sources in the country's fuel and energy balance, in accordance with its 2035 Energy Strategy. The problem's solution calls for the development of wind and solar power plants in addition to the adoption of hydroelectric power plants, which are common in Russia. The high cost of producing power at a renewable energy facility is one of the issues with solar energy's extensive integration into the Russian energy grid.

By the analysis of this paper named "Performance Analysis of Semi-Automatic Solar Panel Cleaning System" written by Mr Samir Bhandari concluded that the findings show that while dust reduces efficiency and affects overall performance, the use of a semi-automatic cleaning system boosts solar panel efficiency. To preserve effectiveness and optimize energy output, routine cleaning and maintenance are essential.The semi-automatic cleaning system significantly increased efficiency in the trial model by 7%.

The design and fabrication of an automatic solar panel cleaning system has been carried out in this research, according to the conclusion of Mr. J. F. Bamidele's article, "Design and Construction of an Automatic Solar Panel Cleaning System." By removing dust and other deposits from the panel surface that can shield the semiconductor material inside

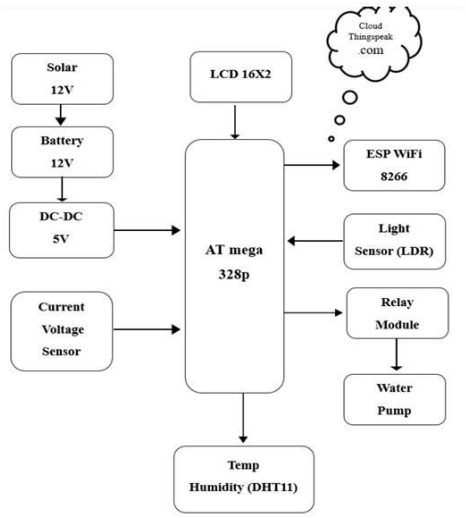
the PV panel from sunlight, the system will help to preserve the efficiency of PV cells. The system has a mechanism that operates automatically in all circumstances and is intended to operate on a recurring basis. The technology works with any PV array and is suitable for both homes and businesses. The semi-automatic method significantly increased the experimental model's efficiency by 7%.

According to paper [4] :A study by Kumar et al. (2017) suggested a wireless sensor network-based system for tracking the performance of solar panels, per publication [4]. This has been demonstrated to be successful in identifying errors and raising system performance generally.

According to paper [5]: A study by Zhou et al. (2021) suggested an AI-based solar panel cleaning system that employs machine learning algorithms to determine the degree of soiling on the panels and adjust the cleaning procedure appropriately, according the report

III. METHODOLOGY

This block diagram shows how a solar panel transforms sunlight into electrical energy, which is subsequently charged and stored in a battery. The buildup of dust and debris on the panel's surface affects the output power produced. To collect information about the solar panel's output, such as voltage, current, temperature, humidity, and readings from LDR sensors, an MCU is connected. To display the data collected from the solar panel, the Arduino microcontroller communicates with an I2C LCD driver. When the solar panel gets filthy, a submersible pump that is attached to a water reservoir can spray water on it. A relay module is used to trigger the DC motor that powers this pump. Depending on whether cleaning is required, the microcontroller sends an activation signal to the relay module. The LDR sensor evaluates the intensity of the sunlight, the voltage and current sensor checks the voltage and current levels of the solar panel, and specialized sensors track the temperature and humidity.



IV. WORKING

- Arduino is the main brain of the project. For demonstration purpose we are using four switches as a four different power supply like solar, wind, battery and mains.
- This all supply input given to the arduino. Arduino sense this input and control the output pins which are connected to relays.
- As per program we define priority to first supply. If first supply is available then first relay on then by go to the message in the gsm. Here all remaining supply input are in don't care condition then gsm message fron the no supply.
- If first is unavailable the supply is no from the message go to the GSM and second is on then load is working on second relay then go to the supply is on message on GSM
  . But when first would become then priority goes to first.
- Like this up to four supplies is available load gets uninterruptable power supply..

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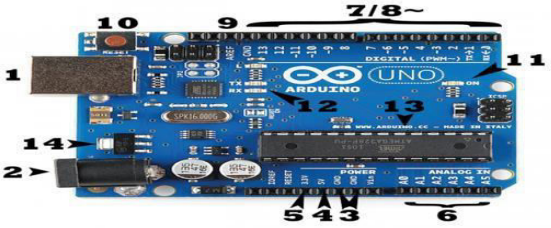
V. HARDWARE DESCRIPTION

i.Solar Panel

A collection of photovoltaic cells is called a solar panel or photovoltaic (PV) module. Direct current electricity is produced by solar panels using sunlight as a source of energy.A PV panel is a group of PV modules, while an array is a system of panels. A photovoltaic system's arrays provide solar power to electrical devices.High-efficiency polycrystalline silicon solar cells were used in the engineering of this 12V, 5W solar panel.

ii.ARDUINO

For creating electronic projects Arduino is a widely-used open-source platform .It comprises a physical programmable circuit board, commonly known as a microcontroller, along with software, referred to as an IDE (Integrated Development Environment), that you can run on your computer to write and upload code to the board.The Arduino platform has gained significant popularity among beginners in electronics, and this is understandable. Unlike many earlier programmable circuit boards, the Arduino does not require a separate programmer to upload new code; you can simply connect it using a USB cable.



iii.LIQUID CRYSTAL DISPLAY (LCD)

We used LCD to display the current state of the operation . Size of LCD is available from 8x2 to 40x4. For this we have used 16x2 LCD. 16x2 means the rows and columns.

IV. RELAY

Controlling any device driven by high voltage and current requires low voltage and current signals. The relay module operates best in these types of situations. It functions like an electrical switch which opens or closes mechanical or magnetic circuits, use to control electricity at high voltage and high current areas. The control signals need to go through a control sequence to relay processing to activate the relays. For this project, we used a 5 V DC to 250 V AC relay module rated for 10 A AC and with about 1 microsecond response time. The relay module is used to control the switching of the DC motor. Other relays may have more or fewer sets of contacts depending on their function.

v.Lithium Ion Battery

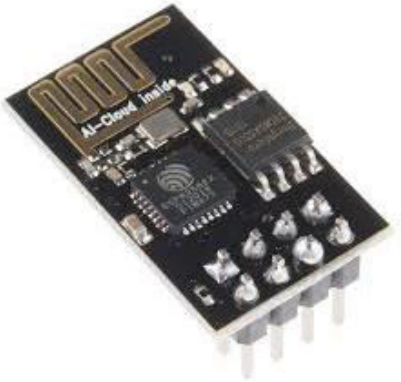
The rechargeable lithium-ion (Li-ion) battery is utilized in this study due to its eco - friendliness, high energy density, and reduced self-discharge rates. Throughout the charging and discharging processes, charged particles move between the anodes and cathodes to generate an electric current. This allows for multiple reuses, making it a cost-effective long-term option. Additionally, it is a lightweight and safe choice for users. Therefore, it can be reused several times. So, it provides a cost-efficient long-term solution. Besides, it is a light weight and safe device for its users.

vi.Water Pump

In order to clean the solar panels, water was lifted from the water tank using a small submersible DC motor pump. This sturdy, compact pump can pump water without priming and uses very little power while operating at great efficiency. These pumps are made with a longer lifespan and superior performance in mind. With a very low current input of about 220mA ,it can pump upto 120 liter of water each hour .

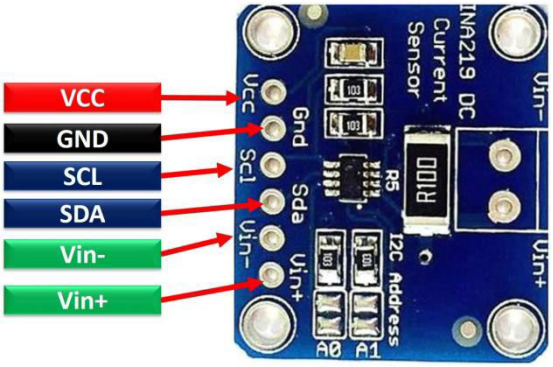
vii. ESP8266 Wi-Fi module

An ESP module is a type of microcontroller module that uses the ESP8266 or ESP32 chip from Espressif Systems. These modules are commonly used for IoT (Internet of Things) applications due to their built-in Wi-Fi capabilities. They can be programmed using the Arduino IDE or other development platforms to connect to the internet, send and receive data, and control various devices remotely.



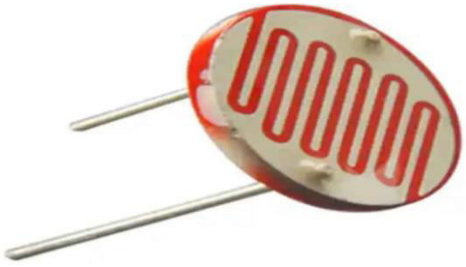
viii.INA219 Sensor

The INA219 is a power and current shunt monitor that may be used with either SMBUS or I2C. With customization conversion timings and filtering, the device keeps an eye on the bus supply voltage as well as the shunt voltage drop. A calibration value that can be programmed in conjunction with an internal multiplier, which makes it possible to read current in amperes directly. Power is calculated in watts by an extra multiplication register. The interface has 16 programmable addresses and is compatible with SMBUS or I2C. There are two grades of the INA219: A and B. The accuracy and precision criteria of the B grade version are higher. The INA219 detects shunts on busses with voltages ranging from 0 to 26 V. The gadget draws no more than 1 mA of supply electricity from a single 3- to 5.5-V source. INA219 has temperature range from -40°C to 125°C .



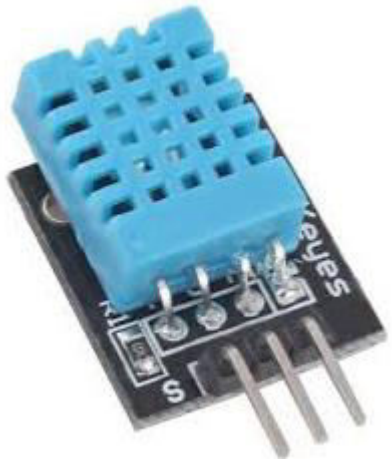
ix. LDR Sensor

The Light-Dependent Resistor (LDR) sensor alters its resistance in response to the light intensity that strikes its surface, making it suitable for detecting dust on solar panels. When dust is present, the panel is less exposed to light, resulting in an increase in the LDR's resistance. If there is a greater accumulation of dust, the resistance of the LDR becomes even higher due to the dust particles obstructing the light that passes through. Consequently, LDRs can effectively gauge the amount of dust accumulation on the surface of solar panels. This sensor is capable not only of determining the presence or absence of light but also of assessing its intensity. Consequently, when a specific threshold for light intensity is reached, LDRs are used to start an action.



x. DTH11 Sensor

With a calibrated digital output, the DFRobot DHT11 Temperature & Humidity Sensor combines a temperature and humidity sensor element. It offers exceptional long-term stability and great dependability by combining its temperature and humidity sensor technology with a novel digital signal collecting technique. This sensor interacts with a high-performance 8-bit microcontroller and has a resistive component for measuring humidity and an NTC component for measuring temperature. It offers outstanding quality, fast response, interference resistance, and affordability.



xi. LM 7805 voltage regulators

The three terminal regulators of the LX78MXX series are useful in a variety of applications because they come with multiple fixed output voltages. These regulators can be utilized in logic systems, instrumentation, Hi-Fi, and other solid state devices due to the voltage that is available electronic devices. Despite being primarily intended devices, they can be used to achieve adjustable voltage and current by utilizing an external component.

VI. ADVANTAGES

1. Improves the solar plate's efficiency.
2. Dust or other particles can occasionally stay on a solar panel for a long time, damaging the metal strip of the solar plate. Thus, we prevent these harms by doing this system.
3. Boosts the output from your solar panels by up to 5 to 30%.
4. Get rid of any dirt or debris accumulation that could harm the solar panels.
5. An automated self-cleaning system that runs without human intervention and can be mounted atop solar panels.
6. Reduce cleaning expenses relative to manual methods.
7. It is possible to control it remotely.
8. A single microcontroller system can manage the entire plant.

VII. Disadvantages

1. Must be scaled for a bigger project (for example, raising the motor's torque).
2. To take care of cleaning water, to avoid nozzles blockages.

VIII. CONCLUSION

Solar panel's output power loss can increase due to dust accumulation. Contaminants like dirt and bird droppings create hot spots on the panel, which lead to temporary malfunctions. While dry cleaning can eliminate some of the surface dirt on solar panels, it does not completely remove all grime. Washing solar panels with water enhances cleaning effectiveness by eliminating most of the dirt that has settled on the surface. When analyzing the expenses associated with manual versus automatic cleaning, it has been shown that automatic cleaning is more cost-effective and considerably less labor-intensive, especially for systems with a large number of solar panels.

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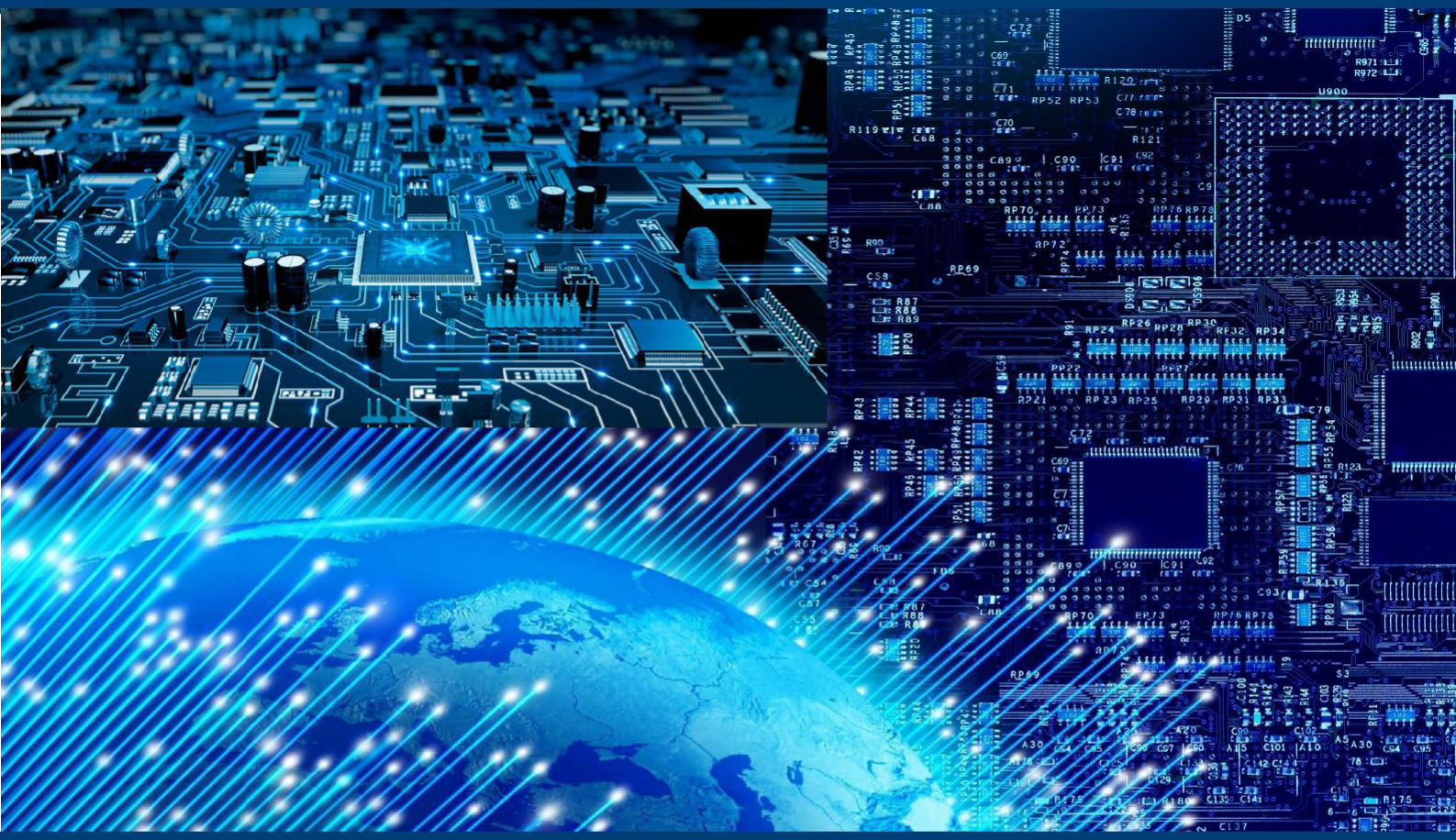

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