Smart IoT based Solar Panel Cleaning System

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***Abstract*— Solar Energy converts heat from the sun into electricity, either directly making use of Photovoltaic (PV) or Compressed Solar Panel (CSP). It is a clean green electricity which is the Earth's most available source of energy. Solar energy is the future of power generation due to its renewability nature. It has gained a wide acceptance across the world. Many research works are going on to harness the maximum power from sunlight, but few of the main hindrances in harnessing maximum power are dust accumulation on solar panels and air pollution, which cuts solar cell energy output by over 25% - 40% in some portions of globe in which one among tropical countries like India . Since our Indian government has set an ambitious target of installation of grid connected rooftop solar photovoltaic project with the capacity of 40GW out of the total target of 175GW of renewable energy capacity over the next five years by 2022, it's also our responsibility to be as a part in achieving nation's target. This proposed paper describes the implementation of a Smart Solar panel cleaning system with primary focus on making use of Internet of things (IoT) technology. This enables dust monitoring capability, advanced analysis and system control which prompts to increase the total efficiency of the solar PV panel.**

***Keywords*— Solar panel, Arduino Uno, Sensors, actuators, IoT**

I. INTRODUCTION

Numerous research oriented works and studies have created IoT for different spaces, for example, a smart city, human services, home automation, vitality framework, and mechanical security. Since the wired and remote system advancements are propelling, web associated gadgets, for example, PDAs and tablets are presently sought after. Along these lines bringing about another idea Internet of Things which has gotten more consideration in the course of recent years. The IoT refers to a network comprised of devices capable of gathering and sharing electronic information. Energy domain based on IoT will let user to have visualization of energy consumption in real time.

Solar energy is the radiant energy and it is the most readily available source of energy. It finds vast application in many domains like an agricultural field, heating water, and industrial application comes with making use of solar panels as a source of electricity instead of implementing heavy generators. Solar PV panel is the device which is used to absorb the sunlight and convert them into electricity. Whereas solar panels allow photons to hit electrons those are free from atoms, by generating a flow of electricity. It basically comprises many smaller units called photovoltaic cells. PV cells convert sunlight into electricity. Hence linkage of many cells together constructs a solar PV panel. Solar cells yield in a few sections of the world is cut by more than 25% because of airborne particles and tidy. Air contamination that is noticeable all around itself likewise diminishes solar panel output, it's not only the dust spread upon the surface of the PV boards that effect the output [1]. Elements like implementation of the PV module, following the sun, temperature of PV module, tilt point of the PV module, shading of the PV panel, mounting housetop material, mounting stature, sun irradiance and sort of PV module, would prompts lessening of PV module's efficiency [2]. The issue of eliminating some of the factors like airborne particles & shading of panels are very paramount in solar panel installation & production of efficient solar power. Hence in order to eliminate shading of panels, panel's height would be raised in case of rooftop solar PV panels. Accumulation of combination of either airborne particles, snow, or dust particles with moisture contents on above raised PV panels could reduce or also even stop energy production. Therefore, regular maintenance of solar PV panels becomes quite harder in above mentioned case. Hence with our proposed system we hope to build an alternative cleaning system for solar PV panels by automating the cleaning mechanism of solar PV panels.

II. LITERATURE SURVEY

In the course of the most recent decades solar oriented industry has demonstrated a quickened development. However PV module cleaning and possibility arranging has gotten minimum measure of consideration. A sun powered ranch (Charanka solar based park) in Gujarat, India spread crosswise over 2000 hectare site for instance utilizes more than 220 liters of water to clean a 10 square meter cluster of PV arrays. Current innovations incorporate hand cleaning gadget for support of PV modules, is the tucker pole which has weak hand nylon brush connected with shaft and at times furnished with water splash framework and requires two individuals to clean a variety of 48 PV cells of 4x4 size in under 3 hours which is less effective and requires more human exertion [4].

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Current labour-based methods for cleaning photovoltaic arrays are costly with respect to time, water and energy usage and lack automation capabilities. In this paper a novel design for the first ever human portable robotic cleaning system is presented which is capable to clean and manoeuvre on the glass surface of a PV array at varying angles from horizontal to vertical [5].

NASA has researched about the diminished effectiveness because of tidy on Mars. They endured over 52.2% power misfortune for a 30 day mission, and represented 89% influence misfortune throughout the following two years. In any case, because of some fate Mars rover experienced an unforeseen breeze (Martian Wind) which cleared all the tidy settled on the PV modules, halfway helping NASA in quickening their electrical yield [6].

In this referred project, a solar PV module cleaning system was developed that utilized pressurized air-water blend. The benefits of this innovation are that it has no moving parts, no protect rails, no battery substitution, less water utilization and no self-cleaning is required for the cleaning framework. This project can be practised in solar farms only, not in standalone system. Also the architecture is bulky and heavy [13].

In this referred paper, they have built a system for a mechanical low power controller uniquely intended for controlling cleaning robots for completely computerized cleaning procedures of solar PV modules based power plants. The controller runs a Linux Debian based circulation, controls the drives of the developed robot, observing the position and all parameters of the framework, permits arrangement through a web interface and can be associated with the web by means of LAN or WLAN. Additionally, for dispatched solar plants, the controller can be coordinated in SCADA frameworks by utilizing Modbus TCP for information transmission and control [15].

III. The Proposed System

The proposed automatic solar panel cleaning system consists of following subsystems:

- The first subsystem is a dust monitoring system that measures the presence of dust particles in the air surrounding the solar PV panel based on which the water motor pump is activated through a microcontroller Arduino UNO and motor driver L293D module.

- The second subsystem is a wiping system to perform cleaning. Where system comprises connections through Arduino UNO and L293D with geared motor, conveyor belt, a pulley and wiper.

- The third subsystem is a rain monitoring system. Here a raindrop sensor, which detects rainfall, is interfaced with the Arduino UNO and wiping system to clean the solar PV panel. The idea behind this subsystem is to make use of rainwater for cleaning solar PV panels instead of the pumped water in presence of rainfall, also in order to reduce water usage.

- The fourth subsystem is the implemented IoT system. Here the Arduino board is linked to the Internet over ESP8266 chip. The ESP8266 SoC contains a fully functional Wi-Fi Stack combined with TCP/IP Stack that lets arduino uno to get connected to Wi-Fi Network. This module can be interfaced with the sensors and other devices which are application specific since it has the necessary capability of storing and on-board processing capability. The solar panel parameters along with the dust sensor and rain sensor values used in the system are uploaded to the Server.

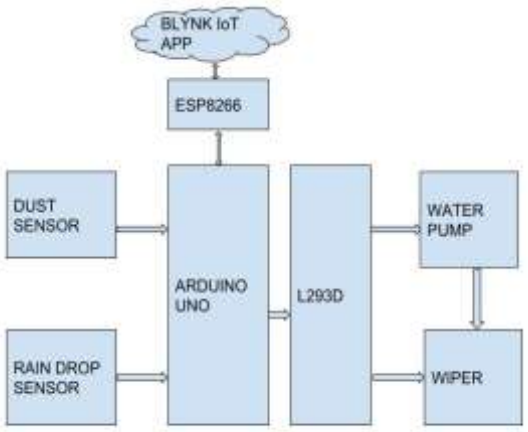

Fig 1: Block diagram of proposed system

IV. Functioning of the Proposed System

The functioning and operation of the proposed system is summarised below with relevant details.

A. Dust Monitoring System

The dust settled over the surface of solar panel diminishes the solar radiation reaching the PV module. Thus, there is a loss in power generated. Hence this subsystem would be detecting the presence of dust particles impacting on power generation from solar PV panels and proceeds with the turning

on of water pump. This subsystem involves operations like dust sensing and water pumping.

The Arduino Uno microcontroller is utilised for controlling the operations. The circuit comprises of an optical air quality dust sensor, a 9V water pump, resistor, capacitor, dc-dc buck converters and an L293D motor driver module. Power to the Arduino board and the 9V to run the water pump are supplied from the solar PV panel using dc-dc buck converters which reduce the panel voltage to the voltage required by the ardunio and dc pump.

1) Dust Sensing: GP2Y1010AU0F, an optical air quality dust sensor, is used to sense dust particles present in the air surrounding the solar PV panel. An infrared emitting diode as a light emitter and a photodiode as a light detector are diagonally placed into this device, to make device to detect the reflected light of dust particles in air. This device works when dust and/or air borne particles enters and exists inside of this device. At this stage, the detector detects the light reflected from the dust and/or air borne particles. Current in proportion to amount of the detected light comes out from the detector and the device gives analog voltage output after the amplifier circuit amplifies the current from the detector [7]. Resistor and capacitor are required for pulse drive of the LED of GP2Y1010AU0F.

Analog voltage obtained from the device as an output is taken as voltage measured through arduino UNO analog pin and further it is made used in calculating voltage. On an Arduino UNO, any analog pin will delineate voltages between number qualities from 0-1023 which can be mapped back to a "genuine" voltage value. Therefore, we want to multiply the reading i,e voltage measured with 5.0/1024.0 in order to obtain voltage value.

Equations are as follows:

analog vol= voltage measured through A0 (1)

calculated vol= analog vol * (5.0 / 1024) (2)

dust density= 0.17 * calculated vol - 0.1 [3] . (3)

Continuously the analog value from dust sensor is taken. When the average dust density value crosses the set threshold value, the water pump is triggered.

2) Water pumping: The components used for pumping water are L293d motor driver, 9V dc water pump and 9V battery. L293D is a type of motor drivers which is capable of driving two DC motors at a same time and it consists of two H-bridge. H-bridge is a circuit which is designed in such a way to allow the voltage to flow in either direction. Also it acts as small current amplifier, which is functioned to draw low-current control signal and convert them into higher-current signal that could be used to run two motors. L293D IC is required to drive single DC motor i.e. 9V DC water pump.

DC water pump is a device used to transform electrical energy into mechanical energy and to pump water to the heights. Here the Arduino Uno microcontroller is programmed to clean the panel once in every 10 days. Otherwise, when the average dust Density value crosses the set threshold value, the water pump is turned on. The water pump, submerged in a water reservoir, pumps water and sprinkles it on the panel through sprinkling system connected to the end of water pipe coming from the water pump. After a delay of 5 seconds the wiping system is triggered to clean the panel.

B. Wiping System

The wiping system is made up of a mechanical frame having a pulley and conveyor belt that supports the wiper and the motion of the wiper is controlled by dc gear motor.

Fleming left hand rule is a main principle of DC motor, this is made use in determining force in a current carrying conductor placed in magnetic field in motors, as electrical energy is converted to mechanical energy. A gear motor is a specific type of electrical motor that is designed to generate high torque while maintaining a low speed, motor output. Gearbox being attached to the main motor rotor, gear motor is accomplished. Gear motors can be found in many different applications. Here, in case of our proposed system, gear motors will be accountable for the motion of the wiper. Conveyor belt along with a pulley is attached on either side of the panel. The conveyor belt converts the rotational motion of the gear motor to give a linear motion to the wiper. The motor rotates forward and backward to rotate the pulley thus moving the wiper up and down over the PV panel. Since, water pumping is followed by wiping of solar panel controlled by the wiping system, programmed Arduino UNO activates the wiping system by sending command to it. When Arduino UNO activates the geared DC motor, the wiper cleans the solar panel.

C. Rain Monitoring System

The main component used in this subsystem is a rain sensor module which is interfaced with wiping system via the Arduino Uno microcontroller.

The rain sensor is used to detect rain. The rain sensor module consists of a rain board and a control board. The rain sensor senses the water that covers the circuits on its sensor sheets' printed leads. The sensor board goes about as a variable resistor that will change from 100k ohms when wet to 2M ohms when dry. So, the wetter the board, more the current that will be flown.

The duration of rainfall is unpredictable. The rain sensor continuously monitors the environment. When it starts raining,

the rain status variable is set to 'Rain Detected' and when rain stops the variable is reset to 'No Rain Detected'. Arduino UNO is programed in such a way that it triggers the wiping system when there is a transition in the variable rain status from 'Rain Detected' back to 'No Rain Detected', in other words when rain stops. The dust density value is set to 0 after the wiper cleans the panel.

D. IoT Implementation

Blynk is an IoT platform which can control equipment remotely, it can show sensor information, and it can store information, picture it and do numerous different things. There are three noteworthy parts in the stage: Blynk application, Blynk Server and Blynk Libraries. Blynk App permits to make interfaces for ventures utilizing different widgets. Blynk Server is in charge of the considerable number of interchanges between the cell phone and equipment. Either Blynk Cloud can be utilized or private Blynk server can be run locally. Its open-source, could without much of a stretch handle a great many gadgets. Blynk Libraries empower interaction with the server and process all the approaching and outcoming instructions.

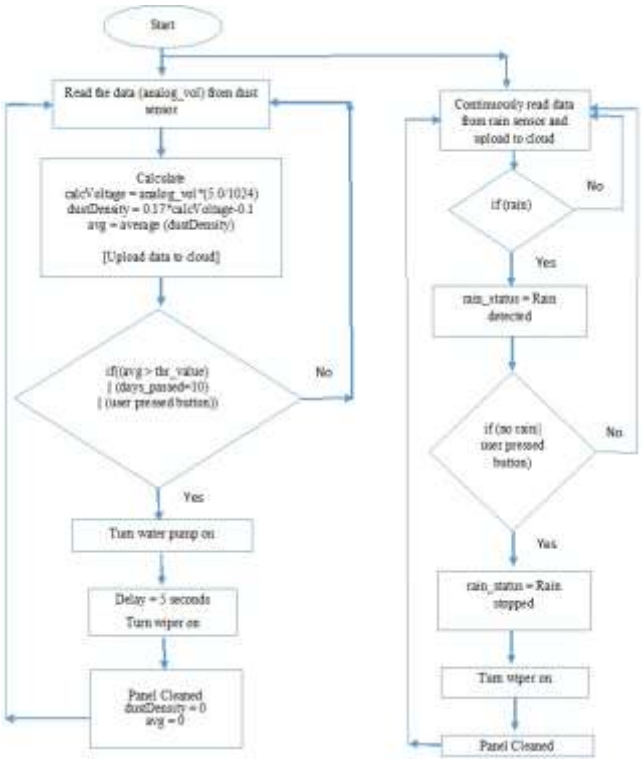

Fig. 2 Flowchart of Proposed System

As shown in the flowchart Fig.2 the sensors measures their respective parameters which would be uploaded to the cloud. The required operations are performed further and updated. These data could be accessed at any point of time from user through mobile application. The user can turn sprinkler and wiper on or off through mobile application remotely from anywhere within its range.

V. Results & Conclusion

TABLE I

Comparison of solar panel voltages before and after cleaning

SL No.	Dust Density	Voltage (V) Before cleaning	Voltage (V) After cleaning
1	0.05	21.2	21.24
2	0.15	21.15	21.19
3	0.30	21.04	21.09
4	0.45	20.83	20.88
5	0.50	20.65	20.71

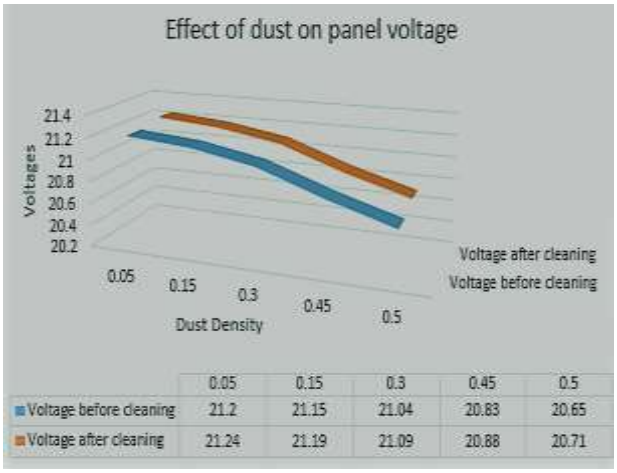

Fig. 3 Graph analysing the effect of dust on panel voltage

The output voltage measured from the solar panel can reduce considerably by the large amount of dust accumulated over the panel. Cleaning PV module with water expands the performance and efficiency of the panel by expelling most of the tidy settled over the panel. No outside powers are required as the programmed – cleaning system takes its energy from the PV module. The assembly of devices used in the system are lightweight. IoT based PV module cleaning framework is effectively viable and the cost for programmed cleaning had exhibited to be more affordable. Likewise regular cleaning guarantees that the PV modules work with a decent transmittance reliably consistently. Finally outcome showed that reduction in the output voltage measured can be up to 5%-

10%. IoT based solar panel cleaning mechanism will analyse the system parameters that will allow the user to make decisions accordingly thus the system proves to be efficient.

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