Impact Factor-4.013 *e-ISSN: 2581-6667*
International Journal of Engineering and Creative Science, Vol. 5, No. 2, 2022
www.ijecs.net

Development of Solar Panel Monitoring and Cleaning Mechanism

Tanaya Nimkar[1], Shruti Burade[2], Jivita Warokar[3], Sukanya Mahapatra[4]

[1]*Final Year Electrical Engineering Student*
[2]*Final Year Electrical Engineering Student*
[3]*Final Year Electrical Engineering Student*
[4]*Final Year Electrical Engineering Student*
Government College of Engineering, Nagpur, India, 441108

Abstract –*Green energy is important for the environment as it replaces the negative effects of fossil fuels with more environmentally-friendly alternatives. Derived from natural resources, green energy is also often renewable and clean, meaning that they emit no or few greenhouse gases and are often readily available. Solar energy is one of the most abundant energy resources on Earth. It is a green energy resource that can provide suitable power for our needs. It's also continuously growing in popularity nowadays since it can provide significant benefits to humans and the environment. In this paper, the solar power plant is becoming smart using internet of things technology and it is being monitored by keeping track of its performance by determining parameters that are mainly voltage, current and power. The solar power plant is monitored by keeping track of its performance by determining parameters that are mainly voltage, current and output power using the voltage sensors and current sensors. The monitoring platform is based on the current, voltage and other measurements of each row of solar panels. The processed parameters are then stored on the IoT cloud to offer smart data analysis. This project aims at focusing on the faults affecting the efficiency of the solar panels and provides solutions on them*

Keywords- ***IoT, cleaning, solar panel, monitoring, efficiency, Arduino.***

I - INTRODUCTION

Green energy is important for the environment as it replaces the negative effects of fossil fuels with more environmentally-friendly alternatives. Derived from natural resources, green energy is also often renewable and clean, meaning that they emit no or few greenhouse gases and are often readily available. Solar energy is one of the most abundant energy resources on Earth. It is a green energy resource that can provide suitable power for our needs. It's also continuously growing in popularity nowadays since it can provide significant benefits to humans and the environment.

The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data, the IoT. The Internet of Things is not new, but the IoT is so popular today because of its relationship with open source, big data, security and privacy and software-defined networking. IoT enables companies to automate processes and reduce labour costs. It also cuts down on waste and improves.

In solar power generation plants, lakhs of solar panels are arranged in multiple arrays. The solar power plant is generally located in the northern hemisphere mainly in tropical areas which are prone to dust and dirt. The

performance of solar panels depends on various factors like weather and temperature, the power generated can decrease if there is dust and dirt accumulated on panels and this is the main factor for the reduction of the efficiency of a solar power plant. This project presents about "SOLAR PANEL MONITORING AND CLEANING" mechanism.

Here solar panels are connected with an ESP8266 microcontroller, which has a built-in Wi-Fi module that helps to monitor solar panels for optimum power output. This helps to bring back efficient power output from power plants while monitoring for faulty solar panels connections, dust accumulated on panels lowering output and other such issues affecting solar performance. This project presents an IoT based automated solar panel monitoring and cleaning device which can be controlled from anywhere across the globe over the internet.

With the help of an effective GUI (Graphical User Interface), displaying various parameters like output current, voltage, temperature and humidity to the users and alerting them about the decrease in efficiency is convenient. When the output parameters fall beyond a preset threshold, the automated cleaning system comes into play.

The panels that are not cleaned properly for 1-2 months can cause a reduction in efficiency. So, to overcome this problem and to increase the efficiency of power production, cleaning of the module on regular basis is necessary. To clean the dust, an automatic cleaner is developed, which will clean the panels at a regular interval of time. The mechanism is based on a controller control circuit based on DC motors which are to clean the panels. The paper provides the idea of optimization of efficiency with the help of automated cleaner for the solar panels

II- PROPOSED METHODOLOGY

The working of the proposed system consists of two main parts:
1) Solar panel monitoring system:

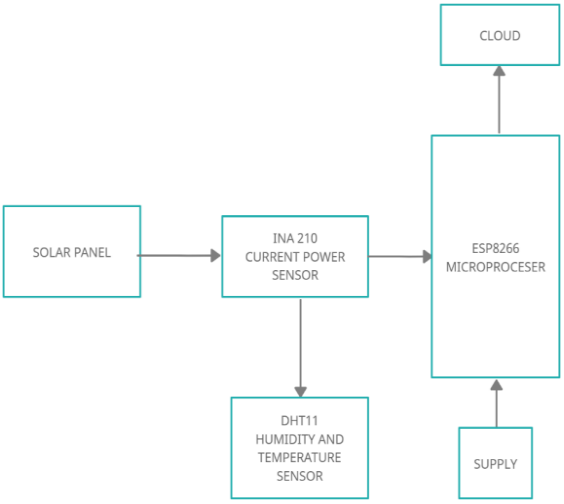

Fig. 1- Block Diagram of proposed work

Here, a solar mini panel with a maximum of 12V output voltage is used. Two terminals of the solar panel are connected to INA210 current power sensor's input voltage terminal which measures the voltage and current generated by a particular array of solar panels and it is then connected to DHT11 which is a temperature and humidity sensor, analysis the temperature and moisture content in the environment to have a better understanding of an output data and ESP8266 microcontroller.

Table 1- INA210 and ESP8266's connection

Sr. No.	**INA210**	**ESP8266**
1.	V_{CC}	Analog to Digital Converting Pin
2.	GND	GND
3.	SCL	D1
4.	SDA	D2

12C protocol servers the purpose of communicating data between module/sensor and microcontroller. Through the 12C protocol, the analog data will be communicated from the sensor to the ESP8266 microcontroller.

Table 2- Connection of DHT11 with ESP8266

Sr. No.	DHT11	ESP8266
1.	V_{CC}	$3.3V_{IN}$
2.	GND	GND
3.	Data Pin	D0

Now, the 7805-voltage regulator is the three-pin regulator which supplies +5V DC at the output pin which provides power to the ESP8266 to function properly, when the input pin is connected to the DC supply i.e., 5V adaptor in this case and ground is connected to the ground of the adaptor. Here, an adaptor is used, as the solar panels cannot provide the required supply but in real life model where there are thousands of panels available, it can provide a sufficient amount of input supply for the proper functioning of the monitoring mechanism without the need of using external power supply making it a self-sufficient device. LED is used as an indicator to indicate the functioning of the above mechanism.

This mechanism will help to monitor the output of the solar panel. As INA219 will measure the output power and DHT11 will compute humidity and temperature, this analog information will transfer to the cloud through ESP8266 as it has a built-in WIFI module. Because of this, we can monitor the output and faults occurring in solar panels remotely. It is not only convenient for large scale solar power plants but also for small size domestic solar power generators.

2) Cleaning Mechanism:

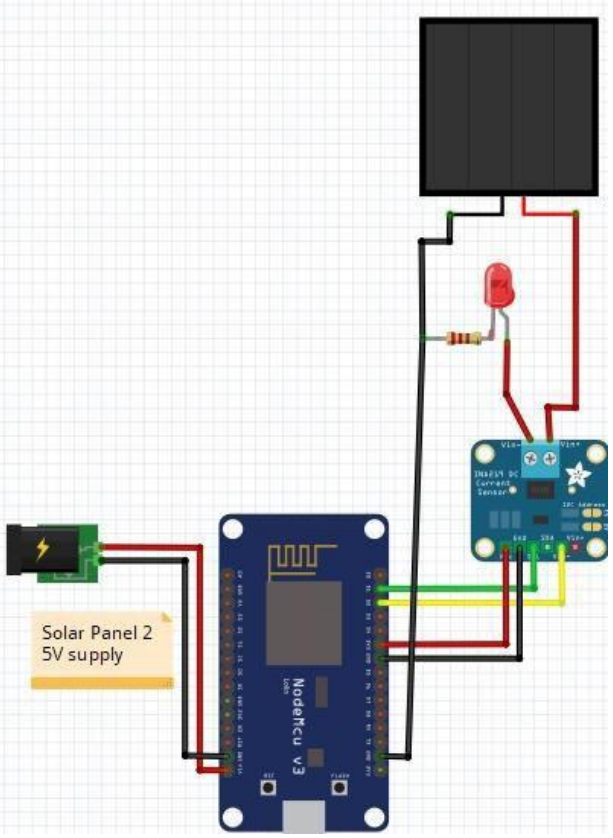

Fig. 2- Circuit Diagram of Solar Panel Monitoring

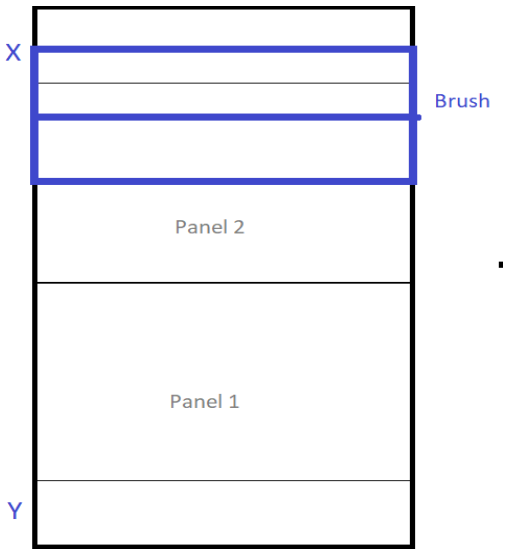

Fig. 3- Proposed System

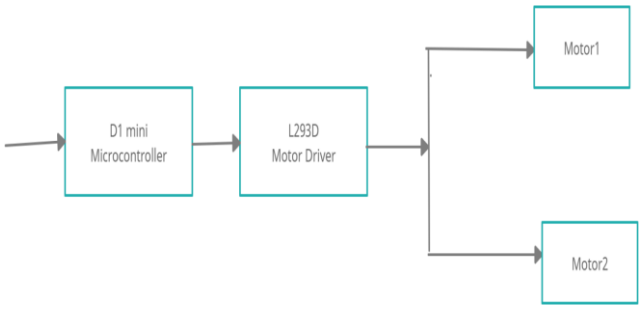

Fig.4- Block diagram of a cleaning mechanism

Here, a brush attached to an iron square pipe frame automatically clean solar panels effectively without water, with four wheels out of which two front wheels are dummy and back wheels are connected with DC motors. These DC motors are controlled using an L293D motor driver which controls the speed and direction. So L293D is connected with the D1 mini microcontroller which will display on the UBIDOTS platform. This mechanism can be controlled from anywhere in the globe via UBIDOTS.

Table 3-mini microcontroller and L293D connections:

Sr. No.	**D1 mini microcontroller**	**L293D**
1	D2	Input
2	D3	Input
3	D5, D6	Output
4	D7, D8	Output

To initiate the cleaning process, the two microswitch roller levers are attached at the end of the iron square pipe frame and on the UBIDOTS platform two switches widgets which control the brush in a certain specified direction, when the X switch on UBIDOTS is pressed, the cleaning robot moves from X end to Y end of the panel and when the Y switch is pressed, it moves from Y end to X end. When the robot reaches the end of the panel, the button on the microswitch gets pressed and the cleaning robot stops moving there itself. This cleaning mechanism can be controlled remotely through UBIDOTS website.

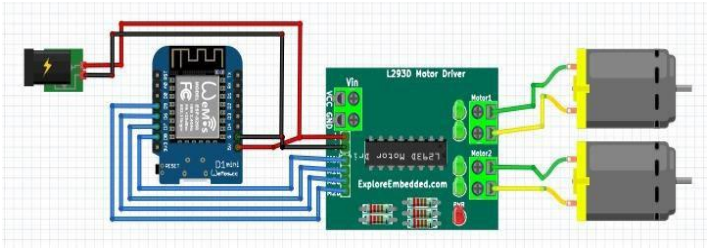

Fig.5- Circuit diagram of cleaning model

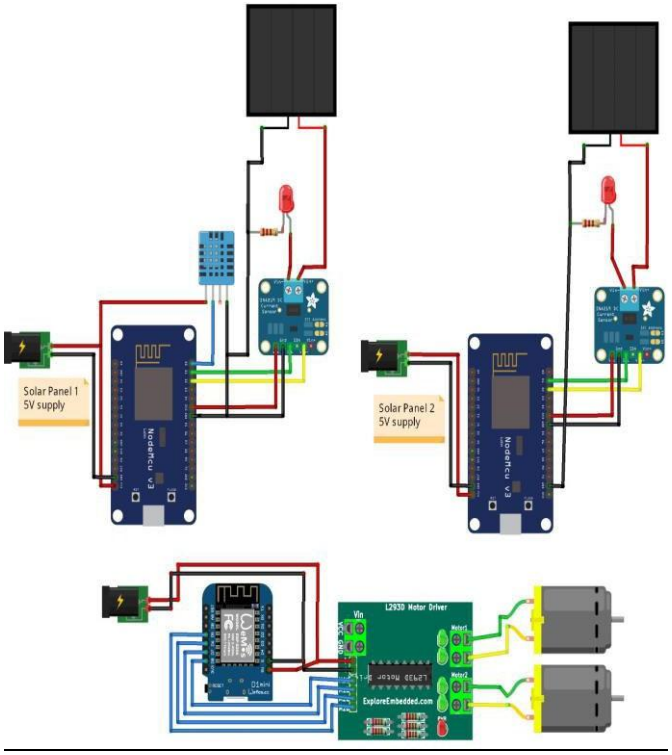

Fig.6- Circuit diagram of the combined model

Fig.6. shows an overall circuit diagram of the proposed work consisting of the solar panel monitoring and cleaning mechanism.

III-HARDWARE AND SOFTWARE DETAILS OF PROPOSED WORK

1) Hardware Details

Table 4- Hardware components of proposed work

Sr. No.	Component Name	No. of components	Component Rating
1.	Solar Panel	2	12V
2.	INA 219	2	Operating Voltage= 3-5.5 V

3.	DHT11	1	Operating Voltage= 3.5-5.5 V, Operating Current= 0.3 Ma
4.	NodeMCU ESP8266	2	Operating Voltage= 3.3V
5.	Adaptor	2	I/P: 110-260V AC, 150mA, O/P: 5V, 1A DC
6.	LED	2	5mm dip
7.	Resistor	2	621 ohms
8.	DC Motor	2	RPM= 60rpm, Current (w/o loading) = 40-180mA, Output Torque= 1kgcm, Operating voltage= 3-12V
9.	L239D Motor Driver	1	$V_{cc1}(V_{ss})$= 4.5-7V, $V_{cc2}(V_s)$=4.5-36V
10.	D1 Mini Microcontroller	1	Analog Input= $3.2V_{max}$
11.	Micro Switch	2	NA

Table 4 provides all the hardware components used in the proposed work along with their ratings.

2) Software details:

An IoT platform is a multiple layer technology that enables straightforward provisioning, management, and automation of connected devices within the Internet of Things. It basically connects the hardware, irrespective of diversity, to the cloud by using flexible connectivity options, enterprise-grade security mechanisms, and broad data processing powers. The IoT platform offers to developers ready-to-use features that greatly speed up the development of applications for connected devices as well as take care of scalability and cross-device compatibility. To call an IOT system complete hardware, such as sensors or devices. These sensors and devices collect data from the e perform actions in the environment. A complete IoT system needs connectivity. In this proposed work, UBIDOTS is used as an IoT platform. UBIDOTS provide the dashboard on which the complete real-time analysis of solar panel is displayed.

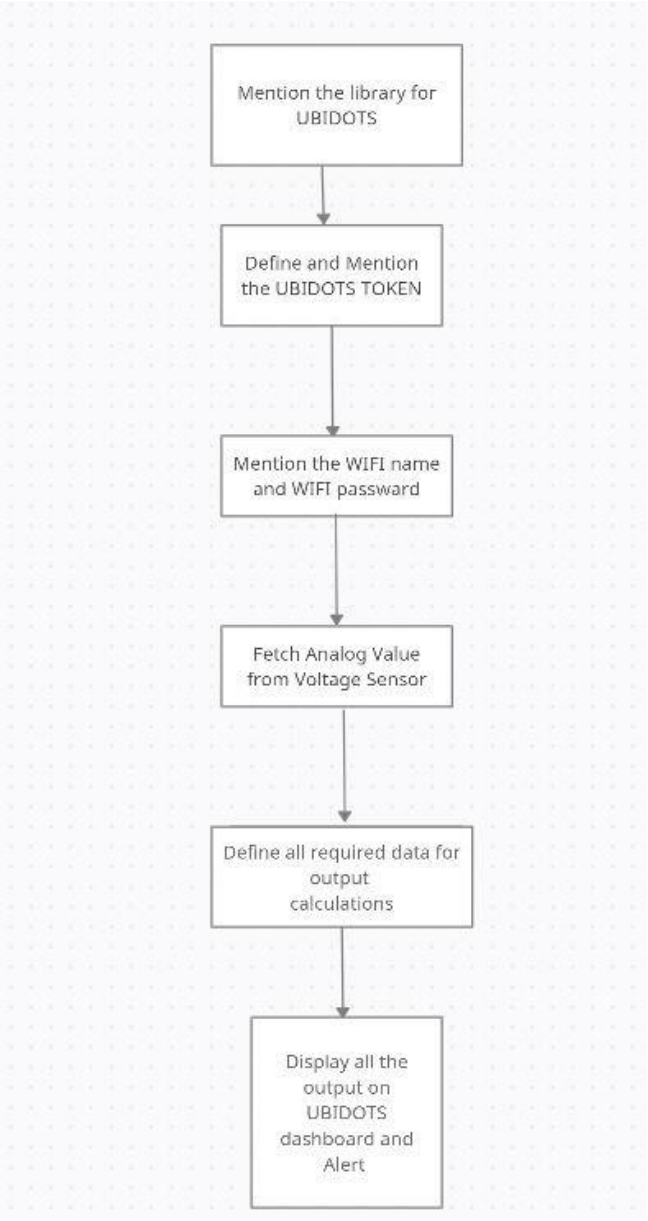

Fig. 7- Flowchart of monitoring and cleaning mechanism

Fig. 7 shows flowchart giving a brief information about the coding of the monitoring and cleaning mechanism. Arduino software is used to execute the code and then it is dumped in the ESP8266 which will process it and shows the output on the UBIDOTs website.

a) For INA219 and DHT11 sensors:

For this code, including all the required libraries such as 'Adafruite_INA219', 'DHTesp'. These libraries are used in the execution of those specific sensors (i.e., INA219 and DHT11). Also include the libraries to connect the microcontroller to the UBIDOTs cloud (UbidotsMicroESP8266). After that define the UBIDOTs token and WIFI name and password to connect the microcontroller to the cloud. Then onto the main code, mention the pin for input data (In this case D2 and D1 pin is used). Set a pin for output(D0). For the next step, check whether the INA219 sensor is gathering the output power or not using the 'IF' statement. If it is, then assign a float variable (v_shunt, v_bus, float current, v_load) for each output parameter to calculate the current and power generated by the solar panels. Similarly, for DHT11 assign the float variables for temperature and humidity and display them on the UBIDOTs dashboard.

b) For cleaning mechanism: Fig. 8 shows a flow chart that briefly explains the working mechanism of the cleaning device. Here assign the int variable for the END points of the solar panels (switch_x, switch_y) and for the position of robot (Position_x_Robot, Position_y_Robot). Here, as the motor driver is used to assign the pins for each terminal of the H-Bridge. The conditions for forwarding and backward movement are defined as well as for the stopping of the robot. Then use the 'if and if else' loop to define the direction and pausing movement of the robot.

IV-EXPERIMENTAL RESULTS OF PROPOSED WORK

The proposed system that is solar power plant monitoring system can measure the voltage, current, temperature and humidity. The real-time monitoring of all these parameters is done by using the IOT platform. After successful of checking all the current and voltage values, the efficiency of the solar panel is calculated. In a situation where the efficiency of the solar panel goes beyond a certain threshold, it is possible to clean the solar panel with the help of an IoT solar panel cleaner machine. Hence, in this manner, efficiency is improved.

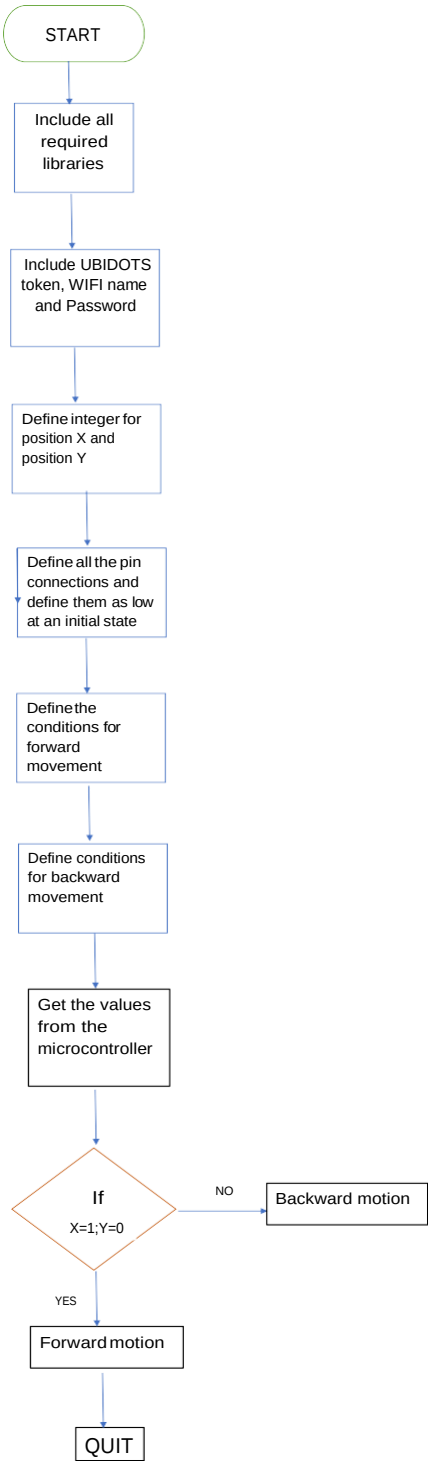

Fig.8- Flowchart of the working mechanism of the cleaning device

Fig.9- Hardware prototype of proposed work (real-time model)

The prototype for the proposed machine is as above.
Layout of UBIDOTS:

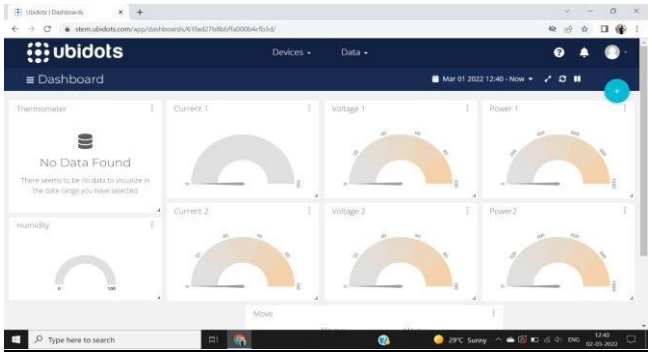

Fig. 10- Dashboard without any data from the ESP8266

Fig. 10 shows the dashboard which has an assigned gauge for each output parameter which will be used to monitor the proper working of the solar panel. And there is a display for humidity and temperature value as well.

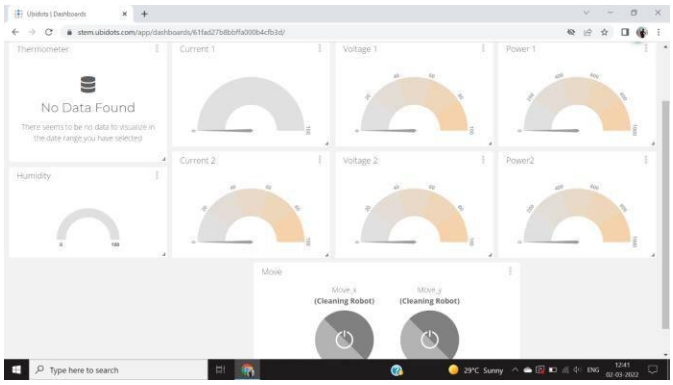

Fig.11- Dashboard for cleaning mechanism

Fig.11 displays the control panel for the cleaning mechanism at the bottom of the dashboard. Switch Move_X and Move_Y control the forward and backward movement of the cleaning machine.

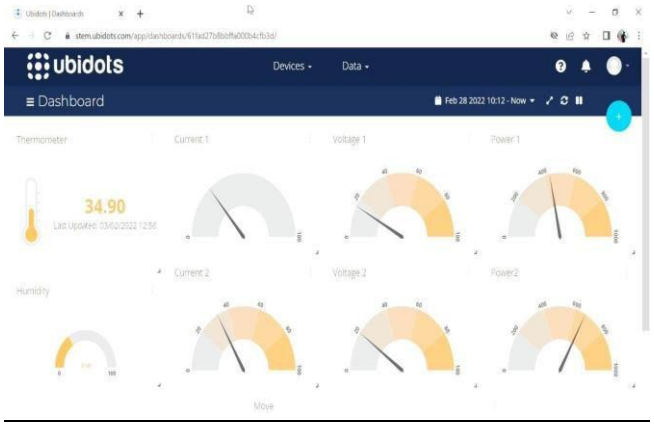

Fig.12- Dashboard with the data from the solar panels

Fig.12. displays all the parameters when the mechanism is in the working condition.

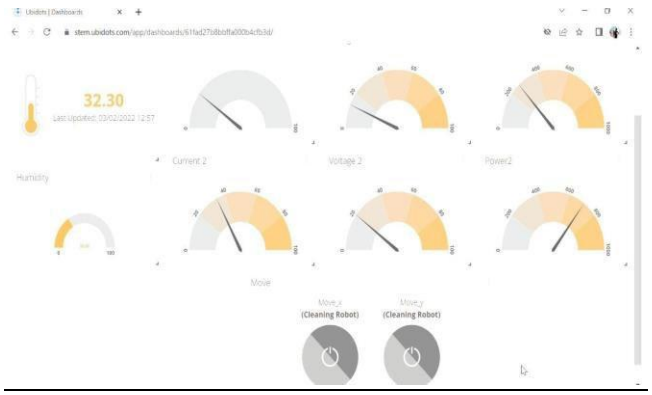

Fig.13- Dashboard

Fig.13. shows a dashboard with a cleaning program which gets initiated if there is a drop in output power through the switches.

V-CONCLUSION

The need for electricity is rising day by day and traditional sources of energy are not producing enough energy to meet the requirements. Applications of the monitoring system are in Rooftop solar, ground-mounted solar, solar cities and many more. The energy is alternatively dependent upon the primary parameters like temperature, voltage, current and keeping track of all these parameters on real-time IoT played a vital role. Results are displayed on LCD as well as on mobile devices. Users will be able to track, monitor and control these panels virtually to maximize electricity generation. Accompanying the monitoring system cleaner is installed in this system to ameliorate the efficiency of the system. Prevention is better than cure as a result the cleaning action prevents the primary accumulating surface dust on the panels before it hinders the efficiency of panels to a greater extent.

REFERENCES

[1] Jiju K. ET. al., 2014. "Development of Android-based online monitoring and control system for Renewable Energy Sources." Computer, Communications, and Control Technology (I4CT), International Conference on. IEEE, 2014.

[2] Kabalci, Ersan, Gorgun A. and Kabalci Y., 2013. "Design and implementation of a renewable energy monitoring system." Power Engineering, Energy and Electrical Drives (POWERENG), Fourth International Conference on. IEEE, 2013.

[3] Yoshihiro G. ET. al., 2007. "Integrated management and remote monitoring system for telecommunications power plants with fully DC-powered center1 equipment." INTELEC 07-29th International Telecommunications Energy Conference. IEEE, 2007.

[4] S. Mubera and N. Uwitonze, "Energy Sector Development in Sub Saharan Africa: Case Study of Rwanda," Journal of Fundamentals of Renewable Energy and Applications, vol. 8, no. 4, 2018.

[5] K. Jager, O. Isabella, A. Smets, R. v. Swaaij and M. Zeman, Introduction to Photovoltaic Solar Energy, Adison-Wesley Publishing Company, 2014.

[6] K. Tsamaase, T. Ramasesane, I. Zibani, E. Matlotse and K. Motshidisi, "Automated dust detection and cleaning system of PV module," IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), vol. 12, no. 6, pp. 93–98, 2017

[7] M. R. Maghami, H. Hizam, C. Gomes, M. A. Radzi, M. I. Rezadad and S. Hajighorbani, "Power loss due to soiling on solar panel: A review," Renewable and Sustainable Energy Reviews, vol. 59, pp. 1307–1316, 2016.

[8] Nandankar, P., Thaker R.; Mughal, S.N.; Saidireddy M.; Linda, A.; Kostka J.E.; Nag, M.A, "An IoT based healthcare data analytics using fog and cloud computing," Turkish Journal of Physiotherapy and Rehabilitation, (2021), 3,32.

[9] Nandankar, P.V., Bedekar, P.P., Dahwas, P.K.V.: Variable switching frequency control for efficient DC/DC converter. Material Today: Proceedings (2021).

[10] Nandankar, P., Dasarwar, A., Kachare, G., "Comparison of improved converter topologies for high voltage gain," International Conference on Communication information and Computing Technology (ICCICT), (2018), DOI: 10.1109/ICCICT.2018.8325893.