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To Design and Implement an IOT-based Solar Monitoring and Data Acquisition System using ESP8266

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Abstract: With the increasing need and awareness for using efficient and sustainable energy resources, solar energy has emerged as a key alternative to traditional energy sources, and its widespread adoption requires the development of an advanced solar monitoring and data acquisition system. This report presents a solar monitoring system that will provide real-time data monitoring on various solar panel parameters, which provides insights for maintaining the efficiency and productivity of the solar panel output. The model is designed on a rooftop college solar panel in which of two solar PV panels connected together in series connection. Based on the panel parameters and specifications, the sensing elements for the system are decided. These sensing devices sense the various system parameters at a given time interval and send them to a cloud for the storage of data with the help of the microcontroller. Simultaneously, the data is displayed with the help of an IOT platform for the users. In the study, the model of the monitoring system was tested at various time intervals throughout the daytime, and the outcome was achieved. This system works on a microcontroller which is a Wi-Fi-enabled module that enables data storage and representation. Smart Solar Monitoring and Data Acquisition Systems provide real-time access to data, allowing operators to make informed decisions promptly, enhancing system efficiency, and enabling remote monitoring.
Keywords: PV System, Solar Monitoring, Data Acquisition, Cloud Computing, Cloud Storage, Internet of Things.

I. INTRODUCTION

With the increasing population, the energy needs of India are also growing rapidly. With a total installed electricity producing capacity of 4 lakh MW, out of which 40% of its energy is generated using renewable energy sources which majorly consist of Hydro, Solar, and Wind energy making India 3rd largest country to produce its energy using renewable resources. Renewable energy sources are inexhaustible in nature providing a solution to the depleting fossil fuels resources and producing a clean and never-ending energy supply for the future.

During the United Nations Framework Convention on Climate Change (COP 26) in the year 2021, India has set a target to achieve a net zero emission by the year 2070 and produce 50% of its energy using renewable sources by the year 2030 which is a crucial step for stabilizing global climate change.

Solar energy is the fastest growing renewable energy source in India. To achieve the set targets solar energy consumption needs to be increased at industrial as well as domestic levels in the country. Recently, the Government has launched PM Surya Ghar Muft Bijli Yojana, which aims to boost the use of rooftop solar panels among people promoting sustainable energy practices. But to make this possible we need to work on increasing the efficiency of our solar energy systems. Hence, the development of advanced monitoring and data acquisition systems will provide real-time insights and accurate data, such a system can enhance the efficiency, performance, and maintenance of solar energy systems, ultimately contributing to the overall growth and sustainability of renewable energy.

II. METHODOLOGY

Creating a Smart Monitoring system involves identifying parameters affecting the overall performance and longevity of solar panels. Those parameters are classified into two categories parameters such as current, voltage, solar panel temperature, and external factors like sunlight intensity, ambient temperature, and atmospheric humidity. An electrical circuit model to acquire data about all specified parameters was designed and simulated. Along with hardware implementation of the designed circuit, a user-friendly interface for the representation of collected data was developed.

This project involved long-term data collection of individual parameters for future analysis as well as specific observations including variation of generated solar power with respective to changes in load, time, temperature, and solar intensity.

III. BLOCK DIAGRAM

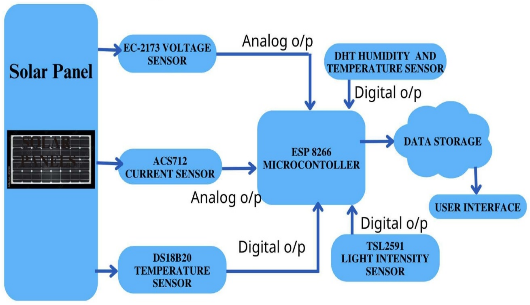

Figure 1. Block Diagram of system

IV. COMPONENTS

As an off-grid solar system is considered where its output is connected to a load bank the voltage and current are measured by respective sensors mentioned in the block diagram (ACS 712 Current Sensor module (20A) and EC – 2173 Voltage sensor module (30V)). Similarly, panel temperature (using a DBS18B20 Temperature sensor), ambient temperature, atmospheric humidity (using a DHT 11 Temperature and humidity sensor), and solar light intensity (using a TCL25911 Light intensity sensor) are measured. All those sensors feed their raw data to the Esp8266 microcontroller which calibrates it and converts it to their SI unit counterparts. The microcontroller being WIFI enabled sends the calibrated sensor data onto the cloud which makes its way to the user interface.

V. CIRCUIT DIAGRAM

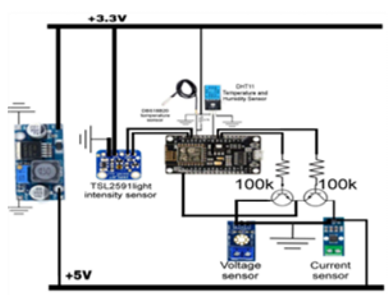

Figure 2. Circuit Diagram of system

VI. HARDWARE

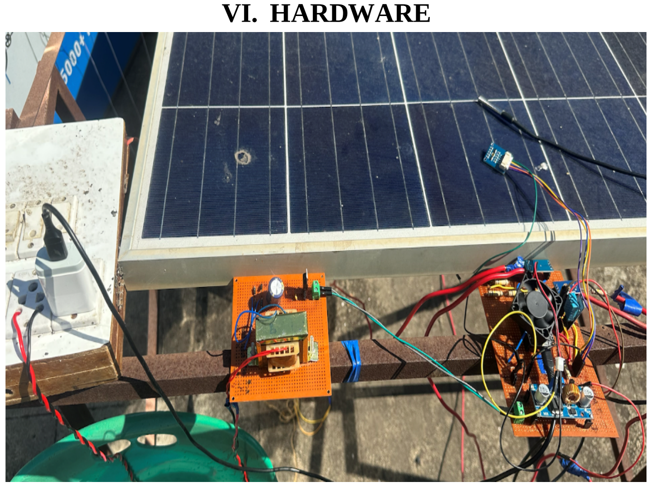

Figure 3. Hardware Implementation of system

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VII. DATA STORAGE TO CLOUD PLATFORM

Microsoft OneDrive is used as a cloud platform and the live data are updated in a Microsoft Excel sheet sensed by various sensors and processed by the microcontroller ESP8266. One Drive allows syncing the data with multiple users and can access the Excel sheet remotely. ESP8266 is a Wi-Fi-based microcontroller that makes use of an internet connection to give real-time data by integrating with Microsoft Excel. The data from each sensor can be directed to a particular space in the sheet using App Script in Microsoft Excel thus having a record of all the data and real-time updating the values along with date and time. It allows HTTP GET requests from specific parameters and writes the data to a specified spreadsheet. Then it is deployed as a web app in App Script and obtains a URL that is used to send a GET request with the required parameter to update the spreadsheet thus achieving real-time monitoring.

A	B	C	D	E	F	G	H
Date	Time	Humidity	Voltage	Current	Temperature	ATemperature	Light Intensity
08/05/2023	12:38:56	79	52.14295197	2120.606934	34.6875	30.8	7364
08/05/2023	12:39:14	79	52.23208618	1775.391113	34.75	30.8	7334
08/05/2023	12:39:31	79	51.96468735	1676.759766	34.75	30.8	7288
08/05/2023	12:39:48	79	52.4103508	1528.809082	34.8125	30.8	7242
08/05/2023	12:40:05	79	51.96468735	1627.442871	34.6875	30.8	7178
08/05/2023	12:40:22	79	52.85601807	1479.492188	34.6875	30.8	7117
08/05/2023	12:40:40	79	51.60815048	1331.543945	34.75	30.8	7063
08/05/2023	12:40:57	78	51.60815048	1479.492188	34.8125	30.8	6998
08/05/2023	12:41:14	78	51.51902008	1578.125977	34.875	30.8	6945
08/05/2023	12:41:33	78	52.23208618	1676.759766	34.875	30.8	6884
08/05/2023	12:41:49	78	51.96468735	1972.65625	34.875	30.8	6819
08/05/2023	12:42:06	78	52.05381775	1775.391113	34.875	30.8	6751
08/05/2023	12:42:25	78	52.14295197	1676.759766	34.875	30.8	6686
08/05/2023	12:42:42	78	52.4103508	1972.65625	34.8125	30.8	6617
08/05/2023	12:42:59	78	52.14295197	1775.391113	34.75	30.8	6541
08/05/2023	12:43:17	79	52.76688766	1874.024902	34.6875	30.8	6473
08/05/2023	12:43:34	79	52.14295197	1676.759766	34.625	30.8	6416

Figure 4. Data Storage in Microsoft Excel

VIII. DIGITAL REPRESENTATION

For better visualization of data and to provide a user-friendly interface Blynk is used for the digital representation of data. Blynk is an IoT platform that can be used to control and monitor devices remotely using a mobile application. The feature of cloud computing allows data storage and real-time monitoring of various parameters. It provides a user-friendly design and customizable options that make it simple for the user to handle. Blynk easily accesses data from ESP8266 using an internet connection and displays it in various graphs as shown in Fig. below

Figure 5. Data Representation in BLYNK Software

IX. OBSERVATION

Realtime data for system parameters such as panel voltage, and panel current, as well as independent parameters such as sunlight intensity, ambient temperature and humidity were collected and plotted against time. Through the fluctuations of system parameters, it is observed that any of them is affected by the load as well as all of the independent parameters acting on the system. The plotted data of all measured parameters are as follows

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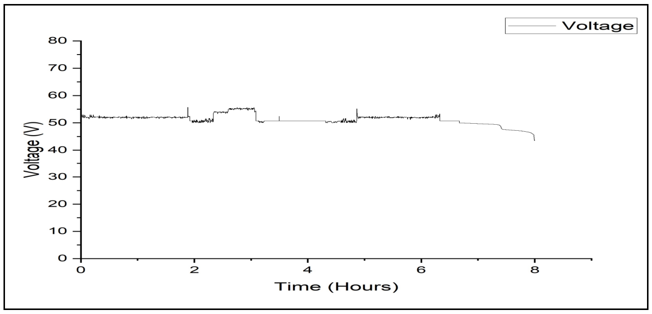

Figure 6. Panel Voltage vs Time

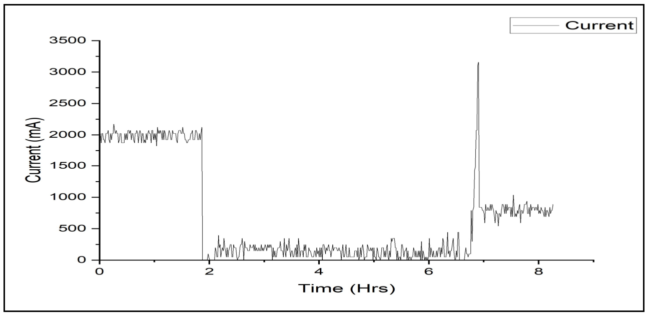

Figure 7. Panel Current vs Time

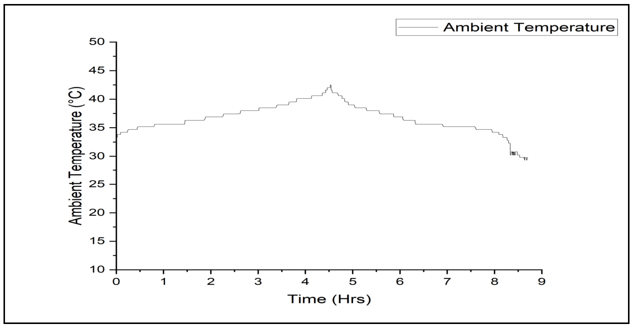

Figure 8. Atmospheric Temperature vs Time

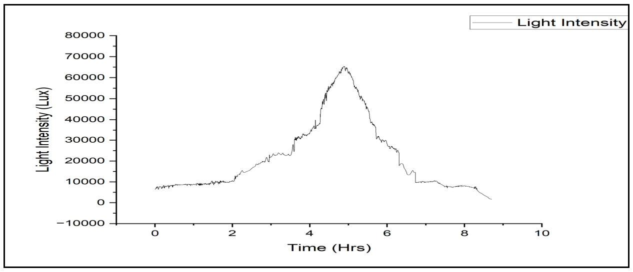

Figure 9. Sunlight intensity vs Time

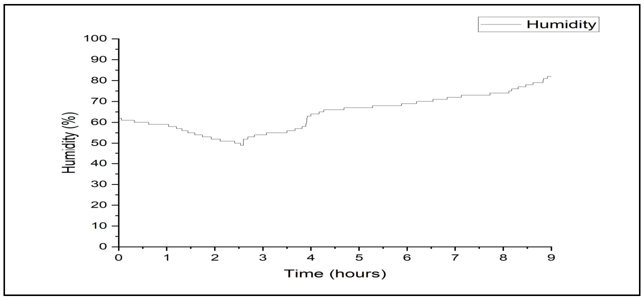

Figure 10. Atmospheric Humidity vs Time

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X. FUTURE SCOPE:

The proposed solar monitoring system offers a wide range of advantages being cost-effective as the hardware cost associated with low, smart monitoring systems with the integration of IoT technology, Real-time Monitoring providing real-time access to critical data, system's comprehensive data collection and analysis capabilities enable data-driven decision-making and by maximising energy production efficiency, the system contributes to a greater utilisation of solar energy resources.

The paper provides basic design for an off-grid solar monitoring system. With help of technology and with the use of mathematical Ml and Al models the scope of the system can be enhanced by the understanding of the photovoltaic solar panel monitoring systems in terms analysis of system parameters.

1) By using a Scada with data logger the system can be used in on-grid and hybrid power systems.
2) With the help of AI-based Deep Learning Model and Machine Learning analysis of Solar Power generation, forecasting can help in performance enhancement of PV panels in solar energy systems.
3) Various AI models such as Machine-Learning algorithms, Convolutional Neural Networks, Recurrent Neural Networks and Transfer Learning can be developed for fault diagnosis in solar monitoring systems which helps in achieving accurate fault detection and diagnosis in solar panels

XI. CONCLUSION

In this paper, a solar monitoring and data acquisition system is developed on a rooftop stand-alone PV system. It tracks the parameters of the solar panel such as voltage, temperature, humidity, current and light intensity. The data is sensed through various sensors, and collected by a microcontroller ESP8266 which stores live data in a database. The system constantly updates the database with new values and stores it in Microsoft Excel sheets which is used as a cloud storage platform using the OneDrive feature that can be accessed from various devices remotely using an internet connection. For better visualization, an IoT-based platform Blynk is used which gives a graphical representation by efficiently analysing any inconsistency in the data generated thus detecting various issues in the PV system. This user-friendly system will facilitate better monitoring of the PV array and timely maintenance by the user.

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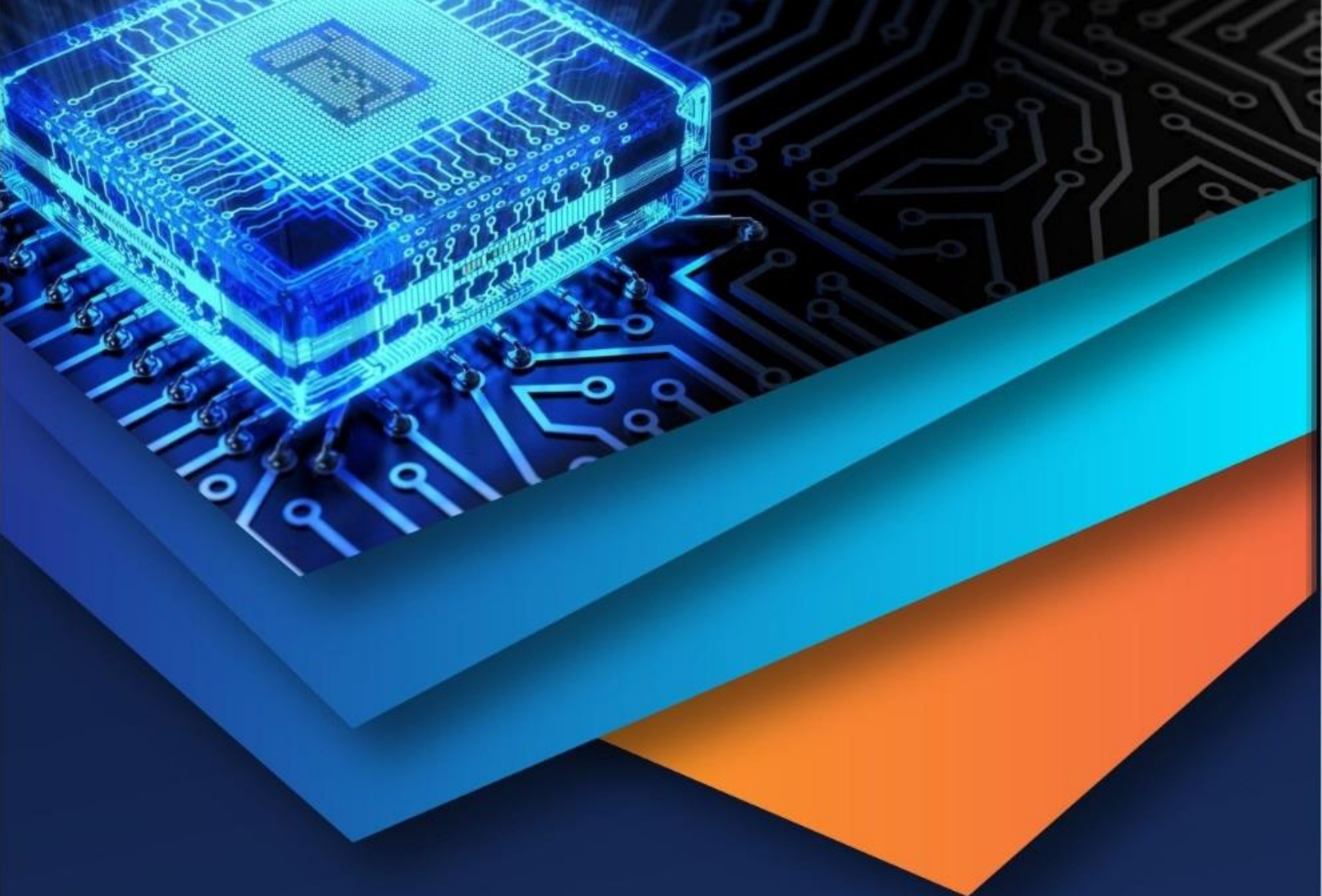

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