A STUDY OF IOT BASED REAL-TIME SOLAR POWER REMOTE MONITORING SYSTEM

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ABSTRACT

We have Developed an IoT-based real-time solar power monitoring system in this paper. It seeks an open-source IoT solution that can collect real-time data and continuously monitor the power output and environmental conditions of a photovoltaic panel.The Objective of this work is to continuously monitor the status of various parameters associated with solar systems through sensors without visiting manually, saving time and ensures efficient power output from PV panels while monitoring for faulty solar panels, weather conditionsand other such issues that affect solar effectiveness.Manually, the user must use a multimeter to determine what value of measurement of the system is appropriate for appliance consumers, which is difficult for the larger System. But the Solar Energy Monitoring system is designed to make it easier for users to use the solar system.This system is comprised of a microcontroller (Node MCU), a PV panel, sensors (INA219 Current Module, Digital Temperature Sensor, LDR), a Battery Charger Module, and a battery. The data from the PV panels and other appliances are sent to the cloud (Thingspeak) via the internet using IoT technology and a Wi-Fi module (NodeMCU). It also allows users in remote areas to monitor the parameters of the solar power plant using connected devices. The user can view the current, previous, and average parameters of the solar PV system, such as voltage, current, temperature, and light intensity using a Graphical User Interface. This will facilitate fault detection and maintenance of the solar power plant easier and saves time.

KEYWORDS

Internet of Things (IoT), Node MCU, PV Solar panel,Current sensor Module,Things peak

1. INTRODUCTION

The Internet of Things (IoT) is a technological advancement that connects computing devices, machines, and objects in everyday life with special identifiers and data transfer over a network without requiring human-to-human or human-to-PC communication. This technology facilitates data exchange between connected devices on a network. The internet enables users to access data and control devices from anywhere in the world.

The main goal of the Solar Power Monitoring System is to promote a data acquisition system that continuously appears remote energy yields. Electricity is required in today's world for heating, lighting, refrigeration, transportation systems, and all home appliances. The graph of energy consumption is increasing day by day, while the graph of energy resources is decreasing. So, in order to balance the electricity deficit, we are using renewable sources such as the sun, wind energy, and tidal energy to generate electricity that can be reused instead of non-renewable sources such as coal, natural gas, and fossil fuels, which are depleting on a daily basis. That is why solar power is referred to as an indestructible energy source. As a result, an IoT-based solar power monitoring system is being proposed to address the issues associated with electricity scarcity.

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In general, our country experiences relatively sunny days for approximately 7 to 9 months of the year, with partially cloudy skies the remainder of the time. This makes our country, especially the areas of Teknaf, Sutiakhali, Mymensingh, and Sunamganj,Cox-bazar prosperous in terms of solar power harnessing. Solar power plants must be monitored to ensure that they are producing the maximum amount of power.Because the range of the sun's radiation is not fixed and can vary depending on location, time, and climatic conditions, solar panels that are exposed to the sun must always be monitored.

The proposed system is an IoT-based solar power monitoring system. Solar cells, which are found in solar panels, convert sunlight into electricity in this system. We use a Node MCU Wi-Fi module, and sensors to measure current-voltage parameters, power, temperature, and light intensity. An IoT device is also linked to the sensors, allowing the displayed parameter to be monitored from any location using any available network.

2. LITERATURE REVIEW

A smart monitoring system is created that used a microcontroller and Lab view to maximize efficiency with the use of sun trackers[1]. The Internet of Things is being used to develop a low-cost solar panel monitoring system for web-based visualization and improved performance. This helps with maintenance and tracking the location of faults[2].

The Raspberry Pi is used to propose and develop an IoT-based cloud monitoring system for remote PV plants[3]. A low-cost smart architecture is proposed to optimize PV panel efficiency by detecting performance degradation via a continuous monitoring system[4]. A real-time supervising and data collection model for solar PV modules are developed using LABVIEW to determine the performance of various solar PV ratings[5-6]. A PV monitoring system is designed to send parameters via wired and wireless networks to a remote coordinator, who then provides a web-based application for remote access[7].

A simple forecasting database is modeled without using existing automation tools, utilizing MySQL to collect raw data, filter out irrelevant values, and generate forecasts. In order to achieve robust performance, machine intelligence techniques are also used for forecasting[8]. A remote solar monitoring and control system for plant operation is proposed, which facilitates decision-making for the central control station, which plays a crucial role in processing, storage, warning, and displaying[9]. To study fault diagnosis in PV plants, the basic characteristics of a PV system are researched using the LABVIEW tool for real-time measurement[10].

Lab View is being used to create a usable graphical user interface for the online monitoring of solar photovoltaic systems. The Arduino controller explores the measured parameters and sends the data to the server to make an effective decision that improves the PV panel's effectiveness[11]. A microcontroller-based displaying system is proposed to monitor the various factors influencing the performance of PV panels. In order to provide the necessary action for improved PV performance, the measured parameters are compared with the standard operating conditions[12]. A smart controller based on the HEM algorithm is used to select the source priority in order to maximize the use of Solar PV for home power management [13]. As a result, the proposed work demonstrates a real-time Solar PV monitoring system using a cost-effective Smart Controller that communicates with a cloud platform that provides large storage space as well as fast data access.

3. PROPOSED METHODOLOGY

Figure 1 depicts the proposed model of this system, which shows the interconnection of these blocks.This System uses a Node MCU microcontroller having ESP8266 Wi-Fi module which control all the data associated with the PV panel.Here voltage and current sensor module senses the voltage, current and power developed on PV panel which are read by NodeMCU. The environment temperature and the amount of Light intensity falling on PV are measured by Temperature Sensor and LDR respectively. The sensors which are linked to the microcontroller (Node MCU) are powered by a power supply.The Node MCU serves as the foundation for live streaming current, voltage, power, light intensity, and temperature, as well as sending sensor data to the server via the ESP8266 Wi-Fi module. Extra power will be stored in the battery via the Battery Charger Module for later use. As a result, the user can keep an eye on the aforementioned parameter.

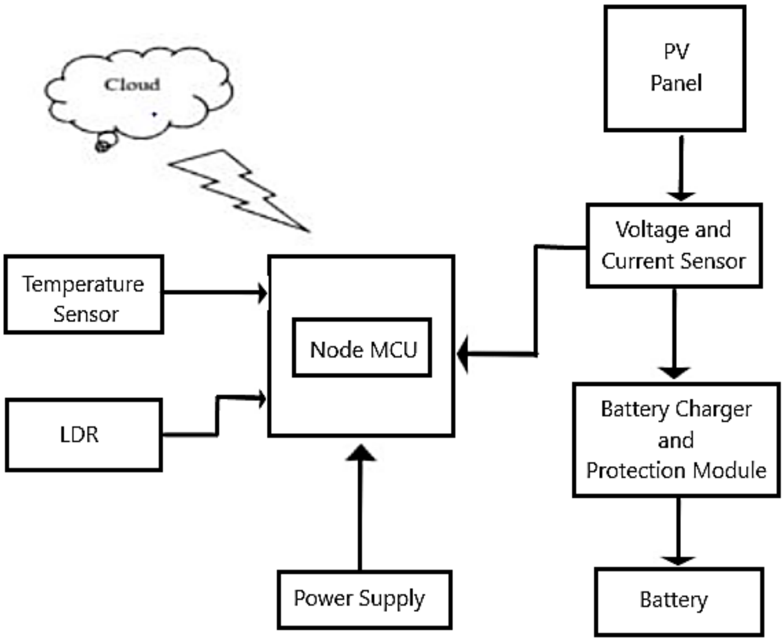


Figure1.Proposed model of the IoT-based solar power monitoring system

The proposed system's flowchart is showed in Figure 2. When a connection is established between the NodeMCU and the Thingspeak server, the NodeMCU sends various sensor data to the Thingspeak server's various fields. The user can then monitor sensor data from any location through the internet.

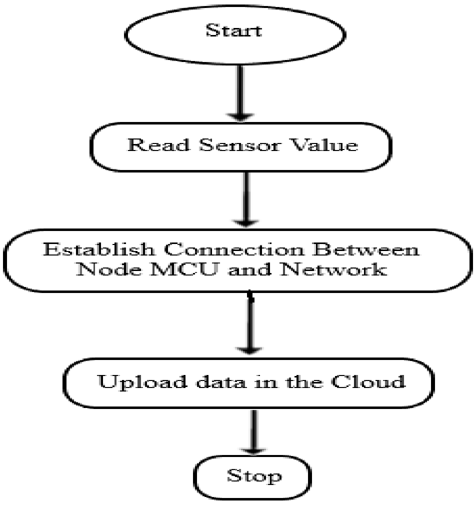


Figure 2. Flowchart of the proposed system

4. EXPERIMENTAL SETUP

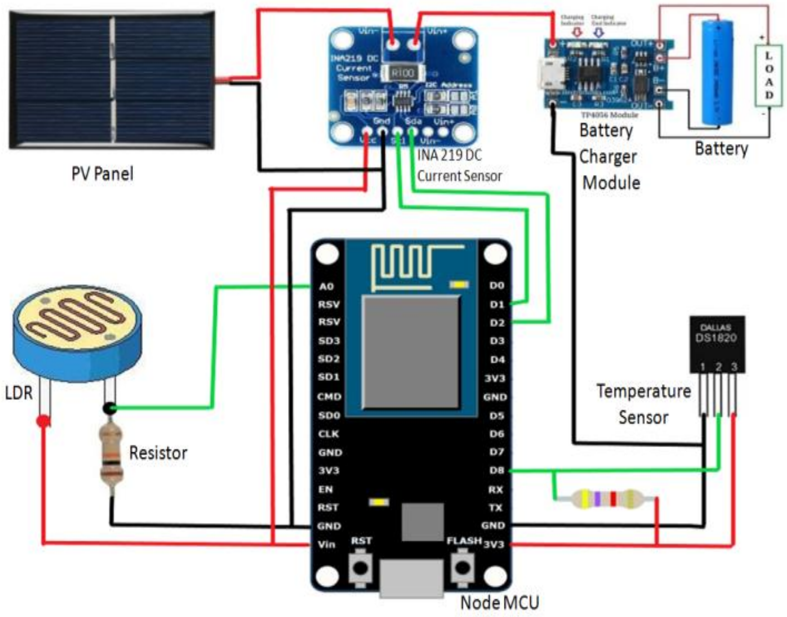


Figure 3. Experimental Setup of the proposed system

Figure 3 Illustrates the Experimental setup of a solar power monitoring system based on IoT. This setup includes a Node MCU microcontroller, Sensors such as a INA219 Current sensor module, a Battery Charger module, a Battery, an LDR, a DS18B20adigital temperature sensor, and a solar panel that measures parameters.The Node MCU is responsible for live streaming current, voltage, power, light intensity, and temperature, as well as sending sensor data to the server via the ESP8266 Wi-Fi module. The sensors are connected to the microcontroller (Node MCU), which is powered by an external power supply.The values of the sensors are read by NodeMCU, and the data is sent to the cloud server by this microcontroller. Extra power will be stored in the battery for later use via the Battery Charger Module. As a result, the user can monitor the above- mentioned parameter. The practical circuit setup of the proposed system is shown in Figure 4.

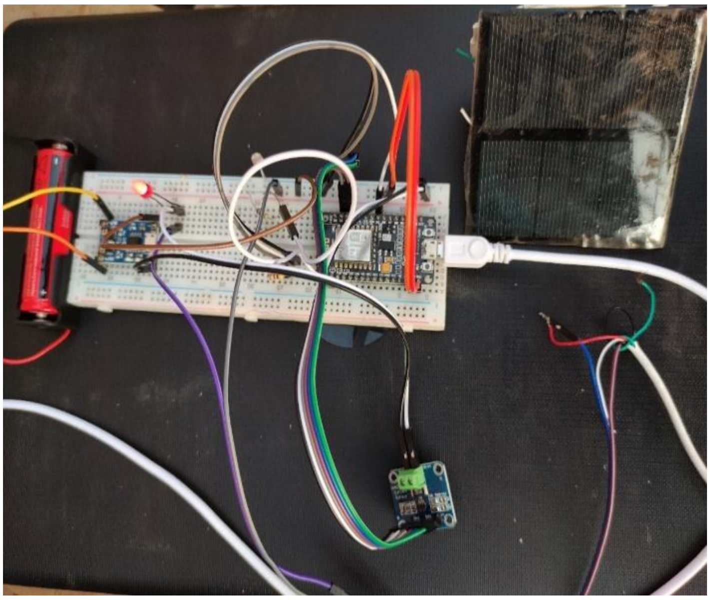


Figure4. Practical circuit diagram of the proposed system

5. RESULTS AND DISCUSSION

This system's readings are taken at a specific field for a single day at a specific time interval. Readings are taken in the morning, afternoon, and night, and are graphically presented below.

(A) At Morning

Figures 5(a)–(e) demonstrates the recorded data of Bus Voltage, Current, Power, Light Intensity, and Temperature at a specific time of the day in the morning. Fig. 5(a) depicts the System Voltage Readings as measured by the INA 219 Current Sensor Module between 8.21 am and 8.28 am on a specific day. The maximum voltage generated by solar photovoltaic panels is 2.5 volts, while the minimum voltage is 2.43 volts.

Figure 5(b) depicts the value of Current across the load, which is Shunt Resistance, as recorded by the INA 219 Current Sensor Module in the morning between 8.21 am and 8.28 am on a specific day. The maximum sensed current in a given time interval is approximately 1 mA, while the minimum sensed current is approximately 0.5 mA. Fig. 5(c) illustrates the Power Curve, which is the product of voltage and current sensed by the INA 219 Current Sensor Module and is recorded at a specific time in the morning between 8.21 am and 8.28 am on a specific day. In this case, the maximum recorded power is 2.5 mW, while the minimum power is around 1.5 mW.

Figure 5(d) shows the recorded value of light intensity on solar PV panels by LDR sensor between 8.21 am and 8.28 am on a particular day. At that time, the maximum light intensity is nearly 840 Candela (cd), while the minimum value is nearly 802 cd.We used the DS18B20a sensor to measure the temperature on the surface of the solar panel, which was recorded in a specific time interval in the morning on a specific day. Fig. 5(e) depicts the temperature variation between 8.21 am and 8.28 am on a particular day. The temperature is varied between 22.5°C and 22.9°C within that specific instance.

(a) (b)

(c) (d)

(e)

Figure 5. Recorded data in the morning (a) Bus Voltage Vs Date/Time graph; (b) Current Vs Date/Time; (c) Power Vs Date/Time; (d) Light Intensity Vs Date/Time; (e) Temperature Vs Date/Time

(B) At Afternoon

(a) (b)

(c) (d)

(e)

Figure 6 Recorded data in the afternoon (a) Bus Voltage Vs Date/Time graph; (b) Current Vs Date/Time; (c) Power Vs Date/Time; (d) Light Intensity Vs Date/Time; (e) Temperature Vs Date/Time

Figures 6(a)–(e) demonstrates the recorded data of Bus Voltage, Current, Power, LightIntensity, and Temperature at a specific time of the day in the afternoon. Fig. 6(a) represents the voltage reading of the developed system between 3.32 and 3.41 pm on a specific day. Since the maximum amount of light falls on the solar PV panel during that time interval, we have a maximum generated voltage of nearly 3.28V, which is higher than the value in the morning.

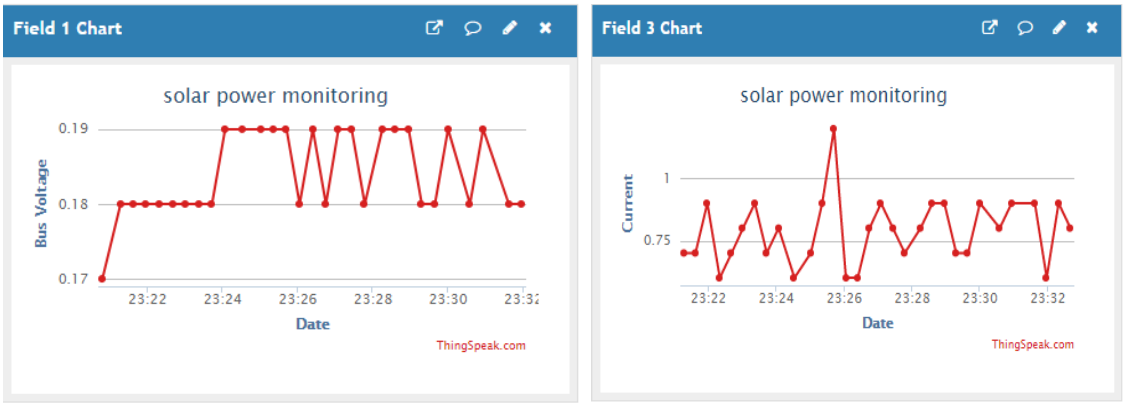
Figure 6(b) represents the value of the current reading in the afternoon, which was recorded between 3.32 pm and 3.42 pm on a specific day. During that time, the maximum current is approximately 1.1 mA, and the minimum current is approximately 0.5 mA. The power curves shown in Fig. 6(c) represent data collected by the INA 219 Current Sensor Module in the afternoon. Due to the extreme light intensity between 3.32 pm and 3.42 pm on a specific day, the maximum value obtained during that period was 3.59 mW, which was greater than the value obtained in the morning for that specific day.

The graph in Fig. 6(d) describes the intensity of light during a time interval between 3.32 pm and 3.42 pm in the afternoon on a specific day. We can see from the graph that the Light Intensity is always at its maximum value, which is 1024 cd. Fig. 6(e) depicts the temperature variation on the surface of the solar panel between 3.32 pm and 3.43 pm on a specific day. The maximum temperature reached 31.2°C in this graph, while the minimum temperature reached 29°C.

(C) At Night

Figures 7(a)–(e) demonstrate the recorded data of Bus Voltage, Current, Power, Light Intensity, and Temperature at a specific time of the day in the night. Fig.7(a) shows the voltage generated by Solar PV panels on a specific day at night in between 11.22 pm and 11.32 pm. Due to low light intensity at night, the maximum value of generated voltage is nearly 0.19V during this period, while the minimum value of generated voltage is 0.17V.

Figure 7(b) depicts the generated current across the load at night between 11.22 pm and 11.32 pm on a specific day. In this case, the maximum generated current sensed by the INA 219 Current sensor is approximately 1.2 mA, while the minimum current is approximately 0.6 mA. The graph of Fig. 7(c) illustrates the value of generated power at night between 11.22 pm and 11.32 pm on a specific day. We can see that the maximum power is about 0.23 mW, which is very low as compared to the afternoon and morning because the light intensity on the solar PV panel is lowest at night. While the lowest value of generated power is approximately 0.11 mW.



(a) (b)

(c) (d)

(e)

Figure 7 Recorded data in the night (a) Bus Voltage Vs Date/Time graph; (b) Current Vs Date/Time; (c) Power Vs Date/Time; (d) Light Intensity Vs Date/Time; (e) Temperature Vs Date/Time

Figure 7(d) depicts the value of light intensity falling on solar PV panels from 11.21 pm to 11.34 pm on a specific day. During this time period, the maximum light intensity was 330 cd, while the minimum light intensity was 325 cd. The variation in light intensity at night is less than it is in the morning and afternoon. Fig. 7(e) represents the value of temperature on the surface of the solar panel at night on a specific day between 11.22 pm and 11.32 pm. It is seen that the temperature fluctuates between 24.5°C and 25.2°C during that time period.

6. CONCLUSIONS

In this paper, an IoT-based real-time solar power monitoring system was successfully developed, which included a microcontroller (Node MCU), a PV panel, sensors (INA219 current module, digital temperature sensor, and LDR), a Battery charger module, and a Battery.The system could collect instantaneous data from remote locations or far from the control center and monitor in real-time of the produced power and environmental conditions of PV panels such as voltage, current, temperature, and light intensity using a GUI via connected devices.The use of IoT enables continuous recording and monitoring of real-time data that can be used for data analysis to predict and estimate future power generation possibilities income output, and so on. As a result, the use of this IoT-based system will make recorded data analysis easier and more efficient, reduce intervention and supervision time, simplify network management, and eliminate the need for regular PV system maintenance. Since the range of the sun's radiation is not fixed and can vary depending on location, time. So, we can control the PV panel by making an arrangement of Solar Power Tracking System for efficient use of maximum possible amount of solar radiation to get maximum output. This Solar Power Monitoring system will also provide an advantage in the event of a fault occurring in any part of the system.

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