IoT-Based Low-Cost Remote Surveillance System for Solar Photovoltaic Panels

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Nowadays Photovoltaic (PV) systems have seen an increase in demand since they produce electricity without harming the environment by directly converting solar energy into electricity. As a result, the sun's irradiance should be correctly exploited. Solar energy is a completely natural and environment friendly source of energy. As a result, the efficiency of solar power plants should be closely monitored to ensure maximum power output. Hence, we propose a machine-driven, IoT-based solar energy monitoring system that allows solar energy monitoring from anywhere via the internet. Tomonitor a 25Watt solar array parameters, we proposed an Arduino board-based system. Our system continuously supervises the solar array and sends the power production to the IOT system through the internet. We are using IOT Adafruit for sending solar energy parameters to the IOT Adafruit server over the web. The main parameters, such as current, voltage, power and energy are presently displayed to the user. This tends to the user can monitor their solar panels from any distant locations.

Keywords: IOT, Solar Photovoltaic, Remote Monitoring, Arduino Nano.

2023. In Saroj Hiranwal & Garima Mathur (eds.), *Artificial Intelligence and Communication Technologies*, 447–452. Computing & Intelligent Systems, SCRS, India. https://doi.org/10.52458/978-81-955020-5-9-42

1 Introduction

Due to the reduction of natural reserves and environmental pollution, the growth of renewable energy has been severely hampered in recent years. Sustainable energy generation technologies can gradually replace traditional energy supply systems. Nowadays, solar photovoltaic (PV) generation is acquiring popularity around the world because of its multiple benefits, the most important of which is that it is a clean and cost-free energy source [1]. It also has advantages such as ease of installation, requires minimal maintenance, noise-free production, and their primary advantage is their ability to provide outputs ranging from microwatts to megawatts as stand-alone systems. As a result, they are employed in power plants, water pumps, remote buildings, solar home systems, communications, satellites and spacecraft, reverse osmosis facilities, and even megawatt-scale power plants. The demand for photovoltaic is growing every year due to its diverse of applications [2]. The efficiency of the PV panels also increasing every day because of the technological advancements.

A solar panel to stop producing power due to multitude of factors including failure of the supporting system, construction issues, and lack of monitoring and maintenance activities. Continuous monitoring of solar panels is the only way to ensure that power delivery is as efficient as possible. Manual investigation and remote wired monitoring are the two most common methods of monitoring systems. These approaches have some drawbacks, including the length of time required and the complication of the wiring. Solar PV system performance must be regularly evaluated for enhanced efficiency and ease of maintenance, especially when plants are installed in rural locations or dispersed over large areas with low operational costs.

A wireless remote monitoring system is proposed for solar photovoltaic (PV) facility. It is an Internet of Things (IoT) application built with a purpose to offer a cost-effective solution of monitoring system, which continuously provides remote energy yields and its performance either on computer or on handheld electronic devices such as smart phones.

The Internet of Things (IoT) is one of the most essential everyday technologies that enable people to live longer and wiser lives. The Internet of Things (IoT) is a smart gadget that can receive, store, and analyze data according to its needs [3]. The Internet of Things (IoT) is a network of connected objects; a typical IoT device contains sensors, actuators, and microchips that send and receive data to and from the network that allows machines to link with the cloud [4-5]. This technology allows data to be exchanged between linked devices on a network [6].

The user can obtain data and control equipment via the internet from any location on the planet [7]. It also makes use of computing facilities and software systems to process data. Since the sun's energy distribution varies based on location, time, and climatic circumstances, solar panels that are exposed to the sun must be constantly monitored.

There are existing systems in development to monitor and evaluate photovoltaic arrays, but the mobility and affordability of these systems should be improved. The same basic approach is applied to produce a more simple and cost-effective photovoltaic cell performance monitoring system [8].

The goal of this research is to make hardware for a photovoltaic monitoring system that can measure voltage and current and also calculate the output power of photovoltaic cells.

2 System Design for Solar Panel Monitoring

The proposed Internet of Things (IoT)-based solar photovoltaic panel tracking systemis intended to track the performance of solar panels. The design system is made up ofthree primary components: sensing, processing, and display. The monitoring systemwas created to keep track of many vital characteristics like voltage, current, power, andenergy, all of which are presented on the Digital display.

2.1 Voltage Sensor

This is a basic but highly handy module that reduces an input voltage by a factor of 5using a potential divider. This sensor is used to both calculate and monitor the amount of voltage obtained in an object. Its main function is to detect and measure AC and DC voltage levels.

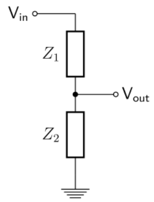

Fig. 1. Voltage divider circuitry

For voltage measurement, voltage divider circuitry with linear resistive elements is used to achieve a desired amount of string voltage, as shown in Fig. 1. The voltage divider circuitry connects the 33k and 10k resistors in series, with one terminal linked to 12 voltage and the other to ground. The ADC channel of the Arduino receives 5-volt maximum equivalent to 24 volt in the midpoint of the circuit, and after acquiring the 5 volt, we can easily measure it using the Arduino.

2.2 Arduino Nano

It is an extremely intelligent gadget that can be used to design anything from robots to toys to industrial applications such as production automation, lift elevators, and automobiles. A microcontroller includes ROM and RAM to store data temporarily and permanently, depending on the necessity. The Arduino Nano has 4KB of ROM and 1KB of RAM. It has a maximum clock speed of 24 MHz and is typically utilized at 16 MHz. This microcontroller includes eight 10-bit analogue channels and fifteen digital outputs. Digital pins are used for sensing and producing digital signals, whereas analogue channels are utilized for fluctuating amount measurement. The USB to UART chip on the board is used for code burning, and there are some pins available for powering various types of sensors.

2.3 Wi-Fi Module (ESP8266)/ NODE MCU

The Wi-Fi Module processes all of the ATmega328's calculated data before storing it on an IOT (Internet of Things) server or in the cloud. On a daily, weekly, and monthly basis, we analyse this data using Adafruit, a popular IoT platform. Adafruit, an open-source cloud platform software that collects and stores data from sensors or other connected devices over the internet using Message Queuing Telemetry Transport (MQTT) from the local network to the cloud, in this proposed solution. It keeps all the sensor's data logs up to date. To utilize it, the user needs first register an account with many channels for monitoring various system metrics or remotely monitored parameters. This cloud can be used by the administrator or user to visualize data in a graphical way. Data on energy output is delivered to a router and made available via an online interface with web-based monitoring. The main benefit of systems like these is that you can access your solar panel production data from anyplace with an internet connection. The suggested system uses the ESP8266 open-source community's microcontroller on a single board that can be programmed using the Arduino IDE and has a RAM size of 128Kbytes and a program storage capacity of 4 Megabytes. It is powered by a USB cable and has a 3.3 to 5 volt operational voltage as well as an in-built Wi-Fi SOC Architecture.

3 Experimental Setup

The prototype model's Hardware Arrangement is depicted in Fig.2 below. The voltage and current sensors are both connected to the Node MCU Esp8266. The AC to DC converter provides power to the model, as the Esp8266 requires 5V DC input.

Fig. 2. Hardware Model of Solar monitoring System Using IOT

- The Internet of Things (IoT) platform combines data from various solar panels and uses analytics to communicate the most useful information with applications tailored to specific needs.
- Some of the hardware are connected to Arduino via serial connection with the Node MCU.
- We may communicate several data at once using the JSON library; in our system, we are sending four different data types: current, voltage, power, and energy generated by solar panels.
- Adafruit, a sophisticated IoT platform, can pinpoint exactly what information is useful.

4 Results

Figure 2 depicts the proposed system's working model. An IoT-based solar power monitoring system is built in this project to get the most output power from the solar panels. The current and voltage characteristics are monitored using sensors once light energy is converted into electricity via solar panels. With the help of IoT technology, the amount of voltage and current received is displayed on the LCD display. We can view the readings on our mobile device by connecting to the Wi-Fi network because the sensors have a Wi-Fi module. Our smartphone is automatically updated if the readings or data change. We can monitor the operation of solar panels using IoT technology, and there is a potential that we will be able to notice a problem if some-thing goes wrong.

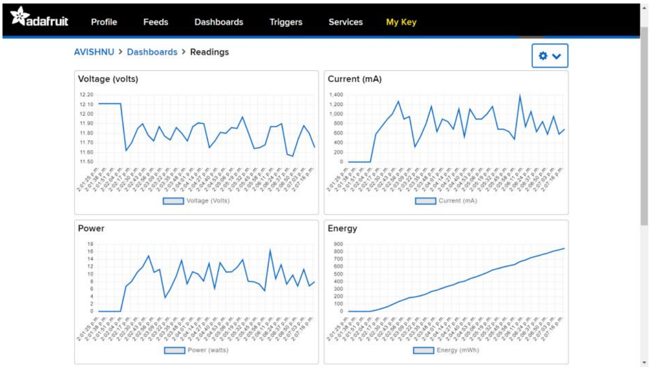

Fig. 3. Performance measured from Solar PV panel

5 Conclusion

As this system keeps records of a solar array, daily, weekly, and monthly analysis becomes very simple and effective. It is also possible to identify any faults that occur within the power plant with the help of this analysis, as generated power may represent a few discrepancies in data from the solar power plant. A smart IoT-based online photovoltaic tracking system is designed using a low-cost microcontroller. The Adafruit programme, which is cloud-based, displays the measured solar parameter in real-time through mobile. The optimum result is based on the observed parameters, and it roughly corresponds to the electrical ratings of solar modules tested under Standard Test Conditions (STC). Through remote access, the proposed work aids in the prediction of the performance of the Solar PV module. This can be extended to a large-scale solar plant to take preventative measures by monitoring the solar plant's performance on a frequent basis. It will be extremely beneficial in both industrial and commercial settings.

6 Future Scope

Through remote access, the suggested work aids in the prediction of the performance of the Solar PV module. This can be extended to a massive solar plant in order to take precautionary measures by examining the solar plant's performance on a frequent basis. It will be extremely beneficial in both commercial and industrial settings.If we add artificial intelligence to our current technology, we can make this project much more inventive and capable of projecting climate conditions as well as human behavior.

References

[1] Barker, P. P. and Bing, J.M. (2004). Advances in solar photovoltaic technology: an applications perspective. In *IEEE Power Engineering Society Summer Meeting*, San Francisco,1-6.

[2] Bhubaneswari. P. S., Iniyan, S. and Ranko, G. (2011). A review of solar photovoltaic technologies. *Renewable and Sustainable Energy Reviews*, 15: 1625–1636.

[3] Priharti, W., Rosmawati, A. F. K. and Wibawa, I. P. D. (2019). IoT based photovoltaic monitoring system application. *Journal of Physics*. IOP Publishing, 1-10.

[4] Pradhan, B., Bhattacharyya, S. and Kunal Pal. (2021). IoT-Based Applications in Healthcare Devices. *Journal of Healthcare Engineering*, 2021: 1-18.

[5] Ali, M. R. (2017). Internet of Things (IOT) Basics - An Introduction to the New Digital World. *International Journal on Recent and Innovation Trends in Computing and Communication*, 5: 32-36.

[6] Arduino-overview of an Arduino.(2016). retrieved from https://store.arduino.cc/usa/arduino-nano.

[7] Loois, G. et al. (1994). Monitoring results of PV for electric propulsion in recreational boating. In *Proceedings of 1994 IEEE 1st World Conference on Photovoltaic Energy Conversion*, 1: 1157-1160.

[8] Sahwee, Z. et al. (2012). Automatic Monitoring of Photovoltaic Cells Performance on Solar Aircraft. *Applied Mechanics and Materials*, 225: 356-360.