

Real Time Monitoring and Analysis of String Faults in Solar Plant Using IoT

B.V. Sai Thrinath¹, B. Lakshmi Prasanna², John Powl.S³, N. Sreeramula Reddy^{4}, Nagalingachary K⁵, P Ponnurugan⁶*

¹ Department of EEE, School of Engineering, Mohan Babu University, Tirupati, AP, India, connectbvst@gmail.com

² Department of ECE, Institute of Aeronautical Engineering, Hyderabad, India, lakshmiprasanna447@gmail.com

³ Department of EEE, Sri Manakula Vinayagar Engineering College, Madagadipet, Puducherry, johnpowl@smvec.ac.in

⁴ Department of EEE, School of Engineering, Annamacharya University, Rajampet, AP, India.

⁵ Department of EEE, Lakireddy Bali Reddy College of Engineering, charylbrce@gmail.com

⁶ Department of Research, Meenakshi Academy of Higher Education & Research, Chennai, India, murugan.pmsm@gmail.com

Abstract. Monitoring solar power facilities closely is crucial for maximizing power output. This involves vigilant oversight to detect issues such as faulty connections, malfunctioning solar panels, and dust accumulation that hampers efficiency. To facilitate seamless integration with photovoltaic (PV) systems and pinpoint faults, this project unveils the hardware architecture of a smart grid home gateway. The proposed solution is an automated Internet of Things (IoT) based solar power monitoring system, allowing remote monitoring of solar power performance via the internet. Utilizing an Arduino-based system integrated with CT and Voltage sensors, the project measures and monitors various solar panel properties. Faults are identified by comparing the recorded voltage of the panels with the data from the Voltage sensor. The solution efficiently communicates power output to the IoT system over the internet, ensuring continuous monitoring of solar panel performance.

1 Introduction

One of the most pressing issues facing our society right now is power usage. The initiative is centered on the crucial problem of energy use. Certain non-renewable energy sources, like nuclear and thermal energy, are expensive and hazardous to human health. Conventional energy sources harm the environment and have a limited supply. The best solution to these problems will be an environmentally friendly system. This project aims to keep an eye on and control the voltage output of a solar panel that is stored in a faraway location. Monitoring the server's output via the Internet of Things (IOT). The server page, which has its own IP address, is used to reach the output page. Relay boards and circuits make the process of regulation and monitoring easier.

This technology facilitates the process of monitoring and controlling in an easy and effective manner.

The sensors send data to a consolidated local sink integrant made up of an ad hoc Wireless Sensor Network framework in order to create a strong and wide coverage area. The information is transmitted to an IOT server, wherein targeted diagnostic methodologies are executed. This technology facilitates the process of monitoring and controlling in an easy and effective manner.

The rapid rise of solar parks as one of the primary sustainable power frameworks highlights the urgent need for better utilization of the services they provide, as well as errors in detection and execution. Non-trivial parameters like voltage are monitored continuously at the board level and prepared in a cloud-based stage to detect these events early in order to achieve this.

The increasing popularity of solar panels as one of the primary sustainable power systems has created a pressing demand for more efficient use of the services they provide, as well as mistakes in placement and implementation. The goal of Internet of Things (IoT) technology is to close this gap by offering long-term, low-cost solutions for the efficient operation of solar parks.

1.1 Literature Review

"IoT-Based Smart Solar PV System for Energy Management and Monitoring" Bansal et al., 2018. Several studies demonstrate how IoT can be used to monitor and control solar PV systems. Real-time data on energy generation, string performance, environmental conditions, and equipment health can be gathered by IoT devices.

Salameh et al. (2017) "A Survey of Fault Detection, Isolation, and Diagnosis in Photovoltaic Arrays" String defects that cause panel deterioration, soiling, or shadowing can drastically lower a solar PV system's

* Corresponding author: ammasreeram@gmail.com

efficiency. Researchers have looked into a number of methods for identifying and treating these errors.

Tey et al. (2018) "Solar PV String Fault Detection Using Machine Learning Techniques" Predictive maintenance of solar PV systems and defect detection depend heavily on data analytics and machine learning. To accurately diagnose faults, these methods can be combined with Internet of Things data.

"IoT-Based Remote Monitoring and Control of Solar PV Power Generation" by Tang et al. (2019) describes how IoT makes it possible to remotely monitor and control solar PV systems, facilitating prompt fault or poor condition detection and remediation. The maintenance of system performance depends on this functionality.

IoT-based monitoring can help maximize energy efficiency by offering insights into energy consumption patterns, load control, and grid integration (Garg et al., 2017), "IoT-Based Smart Grid for Efficient Energy Management in Solar PV Systems".

By supplying precise data for reporting and compliance needs, IoT systems can assist in meeting regulatory standards (Lopez et al., 2020, "IoT-Based Monitoring for Compliance and Reporting in Solar PV Plant").

Effective monitoring of solar power facilities is essential for optimizing power generation. This entails vigilant supervision to identify issues like faulty connections, malfunctioning solar panels, and the accumulation of dust that can impede efficiency. To seamlessly integrate with photovoltaic (PV) systems and detect faults, this project introduces the hardware architecture of a smart grid home gateway. The proposed solution is an automated Internet of Things (IoT) based solar power monitoring system, enabling remote tracking of solar power performance through the internet. Employing an Arduino-based system integrated with CT and Voltage sensors, the project measures and observes various solar panel properties. Faults are detected by comparing the recorded voltage of the panels with data from the Voltage sensor. The solution efficiently transmits power output information to the IoT system over the internet, ensuring continuous monitoring of solar panel performance.

Solar panels are commonly installed in collections referred to as arrays or systems. A photovoltaic system comprises one or more solar panels, an inverter (responsible for converting DC electricity to AC electricity), and occasionally includes supplementary components such as controllers, meters, and trackers.

2 Methodology

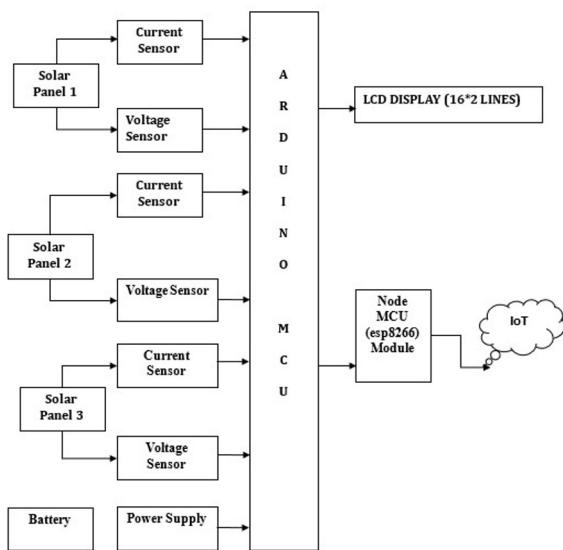


Fig. 1. Block Diagram

2.1 Solar panel



Fig. 2. Solar Panel.

2.2 Voltage sensor



Fig. 3. Voltage Sensor.

Wireless devices, voltage sensors are adaptable across a diverse array of objects, machinery, and apparatus. They provide continuous monitoring, perpetually scanning for voltage data indicative of potential issues. Excessive voltage poses a risk to other assets, while low voltage may signal a potential problem. Immediate alerts are transmitted to a central computer system upon crossing predefined thresholds.

Beyond measuring contact voltage, these sensors can also detect electromagnetic and magnetic fields. This data empowers maintenance staff to gain deeper insights into their assets and equipment.

2.3 Current sensor



Fig. 4. Current Sensor.

A device that detects current and converts it into a measurable output voltage proportional to the current in

the monitored path is termed a current sensor. Various sensor types are suitable for specific current ranges and environmental conditions. The most commonly utilized among these sensors is the current sensing resistor, functioning as a current-to-voltage converter. In this setup, the current is linearly transformed into voltage by incorporating a resistor into the current channel. The technology utilized by the current sensor is crucial due to the diverse features of different sensors catering to various purposes.

2.4 Battery



Fig. 5. 12V Battery.

A battery is an electrochemical device comprising one or more electrochemical cells, capable of being charged with an electric current and discharged as required. Typically, batteries consist of multiple electrochemical cells connected to external inputs and outputs. They find widespread use in powering small electric devices such as flashlights, remote controls, and cell phones. Historically, the term "battery" has consistently referred to the amalgamation of two or more electrochemical cells.

2.5 Arduino UNO



Fig. 6. Arduino R3.

An integrated circuit (IC) called a microcontroller unit, or MCU, is usually employed to carry out particular functions or duties. This kind of IC typically collects data or information from its environment, processes it, and produces particular outputs based on the data collected. These days, microcontrollers are ubiquitous. They are a crucial component of contemporary embedded systems, which are found almost everywhere in our world, from electric cars to smart watches. At the moment, they are even present on the surface of Mars.

A microcontroller's memory is one of its most important components; it may be utilized for a variety of tasks and can store data either permanently or temporarily. We will examine memory organization in microcontrollers in this article, with an emphasis on those found in Arduino® boards. We will also look at a number of approaches for controlling, monitoring, and optimizing memory use in Arduino-based systems

2.6 Node MCU



Fig. 7. NodeMCU.

In this project, the ESP8266 WiFi module played a key role. It is a cost-effective microchip designed around the TCP/IP stack. Using a Hayes-style command and a TCP/IP connection, this microchip facilitates the establishment of wireless network connections by microcontrollers. Manufactured by Express if Systems, the ESP8266 is a 32-bit microcontroller with 1MB of internal flash. It features 16 GPIO pins and employs a RISC processor, with a 10-bit DAC. Express if Systems later released a software development kit (SDK), allowing programming of the chip without the need for a separate microcontroller. Various SDKs, including those for Arduino, Micro Python, and NodeMCU, support communication protocols such as SPI, I2C, 12S, UART, Zerynth, and Mongoose OS for connecting two sensors or modules.

NodeMCU, an open-source LUA-based firmware tailored for the ESP8266 WiFi chip, was developed. The NodeMCU firmware comes pre-installed on the ESP8266 Development board, also known as the NodeMCU Development board, facilitating exploration of the ESP8266 chip's capabilities. Given NodeMCU's open-source nature, individuals have the freedom to edit, modify, or construct the hardware design to suit their needs.

2.7 LCD Display



Fig. 8. LCD Display.

An electronic display module is a liquid crystal display (LCD) panel. There are several uses for an LCD in the electronics industry. The 16x2 display is the most basic and often used LCD in circuits. Because they are affordable, simple to program, and capable of displaying a large variety of characters and animations, LCDs are frequently used in displays. Two display lines, each able to display sixteen characters, make up a 16x2 LCD. There are command and data registers on this LCD. While the data register holds the data that the LCD plays, the command registers carry out commands supplied to the LCD.

2.8 Ubidots (IOT Platform)

An IoT (Internet of Things) platform called Ubidots offers services and tools for gathering, processing, and displaying data from linked devices. With its cloud-based solution, customers can create and implement IoT applications with ease. Real-time monitoring, data

storage, and the building of personalized dashboards to visualize the data acquired from diverse sensors and devices are all made possible by Ubidots.

IoT Application Enablement Platform (AEP) Ubidots helps SMBs and SIs to quickly create and implement IoT apps. Drag-and-drop dashboards, device-friendly APIs, analytics, reports, and alarms are some of the building pieces of Ubidots.

Creating and implementing "Internet of things" solutions is a difficult task. As an IoT entrepreneur or systems integrator, you will work with a variety of IoT technologies. Even if you figure out how to combine the right hardware, cloud, and connectivity, you will still need to create an application in order to provide data to your clients.

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3 Result and Analysis

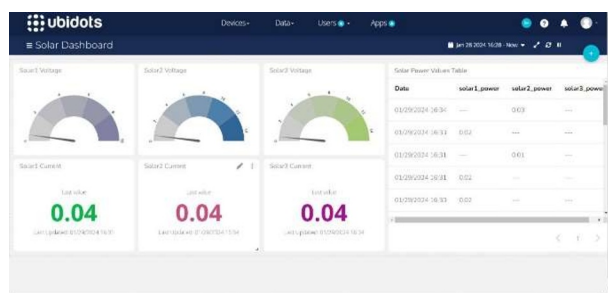


Fig.9. (a)



Fig.9. (b)

A photovoltaic (PV) cell, often referred to as a solar cell, is a non-mechanical device designed to directly convert sunlight into electricity. In the context of Solar Plant String Fault Monitoring, three solar panels are responsible for electricity generation, and all relevant information is accessible through Ubidots (see Figure 1). Additionally, an LCD display provides notifications of any faults, and users receive Gmail notifications specifying which panel is experiencing issues.

3.1 Case 1

Panel 1

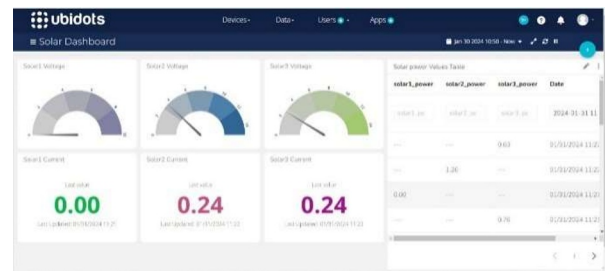


Fig.10. (a)



Fig.10. (b)

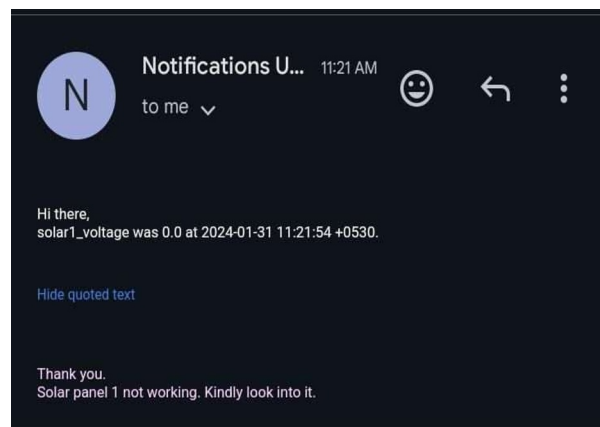


Fig.10. (c)

If Panel 1(Fig.10. (a)) malfunctions, its data is transmitted to Ubidots, reflected on the LCD display with all values set to zero, and a notification is sent to Gmail. Meanwhile, Ubidots and the LCD display continue to display the electricity generated by Panels 2 and 3.

3.2 Case 2

Panel 2

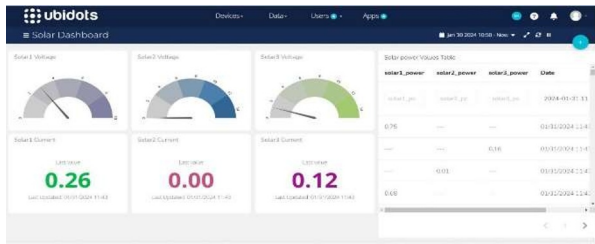


Fig.11. (a)

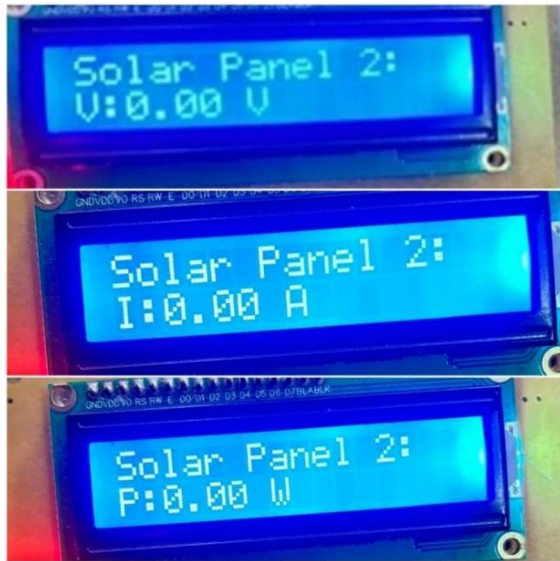


Fig.11. (b)

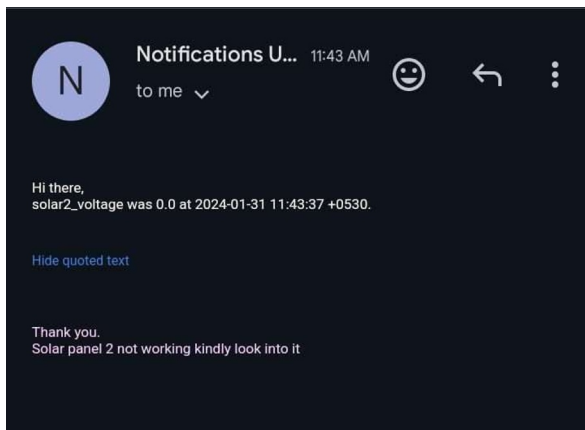


Fig.11. (c)

If Panel 2 (Fig.11. (a)) malfunctions, its data is transmitted to Ubidots, reflected on the LCD display with all values set to zero, and a notification is sent to Gmail. Meanwhile, Ubidots and the LCD display continue to display the electricity generated by Panels 1 and 3.

3.3 Case 3

Panel 3

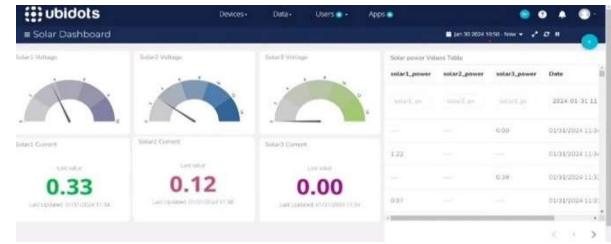


Fig.12. (a)

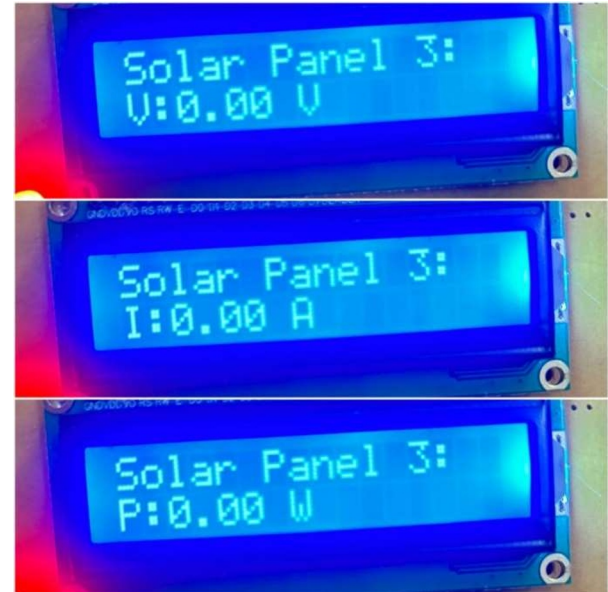


Fig.12. (b)

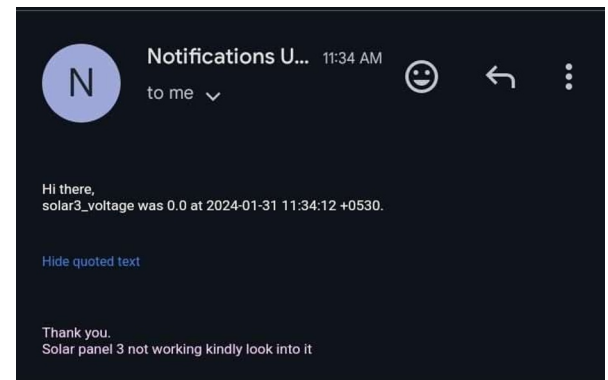


Fig.12. (c)

If Panel 3 (Fig.12. (a)) malfunctions, its data is transmitted to Ubidots, reflected on the LCD display with all values set to zero, and a notification is sent to Gmail. Meanwhile, Ubidots and the LCD display continue to display the electricity generated by Panels 1 and 2.

4 Conclusion

Solar power facilities need to be continuously monitored in order to generate the maximum amount of power. By keeping an eye out for issues with connections, broken solar panels, dust accumulation on panels that lowers output, and other issues that might affect solar

performance, this helps power plants recover their efficient electricity output. This project illustrates the hardware architecture of a smart grid home gateway to enable PV integration with a solar system for fault location identification. Therefore, I recommend an automatic solar power monitoring system based on the Internet of Things (IOT) that can be accessed from anywhere in the world. In order to measure parameters and monitor a solar panel, an Arduino-based system is integrated in this work with a voltage sensor and a CT sensor. Our solution communicates the power output to the IOT system via the internet while continuously monitoring the solar panel.

5 Future Scope

As future updates, we'd love to combine AI models and computations that can estimate the PID in its early stages, ideally with fewer detecting assets. Therefore, it is anticipated that a vital amount of data collected over a sizable period of time will show the PID phenomenon's progression stages. Additionally, investigating the application of big data breakthroughs can help us improve the clarity and presentation of our response to complex and major problems.

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