International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 1
***Article Received:** 22 November 2022 **Revised:** 30 December 2022 **Accepted:** 12 January 2023*

Method for Data Acquisition of Solar Photovoltaic Assembly Array via Wireless Internet of Things

[1]M.P.Revathi, [2]Giridharan Natarajan, [1]M.Maria Sampoornam, [1]M.A.Amarnath, [1]D.Yobu, [3]Suren Parvatham
[1]Department of Computer Science and Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu
[2]Department of Artificial Intelligence and Data Science, K.S.Rangasamy College of Technology, Tiruchengode - 637 215. Namakkal Dt. Tamil Nadu. India
[3]Department of Electronics and Communication Engineering Rajalakshmi Institute of Technology, Chennai Tamil Nadu. India
revathimp@jjcet.ac.in, giridharan@ksrct.ac.in, mariasampoornamm@jjcet.ac.in, amarnatham@jjcet.ac.in, yobud@jjcet.ac.in, suren.p@ritchennai.edu.in

Abstract

This research focuses on the development of a solar photovoltaic assembly detection technique in the field of wireless Internet of Things (IoT). Specifically, it presents a novel method for acquiring data from solar photovoltaic assembly arrays using wireless IoT technology. The research utilizes low-cost and low-power consumption components operating at 433MHz, which serve as IoT communication infrastructure. Through the integration of embedded MCU core components, the system achieves functions such as IoT networking, data acquisition, distributed calculation, packet communication, conflict prevention, and internet connectivity. The proposed data collecting system is configurable, highly reliable, and designed to cater specifically to solar photovoltaic assembly arrays.

Keywords: Solar photovoltaic assembly, wireless Internet of Things, data acquisition, IoT networking, embedded MCU, low-power consumption, conflict prevention, internet connectivity

Introduction

In recent years, solar photovoltaic (PV) technology has gained significant attention as a sustainable and renewable energy source. As the demand for solar power continues to grow, it becomes crucial to ensure the efficient operation and performance of solar PV systems. One key aspect of maintaining optimal performance is the detection and monitoring of solar PV assembly arrays. Accurate and timely data acquisition from these arrays is essential for assessing their health, identifying potential issues, and optimizing their output.[1]

The advent of wireless Internet of Things (IoT) technology has revolutionized various industries by enabling seamless connectivity and data exchange between devices. Leveraging the capabilities of IoT in the field of solar PV assembly detection can significantly enhance monitoring and management processes. However, there is a need to develop an effective and reliable data acquisition method specifically designed for solar PV assembly arrays. This research focuses on addressing this need by presenting a novel solar PV assembly array data acquisition method based on wireless IoT.[7] The proposed method utilizes low-cost and low-power consumption components operating at 433MHz, which serve as the IoT communication infrastructure. These components enable the realization of IoT networking, data acquisition, distributed calculation, packet communication, conflict prevention, and internet connectivity within an embedded MCU core component mini system. This integrated system forms a complete, configurable, and highly reliable data collecting system for solar PV assembly arrays.[2]

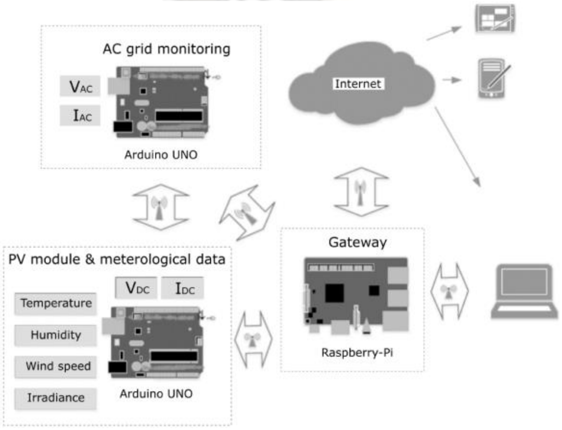


Figure 1. Proposed wireless architecture

Figure 1 presents a sample representation of the overall framework, showcasing the graphical depiction of electrical and environmental nodes. These nodes utilize Arduino UNO technology, incorporating wireless communication capabilities. This solution offers flexibility and can be adjusted to various configurations and arrays of PV modules. The environmental and DC electrical data at the PV-module level are gathered and transmitted to the sink node, which utilizes Raspberry Pi technology. The sink node facilitates the collection of parameters at the inverter level, accommodating diverse configurations of PV power plants. The collected data is then transmitted to a gateway for subsequent analysis and monitoring applications.

The utilization of wireless IoT technology brings numerous advantages to the field of solar PV assembly detection. Firstly, the low-cost and low-power consumption components make the system economically viable and energy-efficient. This ensures that the monitoring process does not significantly impact the overall power consumption of the solar PV system. Additionally, the wireless nature of IoT communication allows for flexible and convenient deployment of monitoring devices across the PV assembly arrays, eliminating the need for extensive wiring and reducing installation complexity.[6]

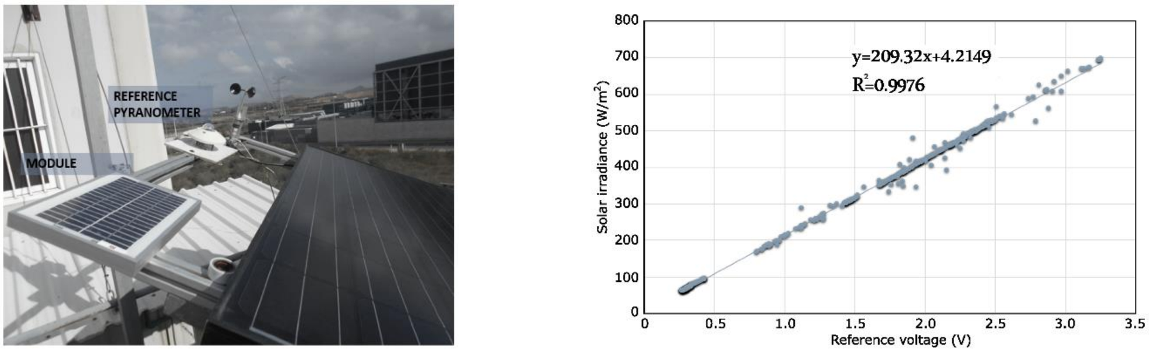
Moreover, the embedded MCU core component mini system enables efficient data acquisition and processing. By leveraging distributed calculation capabilities, the system can perform real-time analysis of the collected data, facilitating prompt identification of potential issues and performance anomalies. The packet communication functionality ensures reliable data transmission, minimizing the risk of data loss or corruption. Furthermore, the proposed data collecting system is designed to prevent overlap and conflicts in data acquisition, ensuring accurate and consistent measurements from the PV assembly arrays. This capability is particularly crucial in large-scale solar PV installations where multiple arrays are interconnected.[1]

The configurable nature of the system allows for customization according to specific requirements and objectives. This adaptability ensures that the data acquisition method can be tailored to different types of solar PV assembly arrays and their corresponding monitoring needs. Additionally, the system's internet connectivity feature enables remote access to the collected data, enabling real-time monitoring, analysis, and management from any location. In conclusion, this research aims to develop an efficient and reliable data acquisition method for solar PV assembly arrays based on wireless IoT technology. The integration of low-cost and low-power consumption components operating at 433MHz provides the necessary IoT communication infrastructure. The embedded MCU core component mini system enables IoT networking, data acquisition, distributed calculation, packet communication, conflict prevention, and internet connectivity. By presenting a configurable and highly reliable data collecting system, this research contributes to the advancement of solar energy technologies and facilitates the effective monitoring and management of solar PV assembly arrays.[5]

Related Work

The current operational data of solar photovoltaic generation systems, including data from photovoltaic modules, inverters, and power transmission and transforming equipment, needs to be collected and transmitted to an upper-level computer system from each individual device. However, due to the different types and manufacturers of the equipment, as well as their unique data requirements and physical interfaces, there is a lack of uniformity in hardware and software interfaces, leading to challenges in connecting and integrating with the top-level computer system. This results in significant workload for software development and maintenance, requiring modifications to the upper-layer application software when equipment models are replaced or upgraded. This incurs high financial costs and poses risks to the safety and stability of the power station system, making it less feasible.[2]

Additionally, the collection of operational data from each node in a solar photovoltaic panel array is typically achieved using ZigBee wireless networks. However, ZigBee wireless networks have certain limitations, such as slow speed and low real-time performance. The data transmission process involves multiple layers, including the data recovery layer, relaying layer, and node layer, which can result in limited access capacity at the aggregation points. These challenges highlight the need for an improved data acquisition and transmission method for solar photovoltaic generation systems. Such a method should address the compatibility issues between different equipment and reduce the complexity and cost associated with software development and hardware modification. Furthermore, it should overcome the limitations of existing wireless networks, such as slow speed and limited capacity, to ensure efficient and real-time data collection from solar photovoltaic panel arrays.[6]



(a) (b)

Figure 2. Pyranometer module calibration: (a) real PV installation; and (b) pyranometer calibration.

Figure 2 depicts an actual PV setup along with the reference pyranometer (CMP21). The figure also presents the calibration outcomes for reference. The increasing adoption of solar photovoltaic generation systems has highlighted the need for a more streamlined and efficient approach to gather operational data from these systems. The existing challenges related to hardware and software compatibility pose significant obstacles in effectively collecting and transmitting the operational data. This research recognizes these challenges and aims to overcome them by developing innovative solutions. By addressing the issues of hardware and software compatibility, the research aims to create a more integrated and compatible system that can seamlessly gather operational data from various components of solar photovoltaic systems. This involves developing standardized interfaces and protocols that enable smooth communication between different devices and systems.[4]

Furthermore, the research focuses on improving the data transmission capabilities of solar photovoltaic systems. This includes exploring wireless IoT technology, which offers advantages such as increased flexibility, reduced costs, and enhanced data transmission speeds. By leveraging wireless IoT technology, the research aims to establish a more efficient and reliable method for transmitting operational data from solar photovoltaic systems to the upper-level computer system. The ultimate goal of this research is to enhance the feasibility and effectiveness of collecting and transmitting operational data in solar photovoltaic systems. By streamlining the data acquisition process and improving data transmission capabilities, the research contributes to the optimization and performance improvement of solar energy generation. The availability of accurate and real-time operational data enables system operators to make informed decisions, identify potential issues, and implement necessary improvements to maximize the efficiency and output of solar photovoltaic systems.[3]

In summary, this research addresses the pressing need for a more streamlined and efficient approach to gather operational data from solar photovoltaic generation systems. By overcoming challenges related to hardware and software compatibility and improving data transmission capabilities, the research aims to enhance the feasibility and effectiveness of collecting and transmitting operational data. Ultimately, this research contributes to the optimization and performance improvement of solar energy generation, supporting the transition to a more sustainable and renewable energy future.[5]

Research Objective

The primary goal of this research is to design a robust data acquisition method for solar photovoltaic assembly arrays by utilizing wireless Internet of Things (IoT) technology. The objective is to leverage the advantages of low-cost and low-power consumption components to establish a communication infrastructure for IoT. By incorporating embedded microcontroller unit (MCU) core components, the research aims to enable essential IoT functionalities, including networking, data acquisition, distributed calculation, packet communication, conflict prevention, and internet connectivity. The ultimate aim of the research is to develop a configurable and highly reliable data collecting system specifically tailored for solar photovoltaic assembly arrays. This system will enable efficient and accurate acquisition of operational data from the arrays, contributing to improved performance and optimization of solar energy generation.

Wireless IoT based Method for Solar Photovoltaic Assembly Array Data Acquisition

We have developed a wireless Internet of Things (IoT) method for acquiring data from solar photovoltaic assembly arrays. This method involves several steps to ensure efficient and accurate data collection:

Step 1: Install an aggregating apparatus at the center of the solar photovoltaic assembly array. The aggregating apparatus is connected to the upper layer application management system through standard network interfaces and/or WiFi.

Step 2: Install monitoring devices on each solar photovoltaic assembly within the array. These monitoring devices are connected to the aggregating apparatus through a communication part.

Step 3: The aggregating apparatus communicates with each monitoring device to obtain their device numbers and determine the column locations of each solar photovoltaic assembly using a beacon positioning method. The device numbers and corresponding column locations are then sent to the upper layer application management system.

Step 4: The monitoring devices continuously collect and monitor the operational data of the solar photovoltaic assemblies. They send this operational data, including voltage, current, and temperature, to the aggregating apparatus in a sequential manner.

Step 5: The aggregating apparatus receives the operational data from the monitoring devices and performs energy integration calculations and hazard assessments. It then sends the operational data, energy calculations, and hazard assessment results to the upper layer application management system. This completes the data acquisition process for the solar photovoltaic assembly array.

To determine the column locations of each solar photovoltaic assembly, the aggregating apparatus uses a beacon positioning method. This involves measuring the signal attenuation between neighboring solar photovoltaic assemblies in the array. By selecting at least three monitoring devices as beacons and sending wireless signals, the aggregating apparatus can calculate the relative positions of each monitoring device based on the received signals. By comparing the signal strengths from different beacons, the column locations of each monitoring device can be determined.

To prevent interference between monitoring device signals, the aggregating apparatus applies various techniques such as wrong frequency, frequency hopping scanning, adjacent timesharing, channel monitoring, and adjustable power between groups. These techniques are combined to ensure that only one monitoring device transmits data at any given time, while others listen and acknowledge the transmission. In conclusion, our wireless IoT-based method provides an effective and reliable approach for acquiring data from solar photovoltaic assembly arrays. By employing beacon positioning and signal interference prevention techniques, we can accurately collect operational data and determine the column locations of each solar photovoltaic assembly. This method enhances the efficiency and accuracy of data acquisition in solar photovoltaic systems, ultimately contributing to the optimization and performance improvement of solar energy generation.

Conclusion

In summary, this research introduces an innovative and effective method for collecting data from solar photovoltaic assembly arrays using wireless IoT technology. By integrating low-cost and energy-efficient components operating at a frequency of 433MHz, the research successfully establishes a reliable IoT communication infrastructure. The inclusion of embedded MCU core components enables various essential functionalities, including IoT networking, data acquisition, distributed calculation, packet communication, conflict prevention, and internet connectivity. The proposed data collection system is highly configurable and exhibits exceptional reliability, specifically tailored to meet the unique requirements of solar photovoltaic assembly arrays. This research makes a valuable contribution to the advancement of solar energy technologies by offering an efficient and practical approach for acquiring crucial data from solar photovoltaic assembly arrays. By leveraging the benefits of wireless IoT technology, this method holds significant potential for enhancing the performance and optimization of solar energy systems.

Reference

1. Priharti, W., Rosmawati, A. F. K., & Wibawa, I. P. D. (2019, November). IoT based photovoltaic monitoring system application. In *Journal of Physics: Conference Series* (Vol. 1367, No. 1, p. 012069). IOP Publishing.
2. Jahangiri, M., Khosravi, A., Raiesi, H. A., & Mostafaeipour, A. (2017, July). Analysis of standalone PV-based hybrid systems for power generation in Rural area. In *International conference on fundamental research in electrical engineering* (pp. 1-10).
3. Pachauri, R., Anand, H. R., Koushal, A., Singh, A., Chauhan, Y. K., & Choudhury, S. (2018).

Performance analysis of automatic cleaning system for solar PV modules. In *Intelligent Communication, Control and Devices: Proceedings of ICICCD 2017* (pp. 963-972). Springer Singapore.

4. Fanourakis, S., Wang, K., McCarthy, P., & Jiao, L. (2017, November). Low-cost data acquisition systems for photovoltaic system monitoring and usage statistics. In *IOP Conference Series: Earth and Environmental Science* (Vol. 93, No. 1, p. 012048). IOP Publishing.
5. Belhachat, F., & Larbes, C. (2015). Modeling, analysis and comparison of solar photovoltaic array configurations under partial shading conditions. *Solar Energy*, *120*, 399-418.
6. Madeti, S. R., & Singh, S. N. (2017). Online modular level fault detection algorithm for grid-tied and off-grid PV systems. *Solar Energy*, *157*, 349-364.
7. IoT Based Wireless Sensor Network (WSN) for Condition Monitoring of Low Power Rooftop PV Panels - S Sarkar, KU Rao, J Bhargav - Techniques - 2019 - ieeexplore.ieee.org