

# Data Acquisition And Monitoring Of Solar Critical Parameter Using Iot Technology

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**Abstract**—This paper presents the design and implementation of an Internet of Things (IoT)-based system for real-time data acquisition and monitoring of critical parameters in a solar power system. With the increasing demand for renewable energy, efficient monitoring of solar panels is essential to ensure optimal performance, reliability and energy efficiency. The proposed system utilizes an Arduino-based embedded platform integrated with sensors to measure key parameters such as output voltage, current, and panel temperature. These parameters are continuously monitored and processed to evaluate the operational status of the solar pane. The acquired data is displayed locally using an LCD module and simultaneously transmitted to a cloud-based IoT platform through a wireless communication module (ESP8266). This enables remote monitoring and analysis of system performance from anywhere in real time. The system also supports data logging and can generate alerts under abnormal conditions, such as overheating or sudden drops in voltage and current, facilitating early fault detection and preventive maintenance.

**Keywords:** Solar Energy, Internet of Things (IoT), Data Acquisition, Solar Panel Monitoring, Arduino, ESP8266, Voltage Sensor, Current Sensor, Temperature Sensor, Real-Time Monitoring, Renewable Energy, Embedded Systems, Cloud Monitoring, Smart Energy Management.

## I. INTRODUCTION

In recent years, The rapid growth in global energy demand and the depletion of conventional fossil fuel resources have accelerated the adoption of renewable energy sources. Among these, solar energy has emerged as one of the most promising and widely used alternatives due to its abundance, sustainability, and environmentally friendly nature. Solar photovoltaic (PV) systems are increasingly deployed in residential, commercial, and industrial applications to generate clean electrical energy. However, the efficiency and performance of solar panels are highly dependent on

various environmental and electrical parameters such as voltage, current, and temperature.

In conventional solar power systems, monitoring of these critical parameters is often performed manually or through basic standalone instruments. Such methods are inefficient, time-consuming, and lack real-time accessibility, making it difficult to detect faults and optimize system performance. Additionally, the absence of data logging and remote monitoring capabilities limits the ability to analyze system behavior over time and take proactive maintenance actions.

With the advancement of embedded systems and communication technologies, the Internet of Things (IoT) has enabled the development of smart monitoring solutions. IoT-based systems allow devices to collect, transmit, and analyze data over the internet, providing real-time insights and remote accessibility. This technology plays a crucial role in enhancing the efficiency, reliability, and automation of modern energy systems.

The proposed system offers several advantages, including real-time monitoring, remote access, improved fault detection, and reduced manual effort. It is cost-effective, easy to implement, and scalable, making it suitable for small- and medium-scale solar installations. By integrating IoT with solar energy systems, this work contributes to the development of intelligent and efficient energy management solutions.

## II. REVIEW LITERATURE SURVEY

Recent advancements in renewable energy systems have emphasized the importance of efficient monitoring and management of solar power generation. Traditional solar monitoring systems rely on manual observation and basic measurement instruments, which are limited in providing real-time data and remote accessibility. These systems often result in delayed fault detection and inefficient energy utilization [1].

To overcome these limitations, several researchers have proposed embedded system-based solar monitoring solutions. Arduino-based systems have been widely used to measure parameters such as voltage, current, and temperature. These systems provide local monitoring but lack remote accessibility and advanced data analysis capabilities [2].

In recent years, Internet of Things (IoT)-based solar monitoring systems have gained significant attention. These systems use microcontrollers and wireless communication modules to transmit real-time data to cloud platforms. This allows users to monitor solar panel performance remotely and perform data analysis. However, some IoT solutions involve high implementation costs and complex architectures [3].

Temperature monitoring has also been identified as a critical factor in solar panel performance. Studies show that increased panel temperature reduces efficiency, making it necessary to continuously monitor thermal conditions. Sensor-based approaches using temperature sensors like LM35 or DHT11 have been widely adopted due to their simplicity and accuracy.

Based on the reviewed literature, it is evident that integrating sensors, microcontrollers, and IoT technology provides an efficient and cost-effective solution for solar monitoring. The proposed system builds upon these concepts to develop a real-time, low-cost, and scalable solar parameter monitoring system..

### III. RESEARCH METHODOLOGY

The proposed system is designed to monitor critical solar parameters such as voltage, current, and temperature using sensors, an Arduino microcontroller, an LCD display, and an IoT communication module.

#### A. System Design

The system consists of a solar panel connected to voltage, current, and temperature sensors. These sensors collect real-time data, which is processed by the Arduino microcontroller. An LCD is used for local display, and a Wi-Fi module (ESP8266) is used for IoT communication.

#### B. Data Acquisition

Sensors continuously measure:

- Voltage from the solar panel
- Current flowing through the system

- Temperature of the solar panel

The analog signals from sensors are converted into digital data using the Arduino's ADC.

#### C. Data Processing

The Arduino processes the collected data and calculates system performance parameters such as power output. It compares the values with predefined thresholds to detect abnormal conditions.

#### D. Display Unit

An I2C LCD module is used to display real-time values of voltage, current, and temperature for local monitoring.

#### E. Alert Mechanism

The ESP8266 module transmits data to a cloud platform, enabling remote monitoring via smartphones or computers. This allows users to track system performance in real time.

## IV. EXISTING SYSTEM

In conventional solar power systems, monitoring of critical parameters such as voltage, current, and temperature is primarily carried out using manual methods or basic standalone instruments. Typically, analog meters or simple digital displays are installed at the site of the solar panel to observe system performance.

These existing systems have several limitations. Firstly, they do not support real-time remote monitoring, requiring users to be physically present at the installation site to access data. This makes continuous supervision difficult, especially in remote or large-scale solar installations. Secondly, data logging is either absent or performed manually, which increases the chances of human error and makes historical analysis of system performance challenging.

Furthermore, fault detection in traditional systems is not automated. Issues such as voltage fluctuations, reduced current output, or panel overheating may go unnoticed for long periods, leading to reduced efficiency and potential system damage. In some advanced setups, monitoring systems are available, but they are often expensive and complex, making them unsuitable for small-scale or residential applications.

Additionally, most traditional systems lack integration with modern communication technologies such as IoT, limiting their ability to provide cloud-based monitoring, alerts, and data analytics.

Due to these drawbacks, existing solar monitoring systems are less efficient, less flexible, and not user-friendly. This creates the need for a smart, cost-effective, and IoT-enabled solution that can provide real-time monitoring, remote accessibility, and improved system performance.

## V. PROPOSED METHODOLOGY

The proposed system presents an IoT-based solution for real-time data acquisition and monitoring of critical parameters in a solar power system. The methodology focuses on continuous sensing, data processing, local display, and remote monitoring using cloud technology.

In this system, a solar panel acts as the primary energy source, and its performance is continuously monitored using sensors. A voltage sensor is used to measure the output voltage of the solar panel, while a current sensor measures the flow of current in the circuit. Additionally, a temperature sensor is employed to monitor the panel temperature, which significantly affects its efficiency.

The collected sensor data is fed into an Arduino microcontroller, which serves as the central processing unit of the system. The Arduino processes the analog signals received from the sensors using its built-in analog-to-digital converter (ADC) and converts them into meaningful digital values. These values are then analyzed to evaluate the performance of the solar panel.

For local monitoring, an LCD module is interfaced with the Arduino to display real-time values of voltage, current, and temperature. This allows users to observe system performance directly at the installation site.

To enable remote monitoring, an IoT communication module (such as ESP8266) is integrated with the system. This module transmits the processed data to a cloud-based platform via a wireless network. Users can access this data through a web interface or mobile application, enabling real-time monitoring from anywhere.

The system also includes a threshold-based monitoring mechanism. Predefined limits are set for parameters such as temperature and voltage. If any parameter exceeds or falls below the specified limits, the system can generate alerts through the IoT platform, allowing timely corrective actions.

Overall, the proposed methodology provides a cost-effective, scalable, and efficient solution for solar parameter monitoring. It reduces manual intervention, improves system reliability, and enhances energy management through continuous monitoring and analysis.

## VI. WORKING PRINCIPLE

The working principle of the proposed system is based on continuous sensing of solar parameters, data acquisition through sensors, processing using a microcontroller, and transmission of information via IoT technology for real-time monitoring.

Initially, the solar panel converts sunlight into electrical energy through the photovoltaic effect. The generated electrical output varies depending on environmental conditions such as solar irradiance and temperature. To monitor these variations, the system employs multiple sensors.

A voltage sensor is connected across the solar panel output to measure the generated voltage. Since the Arduino can only handle low voltage inputs, the sensor uses a voltage divider circuit to scale down the voltage to a safe range. Similarly, a current sensor (such as ACS712) is connected in series with the load to measure the current flowing through the circuit based on the Hall effect principle. A temperature sensor (such as LM35 or DHT11) is placed on or near the solar panel to continuously measure its temperature.

The analog signals from these sensors are fed into the Arduino microcontroller. The Arduino uses its built-in Analog-to-Digital Converter (ADC) to convert these analog signals into digital values. These digital values are then processed using programmed algorithms to calculate meaningful parameters such as voltage level, current, and power output of the solar panel.

The processed data is displayed in real time on an LCD module for local monitoring. At the same time, the Arduino communicates with an IoT module (ESP8266) to transmit the data to a cloud platform using a wireless network. This enables remote monitoring through a web interface or mobile application.

The system operates continuously in a loop, updating the sensor readings at regular intervals. A threshold-based monitoring mechanism is implemented in the program, where predefined limits are set for parameters

such as temperature, voltage, and current. If any parameter exceeds or falls below the defined threshold, the system identifies it as an abnormal condition.

In such cases, the system can trigger alerts through the IoT platform, enabling users to take immediate corrective actions. This helps in early fault detection, such as overheating, panel degradation, or wiring issues.

Thus, the overall working principle integrates sensing, processing, display, and communication in a continuous cycle, ensuring efficient monitoring and management of the solar power system.

**VII. BLOCK DIAGRAM**

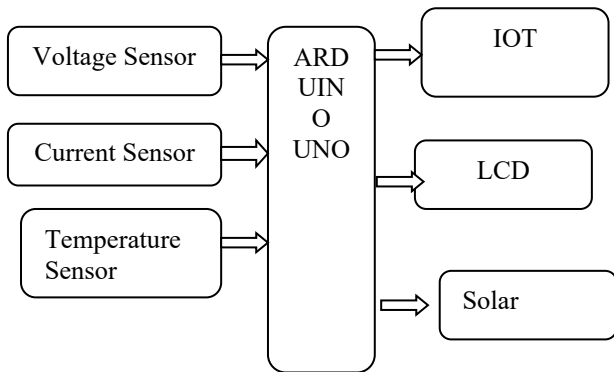


Fig. 6.2. Block Diagram

**VIII. RESULTS AND OUTCOMES**

The proposed IoT-based solar monitoring system was successfully implemented and tested. The sensors accurately measured voltage, current, and temperature values, and the Arduino processed the data effectively.

Fig. 1. The LCD displayed real-time parameters correctly, enabling easy local monitoring. The IoT module successfully transmitted data to the cloud platform, allowing remote monitoring.

Fig. 2. The system responded efficiently to changes in environmental conditions and provided reliable performance. It reduced manual effort and improved monitoring accuracy.

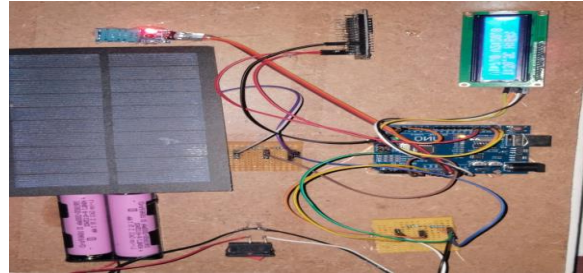


Fig. 7.1. Output1

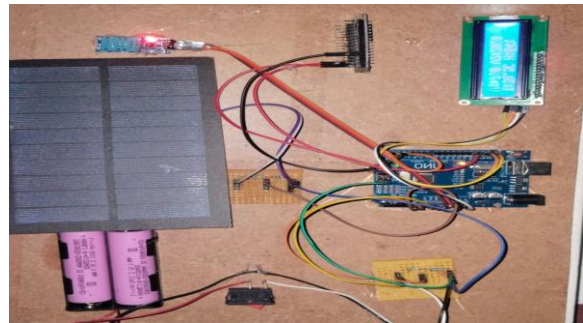


Fig. 7.2. Output2

Overall, the system proved to be stable, cost-effective, and efficient for solar parameter monitoring.

**IX. CONCLUSION**

The development of an IoT-based system for data acquisition and monitoring of solar critical parameters provides an effective solution to the limitations of traditional solar monitoring methods. In this work, a comprehensive system has been designed and implemented using an Arduino microcontroller, along with voltage, current, and temperature sensors, to continuously measure and analyze the performance of a solar panel.

The system successfully acquires real-time data and processes it to provide meaningful insights into the operational condition of the solar power system. The integration of an LCD display enables immediate on-site

monitoring, while the incorporation of an IoT communication module (ESP8266) facilitates remote access to data through a cloud platform. This dual-mode monitoring approach ensures both local visibility and global accessibility, significantly enhancing user convenience and system usability.

The experimental results demonstrate that the system is capable of accurately measuring solar parameters under varying environmental conditions. It effectively responds to fluctuations in sunlight intensity and temperature, providing consistent and reliable output. The implementation of threshold-based monitoring allows the system to detect abnormal conditions such as excessive temperature or reduced voltage and supports timely corrective action. This contributes to improved system efficiency, reduced maintenance costs, and increased lifespan of the solar panels.

Moreover, the proposed system minimizes the need for manual supervision, thereby reducing human effort and the possibility of errors. Its low-cost design and simple architecture make it highly suitable for small-scale and residential solar installations, while its scalability allows it to be extended to larger systems with minimal modifications.

In addition to its practical advantages, this project highlights the significance of integrating renewable energy systems with modern IoT technologies. Such integration plays a crucial role in the advancement of smart energy systems and supports the global shift towards sustainable energy solutions.

Future enhancements of the system may include the integration of advanced data analytics and machine learning techniques for predictive maintenance, mobile application support for improved user interaction, and the incorporation of additional environmental sensors such as light intensity and humidity sensors. These improvements can further enhance system performance, reliability, and intelligence.

In conclusion, the proposed IoT-based solar monitoring system proves to be an efficient, reliable, and cost-effective solution for real-time monitoring and management of solar energy systems, contributing to better energy utilization and sustainable development.

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