

# Automatic PV Grid Fault Detection and Analysis of a System

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**Abstract**—Photovoltaic (PV) systems are widely adopted as a sustainable energy source; however, their performance and reliability are often affected by electrical faults and environmental variations. Conventional PV installations rely on manual inspection and lack real-time monitoring, leading to delayed fault detection, increased downtime, and energy losses. This paper presents an IoT-based automatic PV grid fault detection and analysis system capable of continuously monitoring electrical and environmental parameters. The proposed system employs voltage and current sensors interfaced with an Arduino Mega 2560 for real-time data acquisition and fault decision-making. An ESP32 module enables wireless communication with the Blynk IoT application for live monitoring and fault alerts. A relay-based protection mechanism isolates faulty sections during abnormal operating conditions such as over-voltage, under-voltage, short-circuit, and open-circuit faults. Experimental results demonstrate accurate fault detection, quick response, and improved system reliability, making the proposed solution suitable for domestic and small-scale PV applications.

**Keywords**—Photovoltaic system, Internet of Things, fault detection, Arduino Mega 2560, ESP32, Blynk application.

## I. INTRODUCTION

The growing demand for renewable energy necessitates efficient solar power systems capable of detecting and responding to faults in real-time [1]. Traditional PV systems lack self-diagnosis and monitoring capabilities, often leading to energy losses and maintenance delays. This project integrates IoT and embedded systems to develop an intelligent PV monitoring and fault detection solution. Using Arduino Mega 2560 and ESP32, the system measures key parameters and communicates them to a mobile application via Wi-Fi for remote visualization.

## II. PROBLEM STATEMENT AND OBJECTIVES

### PROBLEM STATEMENT:

1. Manual fault detection in PV grid systems is slow, unreliable, and often leads to delayed response, increased downtime, and potential damage to equipment.
2. Existing PV systems lack real-time monitoring and automated fault classification, making them inefficient for modern, digitally-managed power grids.
3. There is a need for an intelligent, microcontroller-based system that can automatically detect, respond to, and analyse grid faults in PV systems to ensure safety, reliability, and efficiency.

### OBJECTIVES:

1. To develop a comprehensive understanding of PV grid systems and fault types. To isolate faulty sections in real-time and implement wireless data communication.
2. To design and implement a fault detection and analysis of a system.
3. To evaluate the performance of the system using experimental results. To provide historical data logging and reporting.

## III. SYSTEM DESIGN AND ARCHITECTURE

The system begins with a solar PV panel supplying power to a load through a monitoring circuit. Voltage and current sensors are installed to continuously measure electrical parameters [9]. These sensor readings are fed into an Arduino Mega 2560 microcontroller, which runs a real-time fault detection algorithm based on predefined threshold values (for overvoltage, undervoltage, open circuit, etc.).

Upon detecting a fault, the microcontroller activates a relay circuit to isolate the faulty section and

prevent damage. Simultaneously, fault data is transmitted via RF modules to a remote monitoring unit, where it is displayed on an LCD screen or optionally visualized using IOT blink software for data logging and analysis.

The system provides an automated, fast-response solution for detecting and responding to grid faults in PV systems, enhancing both safety and reliability.

**BLOCK DIAGRAM:**

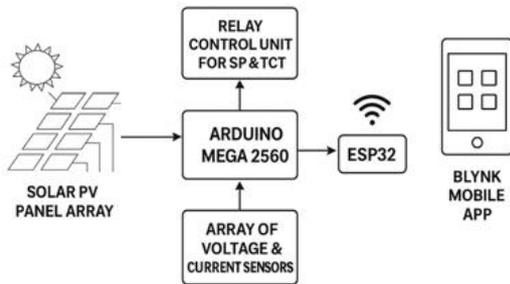


FIGURE 1. Automatic PV grid fault detection and analysis of a system.

The block diagram illustrates an IoT-enabled PV monitoring and fault-detection system built around the Arduino Mega 2560 [5]. The solar PV panel array serves as the primary power source, whose output is continuously monitored by an array of voltage and current sensors. These sensor readings are processed by the Arduino Mega 2560, which also drives the relay control unit responsible for switching between Solar Power (SP) and Transformer Charging Technique (TCT) based on system conditions. The processed data is transmitted wirelessly to the Blynk mobile application through the ESP32 module, enabling real-time monitoring, control, and fault notifications. This integrated architecture ensures efficient PV utilization, automated protection, and seamless remote access for the user.

**ALGORITHM (FLOW CHART)**

This is a rule-based algorithm that continuously monitors electrical parameters (voltage, current, etc.) from sensors and compares them against predefined safe limits (thresholds).

When any parameter crosses the threshold, a fault condition is detected and flagged.

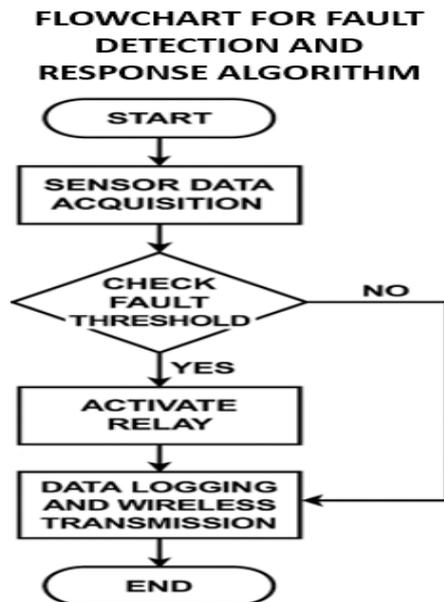


FIGURE 2. Flow-Chart For Fault Detection and Response Algorithm

The methodology includes sensor integration, real-time data acquisition, solar tracking, and IoT communication [2]. Voltage and current sensors capture electrical characteristics, while the DHT11 sensor monitors environmental parameters. LDR sensors and a servo motor enable solar tracking, optimizing sunlight exposure. The ESP32 acts as a Wi-Fi-enabled node, transmitting the processed data to the Blynk app for monitoring.

**IV. WORKING PRINCIPLE**

The system operates on a rule-based fault detection algorithm. Electrical and environmental parameters are continuously acquired and compared with predefined safe operating thresholds. If any parameter exceeds the permissible limit, a fault condition is identified.

Upon fault detection, the relay is activated to disconnect the load, ensuring system protection. Simultaneously, fault information and real-time parameter values are transmitted to the IoT platform and displayed on the Blynk dashboard and LCD unit. This approach ensures fast response and reliable fault management.

**V. RESULTS AND DISCUSSION**

The proposed system was experimentally tested under both normal and faulty operating conditions. During normal operation, the PV panel produced

output voltages in the range of 18–20 V and currents between 0.5–1.2 A. Faults such as short circuits and disconnections were detected immediately, and relay isolation was triggered successfully.

The Blynk IoT application displayed real-time graphs and fault alerts, confirming stable wireless

communication and effective data visualization. The solar tracking mechanism improved power output by maintaining optimal alignment with sunlight. Overall, the results validate the effectiveness and reliability of the proposed system.



Fig (a)

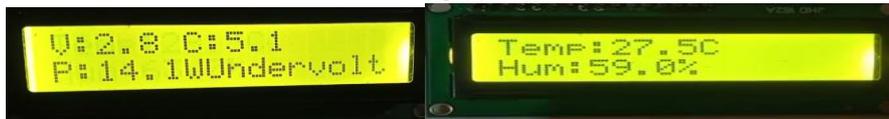


Fig (b)

Fig (c)

FIGURE 2. (a) Blynk Dashboard and (b)&amp;(c) LCD Display

## VI. CONCLUSION AND FUTURE SCOPE

An IoT-based automatic PV grid fault detection and analysis system has been successfully designed and implemented. The system provides real-time monitoring, rapid fault detection, automated protection, and remote accessibility through a mobile application. Its low cost, portability, and scalability make it suitable for domestic and small-scale PV installations.

Future enhancements may include cloud-based data storage, machine learning algorithms for fault prediction, and dual-axis solar tracking to further improve system performance and intelligence.

## REFERENCES

- [1] Sepulveda-Oviedo, E. H. (2025). Framework for effective PV system instrumentation focused on fault diagnosis. *Solar Energy Advances*, 5(1), 12–25.
- [2] IJIRT Conference Paper. (2024). IoT-based renewable energy by solar tracking system (with Blynk integration). *Proceedings of IJIRT International Conference*, 1–6.
- [3] Multiple Authors. (2023–2024). Solar tracking system using Arduino. *IRJET*, 10(3), 50–58.
- [4] Rahman, M. A., et al. (2022). IoT-based fault detection for solar photovoltaic systems. *Renewable Energy Journal*, 189(2), 420–432.
- [5] Authors. (2021–2022). IoT-based solar tracker with panel fault detection. *Advanced Engineering Science*, 4(2), 77–84.
- [6] Samkria, R. (2021). Automatic PV grid fault detection system with IoT. *Computers, Materials & Continua*, 68(3), 1125–1138.
- [7] Kumar, S., & Singh, P. (2019). IoT-based smart PV grid monitoring and control. *Proceedings of International Conference on Smart Energy Systems*, 1–6.
- [8] Suresh, M., Meenakumari, R., Kumar, R. A., Raja, T. A. S., Mahendran, K., & Pradeep, A. (2018). Fault detection and monitoring of solar PV panels using Internet of Things. *International Journal of Industrial Engineering: Theory, Applications and Practice*, 2(6), 146–149.
- [9] Patel, S. K., et al. (2021). A comprehensive review on fault diagnosis in PV systems. *Energy Reports*, 7(1), 568–58