IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

IoT Based Smart Power Grid Monitoring System

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Doi: https://doi.org/10.56975/ijcrt.v14i7.309895

Abstract: The increasing demand for reliable and efficient electrical energy distribution has accelerated the development of smart grid technologies. Traditional power grid systems suffer from delayed fault detection, manual monitoring, and inefficient power management, leading to interruptions and operational losses. To overcome these limitations, this project presents an IoT Based Smart Power Grid Monitoring System capable of real-time monitoring and intelligent fault detection. The proposed system uses voltage and current sensing units along with ESP32 IoT modules for continuous monitoring of electrical parameters. The system detects abnormal conditions such as line faults and ground faults and instantly updates the information on a web-based monitoring platform. A relay module controls the connected load during fault conditions, while an LCD display provides local monitoring of system parameters. Experimental testing demonstrates stable operation under normal and faulty conditions with rapid response and reliable fault identification. The developed prototype improves safety, reduces manual inspection, enhances reliability, and supports smart energy management. The system also contributes toward sustainable energy utilization and smart grid infrastructure development.

***Index Terms* -** IoT, Smart Grid, ESP32, Power Monitoring, Fault Detection, Voltage Monitoring, Current Monitoring, Embedded System, Smart Energy Management.

I. INTRODUCTION

Electrical power systems are essential for residential, industrial, and commercial applications. Conventional power grids mainly depend on manual inspection and periodic maintenance, which often leads to delayed fault detection, inefficient energy distribution, and poor monitoring accuracy. The advancement of Internet of Things (IoT) technology has enabled the transformation of traditional power systems into intelligent smart grids capable of real-time monitoring and automated control. IoT-based smart grid systems provide continuous data acquisition, remote accessibility, fault detection, and efficient power management. The proposed IoT Based Smart Power Grid Monitoring System continuously monitors voltage and current parameters sensors and embedded controllers. The collected data is transmitted wirelessly through ESP32/ESP8266 modules to a web-based monitoring system where users can observe system status remotely. The system is capable of:

- Detecting line faults
- Detecting ground faults
- Displaying real-time voltage and current
- Sending fault alerts instantly
- Reducing manual monitoring effort

The implementation enhances grid reliability, operational efficiency, and electrical safety.

II. LITERATURE REVIEW

Several researchers have contributed toward IoT-based smart grid monitoring systems.

1. Smart Power Management Through Internet of Things Based Energy Meters (2017) D. Pradeep and S. Yuvasri developed an IoT based energy monitoring system capable of remote meter reading and energy management.
2. IoT Based Smart Power Grid Control and Energy Monitoring (2020) Binod Kumar Sahu and Tapas Kumar Mahapatra proposed a smart monitoring system for efficient power control using IoT communication.
3. Power Management Using AI-Based IoT Systems (2022) K.S.S. Reddy introduced AI-integrated IoT systems for predictive maintenance and intelligent power management.
4. A Comprehensive Exploration of IoT-Enabled Smart Grid Systems (2024) S. Tabassum discussed IoT integration in smart grids for real-time monitoring, automation, and energy optimization. The literature review confirms that IoT technologies significantly improve reliability, monitoring capability, and automation in modern power systems.

III. PROPOSED METHODOLOGY

The system is designed to utilize multiple renewable energy sources such as solar energy, wind energy, and AC grid supply for efficient charging and operation of an electric vehicle. The Arduino Nano acts as the central controller for monitoring and controlling the entire system. The following phases explain the working methodology of the proposed system.

Phase 1: Data Sensing and Acquisition In the first phase, the system continuously collects electrical parameters such as voltage and current from the power distribution line using sensing devices.
• Potential Transformer (PT) is used to sense and step down the line voltage into a measurable low-voltage signal.
• Current Transformer (CT) is used to sense the current flowing through the electrical line.
• The sensed analog signals are safely converted into suitable values for processing by the controller.
• These signals are continuously monitored to observe the real-time electrical condition of the system.
Purpose: To collect accurate real-time electrical data for monitoring and fault analysis.

Phase 2: Processing and Fault Detection In this phase, the collected electrical data is analyzed to identify abnormal operating conditions.
• The sensed signals are fed into the comparator circuit, where they are compared with predefined threshold values.
• The comparator identifies abnormal conditions such as:
o Line faults
o Ground faults
o Overvoltage
o Undervoltage
• The comparator sends the processed signal to the Arduino UNO microcontroller.
The Arduino continuously processes the incoming data and determines whether the system is operating normally or under fault condition. Purpose: To detect faults instantly and analyze system status for further action.

Phase 3: Protection and Alert Mechanism Once a fault is detected, the system automatically activates protection and alert mechanisms.
• The relay module disconnects the load immediately to protect electrical equipment.
• The buzzer generates an audible warning alert.
• The 16×2 LCD display shows the fault condition and system status.
• Messages such as “FAULT DETECTED,” “Line Fault,” or “Ground Fault” are displayed.
Purpose: To ensure system safety, prevent equipment damage, and provide immediate fault indication.

Phase 4: IoT Communication and Remote Monitoring The final phase involves transmitting system data for remote monitoring using IoT technology.

- The ESP32 Wi-Fi module sends real-time electrical data to the ThingSpeak cloud platform.
- The uploaded data includes:
  - Voltage values
  - Current values
  - System status
  - Fault conditions
- Users can remotely monitor the system through:
  - Smartphones
  - Laptops
  - Computers
- This enables real-time supervision without physical inspection.

Purpose: To provide remote accessibility and enable smart power grid monitoring through internet connectivity.

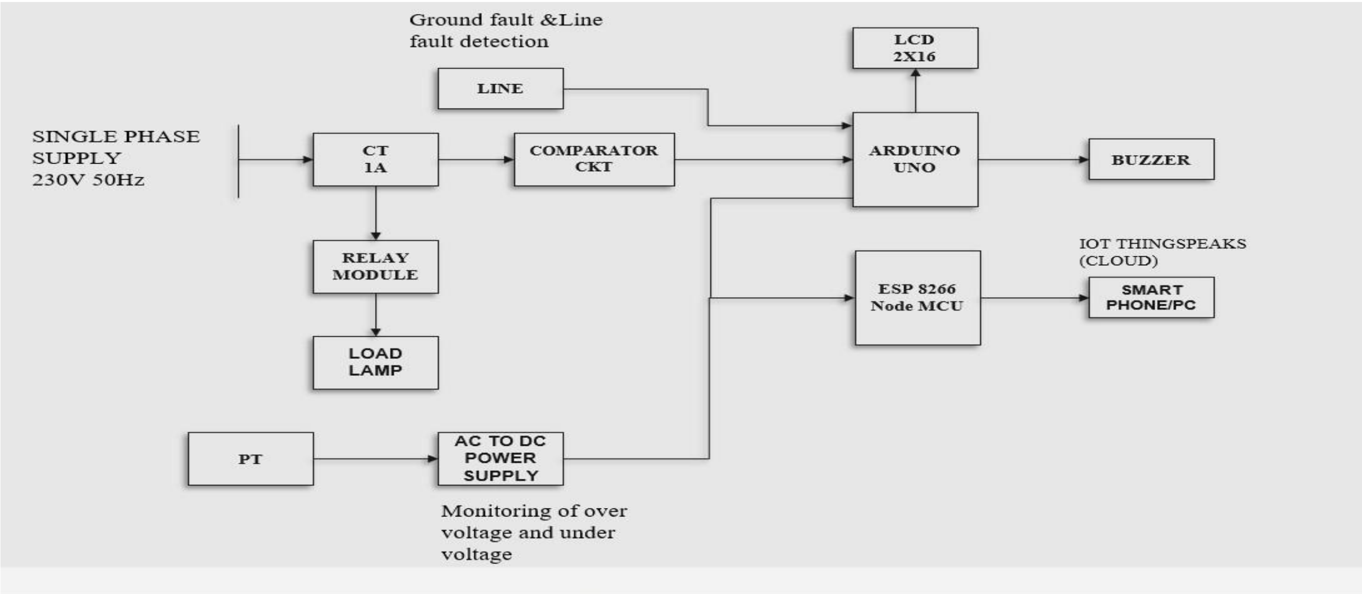

Fig. 1. Complete system block diagram of IOT based smart power grid monitoring system

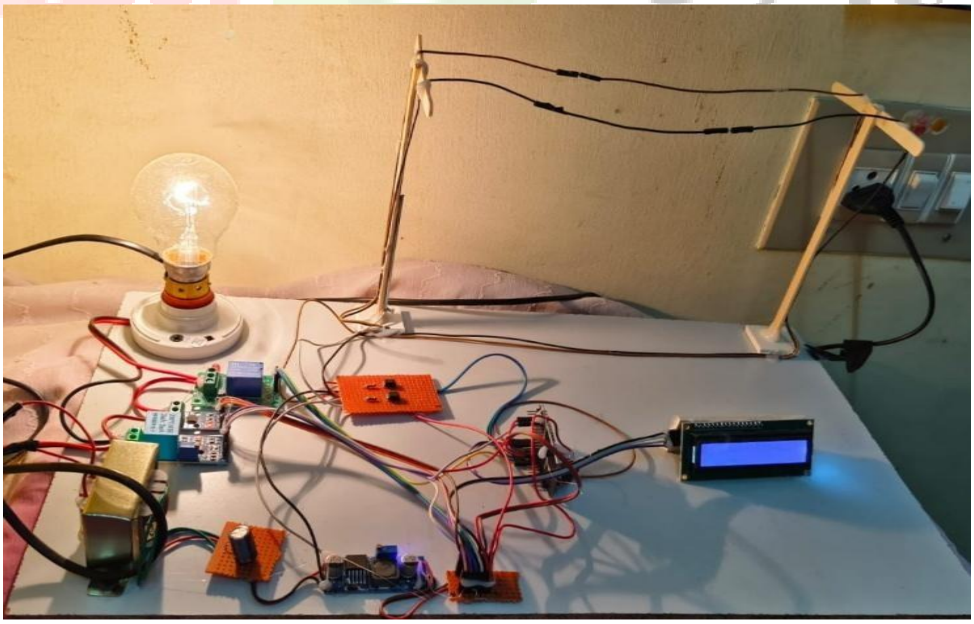

Fig. 2 — Hardware Prototype

IV. EXPERIMENTAL RESULTS

The project titled "IoT Based Smart Power Grid Monitoring System" was successfully implemented and tested under different operating conditions. The developed system effectively monitored voltage and current parameters in real time using sensing circuits integrated with the ESP32 microcontroller. The system continuously collected electrical data and transmitted it to the ThingSpeak cloud platform through Wi-Fi communication. During normal operating conditions, the system displayed voltage and current values accurately on the LCD display and cloud dashboard. When abnormal electrical conditions such as overvoltage, undervoltage, line fault, and ground fault were introduced, the system detected the fault instantly. The relay module disconnected the load automatically to protect connected equipment, while the buzzer generated an alert notification. The experimental observations confirmed that the system provided:

- Real-time monitoring of electrical parameters
- Accurate fault detection
- Automatic relay-based protection
- Remote monitoring through IoT cloud platform
- Fast response during fault conditions
- Reliable wireless data transmission The system demonstrated stable performance and proved to be an efficient, low-cost solution for smart power grid monitoring applications.

V. CONCLUSION

The proposed IoT Based Smart Power Grid Monitoring System was successfully designed and implemented for real-time electrical parameter monitoring and fault detection. The system continuously monitored voltage and current using sensing circuits and processed the collected data through the ESP32 controller. The measured parameters were displayed locally on the LCD display and remotely through the ThingSpeak cloud platform. The system successfully detected abnormal electrical conditions such as overvoltage, undervoltage, line faults, and ground faults. Upon fault detection, the relay module disconnected the load automatically, thereby ensuring equipment protection and improving system safety. The integration of IoT technology enhanced remote accessibility and enabled continuous monitoring without manual inspection. The developed prototype proved to be reliable, economical, and efficient for smart grid monitoring applications. The project demonstrates how IoT-based automation can improve electrical power system reliability, fault management, and operational efficiency.

REFERENCES

[1] V. H. Patil, S. Hundekari, A. Shrivastava, H. M. Al-Jawahry, M. Gupta, A. Reddy, and K. Yadav, "Design and Implementation of an IoT-Based Smart Grid Monitoring System for Real-Time Energy Management," International Journal of Computational and Experimental Science and Engineering (IJCESEN), vol. 11, no. 1, pp. 1370–1376, 2025, doi: 10.22399/ijcesen.854.

[2] S. Tabassum, "A Comprehensive Exploration of IoT-Enabled Smart Grid Systems," Smart Technologies for Energy Transition (STET), 2024.

[3] C. K. Rao et al., "IoT Enabled Intelligent Energy Management System in Smart Grid Environment," Results in Engineering, 2024.

[4] M. A. Alomar et al., "An IoT Based Smart Grid System for Advanced Cooperative Power Management," Sustainable Energy Technologies and Assessments, Elsevier, 2023.

[5] Y. Saleem, N. Crespi, M. H. Rehmani, and R. Copeland, "Internet of Things-Aided Smart Grid: Technologies, Architectures, Applications, Prototypes, and Future Research Directions," IEEE Access, 2017.

[6] J. Sakhnini, H. Karimipour, A. Dehghantanha, R. M. Parizi, and G. Srivastava, "Security Aspects of Internet of Things Aided Smart Grids: A Bibliometric Survey," 2020.

[7] G.-L. Huang, A. Anwar, S. W. Loke, A. Zaslavsky, and J. Choi, "IoT-Based Analysis for Smart Energy Management," 2023.

[8] M. Nikpour, P. B. Yousefi, H. Jafarzadeh, K. Danesh, and M. Ahmadi, "Intelligent Energy

Management with IoT Framework in Smart Cities Using Intelligent Analysis," 2023.

[9] T. S. Kumar et al., "Improving Efficiency in Smart Grid Monitoring Using Hybrid IoT Communication Models," Scientific Reports, 2025.

[10] IEEE Smart Grid Resource Center, "Smart Grid and IoT Technologies," IEEE. Available: IEEE Smart Grid