Research Paper
IMPACT FACTOR VALUE : 6.247 | E-ISSN NO : 2455-295X | VOLUME : 12 | ISSUE : 4 | APRIL 2026

IOT-ENABLED FAULT DETECTION AND MONITORING SYSTEM FOR POWER TRANSMISSION LINES

K.BHARATHI [1*] | N. ESWAR [2] | A.KUSHMITHA [3] | L.SWETHA [4] | V.PRADEEP [5]

[1] ASSISTANT PROFESSOR, DEPARTMENT OF EEE, AVANTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, TAGARAPUVALASA, INDIA.
[2, 3, 4,5] STUDENT, DEPARTMENT OF EEE, AVANTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, TAGARAPUVALASA, INDIA.

ABSTRACT:

Power transmission systems are highly vulnerable to faults such as line-to-ground, line-to-line, overvoltage, and overcurrent conditions, which can severely affect system reliability and safety. This paper presents an IoT-enabled fault detection and monitoring system designed for real-time supervision of three-phase transmission lines. The proposed system integrates voltage sensing units, an embedded controller, and wireless communication modules to continuously monitor electrical parameters. An ESP32-based communication module is employed to transmit real-time data to a cloud platform for remote monitoring and analysis. The system detects fault conditions by comparing measured electrical parameters against predefined threshold limits. Upon detection of abnormalities, the system generates local alerts via an LCD display and buzzer while simultaneously sending notifications through GSM communication. The acquired data is stored in the cloud for visualization and predictive analysis. Experimental validation demonstrates that the system effectively identifies faults and provides real-time monitoring, thereby enhancing system reliability and reducing downtime.

KEYWORDS:

IOT, FAULT DETECTION, ESP32, TRANSMISSION LINE MONITORING, SMART GRID, THINGSPEAK, GSM ALERTS, POWER SYSTEM PROTECTION.

PAPER ACCEPTED DATE:	PAPER PUBLISHED DATE:
3rd April 2026	4th April 2026

INTRODUCTION

Electrical power transmission systems form the backbone of modern infrastructure, ensuring reliable delivery of energy from generation units to end users. However, transmission lines are frequently exposed to environmental disturbances such as lightning, storms, insulation degradation, and mechanical failures, making them highly susceptible to faults [1]. These faults disrupt normal system operation and can lead to equipment damage and power outages if not detected promptly [2].Traditional fault detection mechanisms rely on protective relays and manual inspection, which lack real-time monitoring capabilities and precise fault localization [3]. With the increasing complexity of power systems, there is a need for intelligent and automated fault detection solutions [4]. Recent advancements in embedded systems have enabled the development of microcontroller-based monitoring systems capable of real-time data acquisition and processing [5].

The integration of Internet of Things (IoT) technologies has further enhanced the capability of power system monitoring by enabling remote access and data analytics [6]. IoT-based systems utilize wireless communication protocols to transmit real-time data to cloud platforms, facilitating continuous supervision [7]. ESP32-based solutions have gained popularity due to their built-in Wi-Fi and processing capabilities [8].Furthermore, cloud platforms such as Thing Speak enable real-time visualization and historical data analysis, which support predictive maintenance strategies [9]. Wireless alert systems, including GSM-based communication, ensure immediate notification of fault conditions, thereby reducing response time [10].

In this context, the present work proposes an IoT-enabled fault detection system for three-phase transmission lines that combines embedded control, real-time monitoring, and cloud-based analytics to enhance system reliability and operational efficiency

Materials and Methods:

The proposed IoT-enabled fault detection and monitoring system for power transmission lines is developed by integrating sensing units, embedded control, communication modules, and visualization interfaces into a cohesive framework. The system utilizes voltage sensors (ZMPT101B) connected to each phase of the transmission line to acquire real-time electrical parameters, which are then converted into corresponding analog signals. These signals are processed by an ATmega328P-based Arduino Uno microcontroller, where analog-to-digital conversion and signal conditioning are performed to obtain precise measurements. The controller continuously compares the measured values with predefined threshold limits to detect abnormal operating conditions such as overvoltage, under voltage, phase imbalance, and various fault types including line-to-ground and line-to-line faults. Upon identification of a fault condition, the system initiates multiple response mechanisms simultaneously, including triggering a relay module to isolate the faulty section, activating a buzzer for audible alerts, and displaying the fault status along with parameter values on a 16×2 LCD for immediate on-site monitoring. For remote supervision, an ESP32 module is employed due to its integrated Wi-Fi capability, which enables real-time transmission of system data to the Thing Speak cloud platform, facilitating continuous monitoring, data logging, and graphical visualization of electrical parameters. Furthermore, a GSM communication module is incorporated to send instant SMS alerts containing fault information to authorized personnel, thereby ensuring prompt maintenance action. The system operates in a continuous real-time loop involving data acquisition, processing, decision-making, and communication, which enhances the reliability and responsiveness of fault detection. The overall methodology ensures a cost-effective, scalable, and efficient solution suitable for deployment in modern power systems, smart grids, and industrial monitoring applications.

Results:

Fig. 1 illustrates the developed hardware prototype consisting of transmission line simulation, sensors, controller, and communication modules. The setup demonstrates real-time monitoring capability and fault detection functionality.

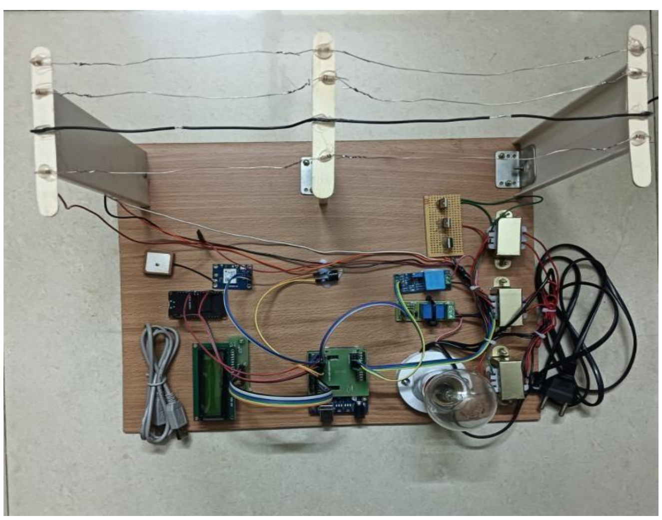

FIG. 1: IOT-ENABLED FAULT DETECTION AND MONITORING SYSTEM FOR POWER TRANSMISSION LINES.

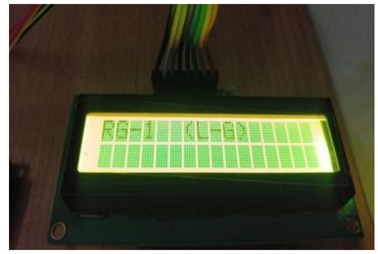

FIG. 2: TYPES OF FAULTS DISPLAYING ON LCD.

Fig. 2 shows the LCD output displaying fault conditions. The system provides immediate local feedback, improving on-site fault identification.

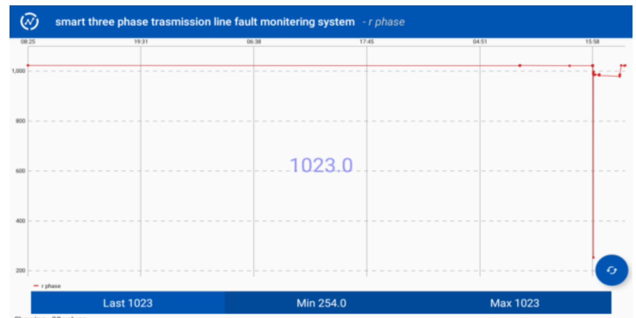

FIG. 3: R-PHASE OBSERVATION.

Fig. 3 represents the R-phase voltage variation obtained from the cloud platform. The graph clearly shows sudden deviations indicating fault occurrence.

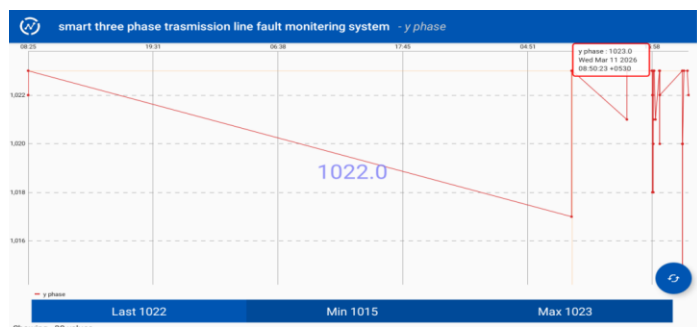

FIG. 4: Y-PHASE OBSERVATION.

Fig. 4 illustrates the Y-phase voltage profile. A gradual decline followed by abrupt changes indicates system instability and fault conditions.

FIG. 5: B-PHASE MONITORING DATA

Fig. 5 shows B-phase observations where voltage fluctuations and spikes confirm the detection of abnormal operating conditions.

DISCUSSION:

The experimental results validate the effectiveness of the proposed IoT-based fault detection system. The hardware prototype (Fig. 1) successfully integrates sensing, processing, and communication modules, demonstrating a compact and scalable design. The LCD output (Fig. 2) confirms that the system provides immediate local fault indication, which is critical for on-site maintenance personnel. The real-time cloud monitoring results (Fig. 3–Fig. 5) highlight the system's capability to track phase-wise voltage variations. The R-phase graph shows stable operation followed by sudden spikes during fault conditions, indicating rapid detection capability. The Y-phase results reveal gradual degradation before fault occurrence, suggesting the possibility of predictive maintenance. The B-phase data shows abrupt fluctuations, which correspond to transient fault conditions.

The integration of IoT enables continuous monitoring, remote accessibility, and data-driven analysis. Compared to conventional systems, the proposed approach significantly reduces fault detection time and improves system reliability.

CONCLUSIONS:

This paper presented an IoT-enabled fault detection and monitoring system for three-phase transmission lines. The system successfully integrates embedded control, real-time sensing, and wireless communication to detect and analyze fault conditions efficiently. Experimental results demonstrate that the system can accurately identify faults and provide real-time visualization through cloud platforms. The addition of GSM alerts enhances responsiveness, while data logging supports predictive maintenance strategies. The proposed system offers a cost-effective, scalable, and reliable solution for modern power systems and can be extended to smart grid applications with advanced analytics and automation features.

REFERENCES

1. Singh, R., Kumar, A., and Patel, S., "Comparative Analysis of Overhead and Underground Transmission Systems for Power Delivery," *International Journal of Electrical Power & Energy Systems*, vol. 134, pp. 107-118, 2022.

2. Zhang, Y., Liu, H., and Chen, X., "Smart Grid Technologies for Real-Time Monitoring and Control of Power Systems," *IEEE Transactions on Smart Grid*, vol. 13, no. 2, pp. 1450–1462, 2022.

3. Mehta, V. K., and Mehta, R., "Analysis of Transmission Line Faults and Their Impact on Power System Stability," *Electric Power Systems Research*, vol. 201, pp. 107-115, 2021.

4. Kumar, P., Singh, B., and Sharma, D., "Microcontroller-Based Fault Detection Techniques in Electrical Distribution Systems," *IEEE Access*, vol. 10, pp. 45832–45845, 2022.

5. Brown, M., Wilson, J., and Taylor, R., "Modern Protection Strategies for Transmission Networks Using Digital Relays," *IEEE Transactions on Power Delivery*, vol. 36, no. 4, pp. 2150–2159, 2021.

6. Zhao, L., Wang, Q., and Sun, Y., "Adaptive Relay Coordination for Improved Fault Detection in Smart Grids," *IET Generation, Transmission & Distribution*, vol. 16, no. 5, pp. 789–799, 2022.

7. Fernandes, D., Costa, P., and Rodrigues, L., "Distributed Sensor-Based Real-Time Monitoring of Transmission Lines," *Sensors*, vol. 22, no. 9, pp. 3356–3368, 2022.

8. Wang, X., Li, Z., and Huang, J., "ESP32-Based Embedded System for Real-Time Electrical Parameter Monitoring," *IEEE Internet of Things Journal*, vol. 9, no. 18, pp. 16845–16856, 2022.

9. Park, S., Kim, H., and Lee, J., "IoT-Based Fault Detection System for Smart Power Grids Using Cloud Platforms," *IEEE Access*, vol. 11, pp. 22345–22358, 2023.

10. Roy, S., Das, A., and Mukherjee, P., "Wireless Fault Detection and Alert System Using ESP32 and IoT Platforms," *International Journal of Electrical and Computer Engineering*, vol. 13, no. 1, pp. 120–130, 2023.