Transmission Line Cut-off Fault Detection and Indication to Electricity Board using and IoT

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***Abstract*—This paper presents the design and implementation of an intelligent system for transmission line cut-off fault detection and indication using Internet of Things (IoT) technology. Reliable power supply is a critical requirement in modern electrical infrastructure; however, transmission lines are frequently affected by faults such as overvoltage, overcurrent, and line interruptions, leading to power outages and equipment damage. Conventional fault detection methods rely heavily on manual inspection, resulting in delayed response and reduced system efficiency.To address these limitations, the proposed system utilizes an ESP32 microcontroller integrated with voltage and current sensors to continuously monitor electrical parameters in real time. Upon detecting abnormal conditions, the system promptly identifies faults and activates a relay mechanism to isolate the affected section, thereby enhancing system safety. Additionally, the integration of GSM communication enables instant fault notifications to the electricity board, while IoT connectivity facilitates real-time monitoring and data visualization through a mobile application. A local LCD display is also incorporated for on-site status indication.**

Keywords— Transmission Line Fault Detection, Internet of Things (IoT), ESP32 Microcontroller, GSM Communication, Smart Grid, Voltage and Current Sensors, Fault Monitoring, Relay Protection, Real-Time Monitoring, Power Distribution Systems

I. INTRODUCTION

Electric power transmission and distribution systems form the backbone of modern infrastructure, ensuring continuous electricity supply to residential, commercial, and industrial sectors. However, transmission lines are highly vulnerable to faults such as line cut-offs, overvoltage, overcurrent, and short circuits caused by environmental factors, equipment failure, or human interference. These faults can lead to severe consequences, including power outages, damage to electrical equipment, and economic losses.

Traditional fault detection methods primarily depend on manual inspection and periodic monitoring, which are time-consuming and often result in delayed fault identification and restoration. With the growing demand for reliable and uninterrupted power supply, there is a need for intelligent and automated systems capable of detecting faults in real time and providing immediate alerts.

Recent advancements in embedded systems and communication technologies have enabled the development of smart monitoring solutions. In this context, the Internet of Things (IoT) plays a significant role by allowing remote monitoring, data

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analysis, and control of electrical systems. By integrating sensors, microcontrollers, and communication modules, it is possible to design efficient systems that continuously track electrical parameters and detect abnormalities instantly.

This paper proposes an IoT-based transmission line fault detection and indication system that utilizes an ESP32 microcontroller to monitor voltage and current parameters in real time. When a fault is detected, the system activates a relay mechanism to isolate the affected section and sends alerts to the electricity board using GSM communication. Additionally, IoT connectivity enables real-time data visualization through a mobile application, while an LCD display provides local status updates.

The proposed system aims to improve fault detection speed, reduce manual intervention, and enhance the overall reliability and efficiency of power distribution systems. It also provides a cost-effective and scalable solution suitable for modern smart grid applications.

II. REVIEW LITERATURE SURVEY

The problem of transmission line fault detection has been widely studied, with various approaches proposed using embedded systems, communication technologies, and smart monitoring techniques.

Early work by S. R. Bhadke and A. Kulkarni (2018) introduced a microcontroller-based system for detecting faults in transmission lines by monitoring voltage and current parameters. Although the system effectively identified abnormal conditions such as overcurrent and short circuits, it lacked remote communication capabilities, limiting its application in modern smart grid environments.

M. K. Reddy and P. V. Kumar (2019) proposed an IoT-based smart power monitoring system that enabled real-time data acquisition and remote monitoring through cloud platforms. While this approach improved accessibility and data visualization, it did not incorporate mechanisms for fault isolation or immediate protective actions.

J. Singh and R. Kaur (2020) developed a GSM-based fault detection and alert system that significantly reduced response time by sending SMS notifications to maintenance personnel. However, the system lacked continuous monitoring and advanced data analytics features, which are essential for modern energy systems.

Further advancements were presented by A. Sharma and N. Gupta (2021), who implemented an ESP32-based IoT system for smart grid fault detection. Their work demonstrated improved scalability and real-time monitoring capabilities, but highlighted the need for integrating additional communication technologies like GSM for reliable alert delivery.

K. L. Prasad and V. Rao (2022) proposed an automated power line monitoring and protection system that combined sensors and relays for fault detection and isolation. While the system enhanced protection mechanisms, it had limited communication features, restricting real-time remote monitoring.

More recently, P. Mehta and S. Verma (2023) introduced a hybrid approach combining GSM and IoT technologies for fault detection in electrical distribution systems. Their system achieved both real-time monitoring and instant alerting, demonstrating improved reliability and faster response times.

From the above studies, it is evident that individual approaches—whether based on microcontrollers, GSM, or IoT—have certain limitations when used independently. Therefore, there is a need for an integrated system that combines real-time monitoring, fault isolation, and reliable communication. The proposed work addresses these gaps by implementing a hybrid IoT and GSM-based fault detection system with enhanced efficiency and scalability.

III. RESEARCH METHODOLOGY

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This research focuses on the design and implementation of an IoT-based system for transmission line cut-off fault detection and indication. The methodology involves system design, hardware integration, software development, and testing to ensure accurate fault detection and reliable communication.

3.1 System Design

The proposed system is developed as an embedded solution that integrates sensing, processing, control, and communication units. Voltage and current sensors are used to continuously monitor electrical parameters of the transmission line. These signals are fed into an ESP32 microcontroller, which acts as the central processing unit. Based on predefined threshold values, the system identifies abnormal conditions such as overvoltage, overcurrent, and line interruptions.

3.2 Hardware Implementation

The hardware setup consists of the following components:

- ESP32 microcontroller for data processing and control
- Voltage and current sensors for parameter monitoring
- Relay module for isolating faulty sections
- GSM module for sending fault alerts
- LCD display for local status indication
- Regulated power supply for stable operation

The sensors continuously provide analog signals, which are processed by the microcontroller. When a fault is detected, the relay disconnects the load to prevent further damage.

3.3 Software Development

The system software is developed using embedded C and Arduino IDE. The program continuously reads sensor data, compares it with predefined threshold values, and executes control actions accordingly. IoT functionality is implemented using cloud platforms or mobile applications to enable real-time monitoring. GSM communication is programmed to send SMS alerts whenever a fault is detected.

3.4 Communication and IoT Integration

The system integrates both GSM and IoT technologies to enhance reliability:

- **GSM module** ensures instant alert notifications to the electricity board
- **IoT platform** enables real-time monitoring, data logging, and remote access via a mobile application

This hybrid communication approach ensures both immediate alerts and continuous monitoring.

3.5 Testing and Validation

The system is tested under different fault conditions such as:

- Overvoltage
- Overcurrent
- Line cut-off

The performance is evaluated based on response time, accuracy of fault detection, and communication reliability. Experimental results confirm that the system can detect faults quickly and provide timely notifications.

IV. EXISTING SYSTEM

In traditional electrical power transmission and distribution systems, fault detection and monitoring are predominantly performed using manual methods and conventional protective devices. These systems depend heavily on periodic inspection, human supervision, and basic electromechanical or static protection mechanisms such as fuses, circuit breakers, and relays to identify faults like overcurrent, overvoltage, short circuits, and transmission line cut-offs. When a fault occurs, it is typically detected only after noticeable disruptions such as power outages or equipment malfunction, which often leads to delays in response and restoration. Maintenance personnel must physically inspect transmission lines over large geographical areas to locate the fault, making the process time-consuming, labor-intensive, and inefficient.

In some improved conventional systems, microcontroller-based fault detection mechanisms are used to monitor electrical parameters like voltage and current. These systems can identify abnormal conditions and provide local indications through displays or alarms. However, they are limited in their ability to communicate fault information remotely, which restricts their usefulness in large-scale power networks. Similarly,

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GSM-based systems have been introduced to send SMS alerts to operators when a fault is detected. While this improves response time compared to manual methods, such systems still lack continuous monitoring, real-time data analysis, and advanced visualization features.

Furthermore, most existing systems operate independently without integration into a centralized monitoring platform. They do not support real-time tracking, historical data storage, or predictive analysis, which are essential for modern smart grid applications. The absence of automation and intelligent decision-making capabilities results in delayed fault isolation, increasing the risk of equipment damage and extended power outages. Additionally, these systems are not scalable and often fail to provide accurate and immediate information required for quick corrective action.

Overall, the existing systems suffer from several limitations, including delayed fault detection, lack of real-time monitoring, high dependency on manual intervention, limited communication capabilities, and reduced operational efficiency. These drawbacks highlight the need for an advanced, automated, and integrated solution that can provide faster fault detection, real-time monitoring, and efficient communication, which is addressed by the proposed IoT-based system.

V. PROPOSED METHODOLOGY

The proposed system introduces an advanced and automated solution for transmission line cut-off fault detection and indication using a combination of IoT and GSM technologies. Unlike traditional methods, this system is designed to provide real-time monitoring, rapid fault detection, and immediate communication to the electricity board, thereby improving the reliability and efficiency of power distribution systems.

The system is built around an ESP32 microcontroller, which serves as the core processing unit. It continuously monitors electrical parameters such as voltage and current using dedicated sensors connected to the transmission line. These sensor readings are analyzed in real time by comparing them with predefined threshold values to detect abnormal conditions such as overvoltage, overcurrent, and line interruptions. Once a fault is identified, the system instantly triggers a relay mechanism to isolate the affected section of the line, preventing further damage to equipment and ensuring safety.

To enhance communication capabilities, the proposed system integrates both GSM and IoT technologies. The GSM module is used to send immediate SMS alerts to the electricity board or maintenance personnel, ensuring quick response to faults. Simultaneously, the IoT platform enables continuous monitoring and data visualization through a mobile application or web interface, allowing authorized users to access system status remotely at any time. This dual communication approach ensures both instant notification and long-term monitoring.

Additionally, an LCD display is incorporated into the system to provide real-time local status updates, including voltage, current values, and fault conditions. The system also utilizes a regulated power supply to ensure stable and reliable operation of all components.

The proposed system offers several advantages over existing systems, including faster fault detection, reduced manual intervention, real-time remote monitoring, improved accuracy, and enhanced safety. It is cost-effective, scalable, and suitable for integration into modern smart grid infrastructures. By combining embedded systems with IoT and GSM technologies, the proposed system provides an efficient and intelligent approach to power line fault management.

VI. BLOCK DIAGRAM

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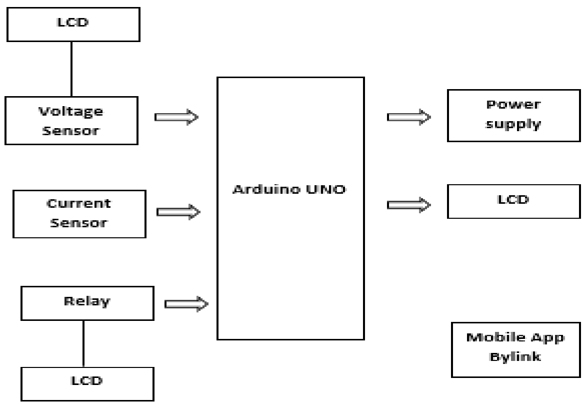

Fig. 6.2. Block Diagram

VII. RESULTS AND OUTCOMES

The implementation of the proposed IoT-based transmission line fault detection system produced effective and reliable results under various operating conditions. The system was successfully able to monitor electrical parameters such as voltage and current in real time and accurately detect abnormal conditions including overvoltage, overcurrent, and line cut-off faults. During testing, the ESP32 microcontroller processed sensor data efficiently and responded immediately when threshold limits were exceeded.

One of the key outcomes observed was the rapid detection and response to faults. As soon as a fault condition occurred, the system triggered the relay mechanism to isolate the affected section of the transmission line, thereby preventing further damage to connected equipment. This automatic response significantly reduced the risk associated with delayed fault handling in conventional systems.

The communication performance of the system was also highly effective. The GSM module successfully transmitted instant alerts to the electricity board or maintenance personnel, ensuring quick awareness and action. At the same time, the IoT platform enabled continuous real-time monitoring, allowing users to view system status, electrical parameters, and fault conditions remotely through a mobile application. This dual communication approach improved both responsiveness and accessibility.

Additionally, the LCD display provided accurate on-site information regarding system status, including normal operation and fault conditions, which is useful for local monitoring and debugging. The overall system demonstrated high reliability, low response time, and consistent performance across multiple test scenarios.

The outcomes of this project indicate that the proposed system significantly enhances fault detection speed, reduces dependency on manual inspection, and improves the efficiency of power distribution systems. It also proves to be a cost-effective and scalable solution suitable for real-world implementation in smart grid environments

VIII. CONCLUSION

This paper presented the design and implementation of an intelligent IoT-based transmission line cut-off fault detection and indication system aimed at improving the reliability and efficiency of power distribution networks. The proposed system successfully integrates sensing, processing, protection, and communication technologies into a single automated solution capable of real-time monitoring and rapid fault response.

The system utilizes voltage and current sensors in conjunction with an ESP32 microcontroller to continuously monitor electrical parameters and detect abnormal conditions such as overvoltage, overcurrent, and line interruptions. Upon fault detection, the system promptly activates a relay mechanism to isolate the affected section, thereby minimizing equipment damage and enhancing operational safety. Furthermore, the integration of GSM technology ensures immediate fault notification to the electricity board, while IoT

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connectivity enables continuous remote monitoring and data visualization through a mobile platform.

The results demonstrate that the proposed system significantly reduces fault detection time and eliminates the dependency on manual inspection, which is a major limitation in conventional systems. The dual communication approach enhances both reliability and responsiveness, ensuring that faults are not only detected quickly but also communicated effectively to the concerned authorities. The inclusion of a local display further improves usability by providing instant on-site system status.

In addition to improved performance, the system is cost-effective, scalable, and easy to implement, making it suitable for deployment in both urban and rural power distribution networks. It also aligns well with the requirements of modern smart grid infrastructure by enabling automation, remote accessibility, and efficient energy management.

Overall, the proposed solution offers a robust and practical approach to transmission line fault detection and management. It enhances system reliability, reduces downtime, and contributes to the development of smarter and more resilient electrical power systems.

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