Smart Monitoring & Fault Detection System for Power Transmission Lines

Yogita Raut[1], **Aditi Shinde**[2], **Purva Pokale**[3]

**1,2,3Student, Department Of Electronics And Telecommunication, Zeal College Of Engineering And Research Narhe, Pune, India.*

* * *

Abstract - High-voltage power cables are vulnerable to faults caused by environmental factors, physical damage, or technical issues, often resulting in high maintenance efforts and system downtime. This paper presents an IoT-based fault detection and location system using an ESP32 microcontroller and GSM technology. The system continuously monitors voltage levels, identifies abnormal conditions during a fault, calculates the fault location, and displays it on a 16x2 LCD. GSM help users locate the fault precisely for quicker repair. This solution offers a cost-effective and efficient method to reduce downtime, enhance maintenance response, and improve the reliability of power transmission networks.

Key Words: Power Transmission Line Monitoring, ESP32, IoT, Real-Time Fault Alerts, GSM, Relay.

1.INTRODUCTION

Electrical power systems rely on transmission lines to deliver electricity over long distances, but these lines are prone to faults such as open circuits, short circuits, and earth faults. While underground cables offer protection from environmental damage, finding faults in them is difficult and often costly. This project introduces a smart fault detection system using IoT technology and an ESP32 microcontroller. It continuously monitors voltage levels, detects irregularities during faults, and displays the fault location with GSM on an LCD. This method enables faster fault identification, reduces maintenance time, and improves the reliability of power distribution systems.

1.1 PROBLEM STATEMENT

A Smart Monitoring & Fault Detection System is essential for power transmission lines to quickly detect and address faults, minimizing disruptions and damage. Traditional methods are often slow, while smart systems using IoT and GSM provide real-time alerts, precise fault locations, and remote monitoring, leading to faster response times, improved reliability, and enhanced system performance.

1.2 OBJECTIVE

1.To design and simulate a fault detection system using a programmable controller for overhead lines.

2. To monitor line conditions with ESP32 and ensure quick fault response.

3. To locate faults using GSM and send alerts to users.

4. To test system accuracy by introducing faults at different locations.

2. LITERATURE REVIEW

S. K. Satyanarayana and S. N. Chandra Shekhar [1] proposed an IoT-based solution for underground cable fault detection. Their approach involves utilizing sensors to monitor the state of underground cables and detect faults accurately. This model is implemented within a real-time framework to continuously assess the health of power transmission lines, making it suitable for urban environments where fault detection is critical. The system's efficiency lies in its ability to quickly identify faults, enabling rapid response and reduced downtime for maintenance.

A. Firos et al. [2] presented a model using artificial intelligence (AI) for fault detection in power transmission lines. This model integrates machine learning algorithms to analyze transmission line data, aiming to predict and locate potential faults before they lead to system failures. The use of AI enhances the model's accuracy in fault detection, making it highly beneficial for critical infrastructure where reliability is essential. The study demonstrates that AI-driven fault detection can significantly reduce the likelihood of widespread outages.

M. T et al. [3] developed an IoT-based fault detection system focused on essential power transmission lines. Their system uses a network of sensors connected to IoT devices, enabling real-time monitoring of transmission line health. This model emphasizes on-site deployment and utilizes cloud storage for data, allowing maintenance teams to access fault data remotely. The research highlights the advantages of IoT in making fault detection systems more efficient and accessible across various geographical areas.

L. Goswami and P. Agrawal [4] explored a solution that leverages IoT with Google Firebase for diagnosing faults in power line transmissions. Their proposed model integrates sensor networks with Firebase, creating a centralized platform for data collection and analysis. By utilizing

Google's cloud services, this system offers scalable and reliable data storage, suitable for large-scale deployments. The study emphasizes the potential for cloud-based fault detection systems to streamline monitoring and improve fault localization.

A. Mukherjee et al. [5] provided a comprehensive review of fault detection methods for power transmission lines. Their research compares different algorithms for fault identification, classification, and localization, offering insights into the advantages and limitations of each approach. The review underscores the importance of algorithm selection in designing effective fault detection systems, particularly in complex power networks. The authors conclude that a combination of advanced algorithms is necessary to achieve optimal fault detection and classification.

L. Goswami and P. Agrawal [6] proposed an IoT-based system for fault detection in power line transmission, utilizing Google Firebase as a centralized database. This model involves the realtime monitoring of transmission line parameters, with data stored and analyzed via Google's cloud services to detect anomalies. Their study emphasizes the reliability of cloud-based platforms in managing large data volumes, enabling prompt fault identification and response. By combining IoT with Firebase, this system ensures a scalable and efficient approach to fault management in power distribution networks, which is essential for maintaining grid stability.

3.SYSTEM DEVELOPMENT

The proposed system is designed to efficiently detect and locate faults in overhead transmission lines and provide real-time fault information using IoT technology. It consists of the following major components:

3.1 BLOCK DIAGRAM

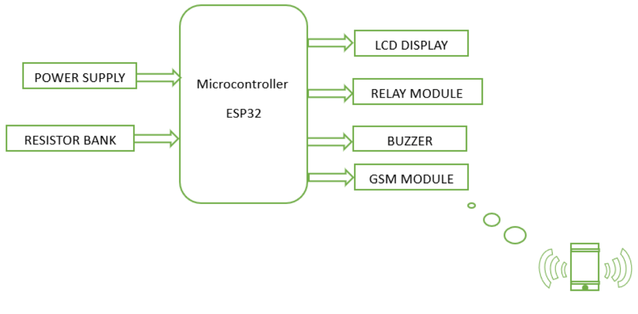

Fig -1: Block Diagram

3.2 HARDWARE DESIGN

The hardware design of the system is divided into the following three major subsystems:

3.2.1 POWER SUPPLY SYSTEM

The power supply system plays a crucial role in ensuring the reliable and efficient operation of the entire hardware setup. In this work, a 12V, 2A DC power supply serves as the primary source of power for all connected components.

The power distribution in the system is as follows:

1.Relay Modules: Powered directly by the 12V DC supply for switching operations.

2.Microcontroller (ESP32): Operates at 3.3V, derived from 12V using an onboard regulator.

3.GSM Module: Requires 5V, supplied via a buck converter from the 12V input.

4.Low Voltage Components: Powered through the same buck converter for efficient small voltage requirements.

3.2.2 FAULT ISOLATION SYSTEM

The fault isolation system is designed to detect and manage faults by isolating faulty sections and ensuring the safe operation of the system. The components and processes involved are as follows:

1.Relays are utilized to automatically connect or disconnect resistor banks based on system conditions, allowing for dynamic fault isolation.

2.Resistor Banks are strategically employed to control fault current by either shorting or isolating specific sections of the circuit.

3.Manual Switches provide the capability for manual intervention, allowing users to short or isolate the resistor banks during fault conditions.

3.2.3 LOCATION TRACKING AND DISPLAY SYSTEM

The Location Tracking and Display System facilitates real-time fault reporting and communication. The GSM module transmits messages to the user, providing details about the fault type and its location, ensuring constant monitoring of the system's status and allowing for quick intervention.

Locally, a 16x2 LED display is used to show critical information such as fault status, operational details, and location information directly to the user. This enables effective on-site monitoring and helps in managing the system efficiently.

4. CIRCUIT DIAGRAM

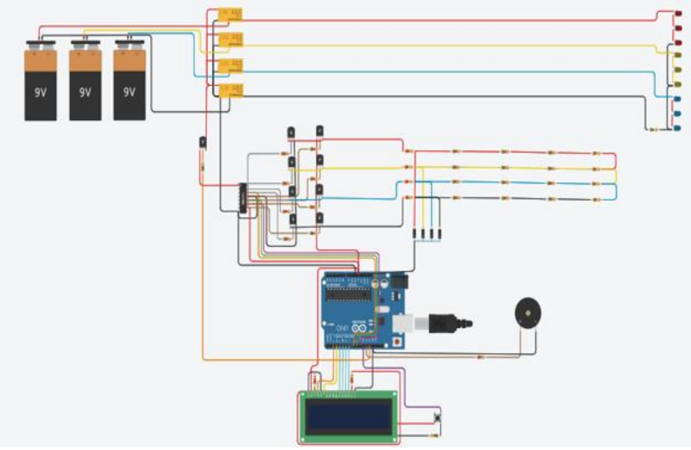

Fig -2: Circuit diagram

5. FLOW CHART

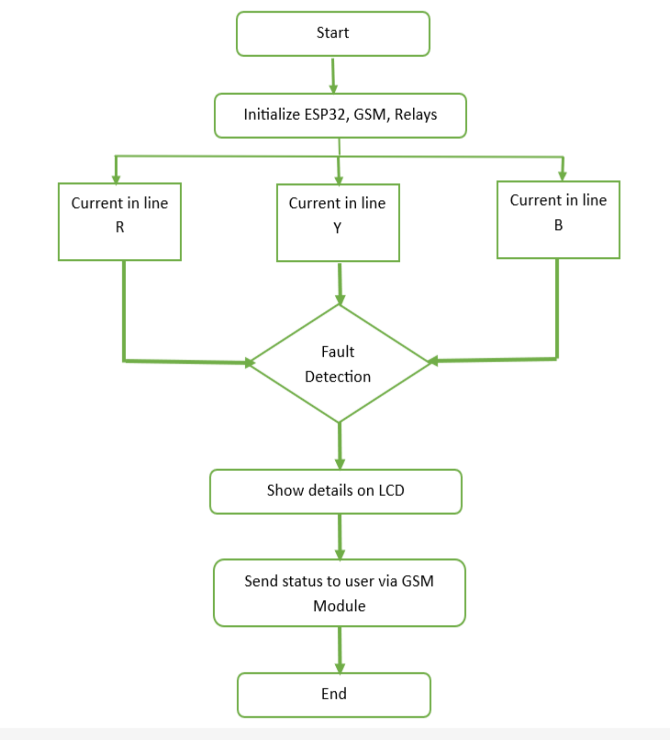

Fig -3: Flow Chart

6. PERFORMANCE ANALYSIS

This system provides an efficient solution for real-time fault detection and isolation in power transmission lines. Fault conditions are identified through manual switching, with immediate isolation achieved via controlled relay activation. Upon fault detection, an automated message is sent to the user, detailing the type and location of the issue, ensuring rapid response and enhanced system safety. Local status and fault information are displayed instantly, enabling on-site monitoring without the need for external tools. A regulated power supply ensures stable operation of all hardware under varying field conditions, while voltage conversion is managed effectively for components requiring lower levels.

The system offers significant improvements over traditional fault detection methods by integrating automated isolation, instant remote fault alerts, and on-site status indication. This approach minimizes downtime, enhances operational reliability, and reduces the risks associated with prolonged faults in transmission networks. Its modular, energy-efficient, and scalable design makes it suitable for both urban and remote applications, ensuring reliable performance and effective fault management.

7. CONCLUSION

Conventional transmission line protection systems often struggle with delayed fault identification and limited communication capabilities, especially in distributed or remote networks. This work addresses these challenges by developing a real-time fault monitoring and isolation system utilizing microcontroller-based control, automatic relay operation, and wireless communication.

The proposed system effectively detects and isolates faults by manually shorting resistor banks through switches, with relay modules ensuring safe disconnection of faulty sections. Fault details, including type and specific location, are promptly transmitted to the user via GSM messaging, providing immediate remote awareness. Additionally, operational status and fault notifications are displayed locally using a 16×2character display, improving on-site responsiveness.

By integrating real-time communication, local indication, and automated isolation, this system enhances reliability, reduces downtime, and offers a cost-effective, scalable solution for improving safety in power transmission networks.

8. FUTURE SCOPE

1. Cloud-Based Monitoring Dashboard: Integrate cloud storage and web dashboards to log fault history and remotely monitor system status. This allows operators to access real-time data from anywhere and analyze long-term trends for better decision-making.

2. Voice Call or App-Based Alerts: Enhance GSM communication to send voice call alerts or integrate with a mobile app for real-time notifications, enabling quick responses from anywhere.

3. Machine Learning for Fault Prediction: Use collected data to implement simple AI/ML models to predict potential faults and alert in advance. This proactive approach would reduce unplanned outages and allow for scheduled maintenance, improving overall grid reliability. The system could continuously learn from historical data to enhance prediction accuracy over time.

4. Modular Multi-Line Monitoring: Design a scalable modular setup capable of monitoring multiple transmission lines simultaneously with one central controller. This approach would enable the system to be easily expanded to accommodate more lines as the grid grows. It would also allow for efficient management and fault detection across various sections of the network from a single interface.

5. Smart Grid Integration: Future-proof the system for integration with smart grid networks for automatic load balancing and dynamic power management. This integration would enable the system to adapt in real-time to fluctuating power demands and automatically isolate faults. It would enhance grid reliability and efficiency, optimizing power distribution across vast networks.

9.APPLICATIONS

1.Fault Detection and Isolation: Detects and isolates faults instantly.

2. Remote Monitoring and Control: Monitors and controls faults via GSM.

3.Grid Health Monitoring: Tracks grid status continuously.

4.Rural and Remote Area Monitoring: Enables fault alerts in remote areas.

5.Energy Distribution Optimization: Balances and manages power loads.

6.Emergency Response and Disaster Management: Assists in quick fault handling during disasters.

7.Integration with Renewable Energy Networks: Supports reliable renewable energy integration.

REFERENCES

[1] S. K. Satyanarayana and S. N. Chandra Shekhar, "UNDERGROUND CABLE FAULT DETECTION USING IoT," 2024 15th International Conference on Computing Communication and Networking Technologies (ICCCNT), Kamand, India, 2024.

[2] A. Firos, N. Prakash, R. Gorthi, M. Soni, S. Kumar and V. Balaraju, "Fault Detection in Power Transmission Lines Using AI Model," 2023 IEEE International Conference on Integrated Circuits and Communication Systems (ICICACS), Raichur, India, 2023, pp. 1-6

[3] M. T, T. M, G. T, C. R. A. Darshan, S. F. F and B. K, "Fault Detection Using IoT in Essential Power Transmission Lines," 2023 Intelligent Computing and Control for Engineering and Business Systems (ICCEBS), Chennai, India, 2023, pp. 1-6.

[4] L. Goswami and P. Agrawal, "IOT based Diagnosing of Fault Detection in Power Line Transmission through GOOGLE Firebase database," 2020 4th International Conference on Trends in Electronics and Informatics (ICOEI)(48184), Tirunelveli, India, 2020, pp. 415-420

[5] A. Mukherjee, P. K. Kundu, and A. J. J. o. T. I. o. E. S. B. Das, "Transmission line faultsin power system and the different algorithms for identification, classification andlocalization: a brief review of methods," vol. 102, no. 4, pp. 855-877, 2021.