



IoT-Based Intelligent Fault Detection System for Wall-Embedded Cables

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Abstract:

Electrical faults in wall-embedded cables pose risks such as short circuits, overheating, and fire hazards. Traditional fault detection methods rely on manual inspection and are inefficient. This paper proposes an IoT-based Intelligent Fault Detection System that monitors electrical parameters in real time using voltage, current, temperature, and insulation-resistance sensors. A microcontroller processes sensor data and detects anomalies, sending alerts through IoT cloud platforms. The system enhances electrical safety, minimizes maintenance costs, and provides faster and more accurate fault localization.

Keywords: IoT, Fault Detection, Embedded Cables, ESP32, Sensors, Real-Time Monitoring, Predictive Maintenance

1. INTRODUCTION

Wall-embedded cables are widely used in residential, industrial, and commercial installations. Detecting faults in these concealed cables is difficult because traditional methods depend on thermal imaging or physical inspection. Faults such as **insulation failure**, overheating, and overload can lead to electrical fires. IoT enables real-time monitoring of electrical parameters, allowing early fault detection. The proposed system integrates sensors, microcontrollers, and cloud services to monitor voltage, current, temperature, and resistance continuously. When abnormal values are detected, the system sends instant alerts to users, improving safety and reducing downtime.

2. LITERATURE REVIEW

Research in IoT-based electrical monitoring highlights its potential to improve fault detection accuracy. Previous studies in IEEE and Elsevier journals show advancements in sensor-based monitoring, smart grid automation, and machine learning-driven predictive maintenance. Embedded systems combined with IoT enhance scalability and allow remote monitoring. These studies emphasize the need for proactive fault detection in concealed wiring.

3. SYSTEM OBJECTIVES

1. Detect electrical faults in real time.
2. Monitor voltage, current, temperature, and insulation resistance continuously.
3. Transmit data wirelessly using IoT modules.
4. Localize faults using threshold-based or ML algorithms.
5. Provide instant alerts via SMS, email, or mobile app.
6. Enable predictive maintenance using AI/ML.
7. Offer a user-friendly dashboard for monitoring.
8. Reduce maintenance cost, energy loss, and downtime.

4. METHODOLOGY

A. System Architecture

The system consists of sensors, a microcontroller (ESP32/Arduino), LCD display, IoT communication modules (Wi-Fi/GSM/LoRa), and cloud dashboards. Sensors continuously record electrical parameters and send them to the microcontroller. The system architecture enables real-time data collection, processing, cloud storage, and alert generation.

B. Working Principle

1. Sensors acquire real-time values (voltage, current, temperature, insulation resistance).
2. Microcontroller filters data and compares it with predefined thresholds.
3. If an anomaly is detected, fault classification is performed.
4. Fault data is sent to cloud-based platforms for monitoring.
5. Alerts are sent instantly through SMS, email, or mobile applications.
6. Data stored in the cloud is used for predictive analytics.

5. SYSTEM DESIGN

A. Hardware Components

- ESP8266/ESP32 microcontroller
- Voltage sensor
- Current sensor
- Temperature sensor
- Insulation resistance sensor
- LCD 16×2 display

- GSM/Wi-Fi IoT communication module
- Buzzer for fault alerts
- Transformer (230V to 12V)

B. Software Requirements

- Arduino IDE / Python
- Firebase, AWS IoT, or ThingSpeak
- Machine Learning tools (TensorFlow/Scikit-Learn)
- SQL/NoSQL database for storage

6. DATABASE DESIGN

The system uses structured tables such as:

- Tbl_Login – for user authentication
- Tbl_ResultInfo – for storing sensor outputs and fault results

The database stores historical readings, alerts, and reports for analysis.

7. RESULTS AND TESTING

Testing included sensor accuracy verification, threshold detection testing, IoT communication testing, and interface testing.

Functional test cases confirmed:

- Correct login validation
- Accurate sensor readings
- Successful IoT data upload
- Real-time alert generation
- Fault classification accuracy

All modules performed as expected.

8. DISCUSSION

The IoT-based fault detection system improves electrical safety by automating the monitoring process. It detects faults quickly, reduces manual inspection efforts, and prevents accidents. Compared to conventional systems, it offers remote monitoring, predictive analytics, and scalability. It can be implemented in homes, industries, data centers, and commercial buildings.

9. CONCLUSION

The proposed IoT-based Intelligent Fault Detection System provides a reliable solution for monitoring wall-embedded electrical cables. By combining IoT sensors, cloud integration, and predictive analytics, the system ensures early detection of electrical faults, reduces downtime, and enhances safety. Its scalability and cost-effectiveness make it suitable for large-scale deployment.

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