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Underground Cable Fault Detection Using IoT

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ABSTARCT

To precisely detect and locate short-circuit faults in metropolitan power distribution networks, this research proposes an Internet of Things (IoT)-based underground cable fault detection system. Modern cities use a large number of underground cables; therefore, accurate and timely fault detection is essential for maintaining a reliable power supply and efficient maintenance. The proposed system monitors voltage fluctuations caused by faults using an Arduino microcontroller and current-sensing circuitry. The microcontroller's built-in Analog-to-Digital Converter (ADC) converts these signals into digital values, enabling the calculation of the fault distance from the base station in kilometers. Switches are used to simulate fault conditions, while relay circuits control system operations. The type and location of the fault are displayed in real time on a 16×2 Liquid Crystal Display (LCD). In addition, fault data is transmitted to a cloud platform through an ESP8266 Wi-Fi module for remote monitoring and analysis. A buzzer is also included to immediately alert field personnel when a fault occurs. This system provides a reliable, efficient, and cost-effective solution for detecting underground cable faults, reducing repair time, and improving service continuity.

Keywords : Arduino, ADC, ESP8266, LCD display, fault detection, Internet of Things (IoT), underground cable, short-circuit fault, cloud monitoring, power distribution.

I. INTRODUCTION

The safety, dependability, and aesthetics of electricity distribution networks have been greatly enhanced by the growing use of underground cables in modern cities. These cables play a vital role in providing essential services such as power, communication, and data transmission. However, because underground cables are difficult to access and invisible, detecting and locating faults in them is a challenging task. Identifying the exact location of a fault often takes a long time, leading to extended power outages, increased maintenance costs, and inconvenience to the public. Therefore, an accurate and efficient fault detection system is crucial for ensuring a reliable power supply and effective maintenance.

Recent advancements in embedded systems and Internet of Things (IoT) technologies have enabled the development of intelligent and automated fault detection solutions. Embedded systems are well suited for monitoring and control applications because they can perform specific tasks with high accuracy and low power consumption. By integrating IoT with embedded systems, fault data can be transmitted remotely, allowing real-time monitoring and faster decision-making.

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In the proposed system, an Arduino microcontroller acts as the core processing unit. It continuously monitors voltage variations across current-sensing resistors connected to the underground cable. When a short-circuit fault occurs, the voltage across these resistors changes, and the built-in Analog-to-Digital Converter (ADC) of the Arduino converts these variations into digital values. Based on these digital readings, the distance of the fault from the base station is calculated in kilometers, enabling precise fault localization.

To test and demonstrate the system, fault conditions are created using switches, while relay circuits are used to control the fault detection process. A 16×2 Liquid Crystal Display (LCD) shows the type of fault and its location in real time. In addition, an ESP8266 Wi-Fi module transmits the fault information to a cloud platform, enabling remote monitoring and data analysis. A buzzer is also included to immediately alert maintenance personnel when a fault occurs.

This IoT-based underground cable fault detection system provides a reliable, fast, and cost-effective solution for identifying faults and reducing power restoration time. By accurately locating faults, the system helps maintenance teams take prompt corrective action, thereby improving the overall reliability and efficiency of urban power distribution networks.

The remainder of this paper is organized as follows. Section II presents a review of related work on underground cable fault detection. Section III describes the hardware and software implementation of the proposed system. Section IV discusses the experimental results and cloud-based fault monitoring. Finally, Section V concludes the paper and suggests possible future enhancements.

II. LITURATURE REVIEW

The rapid expansion of underground power distribution networks in modern cities has significantly increased the need for quick, accurate, and reliable fault detection systems. Conventional fault detection techniques are often expensive, time-consuming, and inefficient because underground cables are difficult to access. To overcome these limitations, researchers have proposed various methods based on embedded systems, signal processing, sensor technologies, and Internet of Things (IoT) platforms.

Yang et al. [15] presented a distributed parameter–based technique for identifying defects in underground power cables. This method accurately estimates the fault location using mathematical models of cable properties, thereby reducing service restoration time. Similarly, Zhao et al. [13] improved the traveling-wave fault location method by integrating GPS and wavelet analysis, which significantly increases the accuracy of fault detection in power cables.

Westrom and Larsen developed a fault distance estimation technique to determine the approximate location of faults in underground cable systems. Gilany et al. [14] proposed a traveling-wave–based fault location approach for multi-ended underground cable networks, providing a practical solution for complex power distribution systems.

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Zhang et al. [8] proposed an online incipient fault detection method based on single-end sheath current measurements. This method helps identify early-stage faults before they result in major failures. Schulze and Schegner [9] studied fault location techniques for unsymmetrical transmission lines, contributing to improved fault analysis in power systems.

Sun et al. [10] developed a magnetic-field–based sensing method to detect and inspect underground power cables from ground level. This non-intrusive technique enables cable monitoring without excavation. Paul and Kakoti [11] designed a practical underground cable fault locator that simplifies the identification and repair of faulty cable sections.

Recent research has also focused on integrating IoT technologies into underground cable fault monitoring systems. Islam et al. [5] reviewed various fault detection techniques and suggested future research directions. Teresa et al. [12] introduced an IoT-based underground cable fault detection system that enables real-time monitoring and remote fault reporting, thereby improving maintenance efficiency. In summary, the literature indicates that modern underground cable fault detection systems are moving toward intelligent, automated, and IoT-enabled solutions. The application of wavelet analysis, magnetic-field sensing, mathematical modeling, and real-time IoT monitoring has significantly improved the speed, accuracy, and reliability of fault detection. These advancements help ensure uninterrupted power supply and communication services while enhancing the resilience of urban power infrastructure.

III. PROPOSED METHODOLOGY

A. Proposed Work

The proposed system uses an Arduino microcontroller to design and develop an Internet of Things (IoT)-based underground cable fault detection system. The primary objective is to continuously monitor underground power cables and reliably detect and locate faults in real time. Since underground cables are difficult to access, the system provides an efficient and automated method for fault detection without requiring physical inspection.

The system monitors variations in voltage and current along the cable using current-sensing circuits connected to the Arduino. Any abnormal change in these electrical parameters indicates the presence of a fault. By analyzing the measured values, the distance of the fault from the monitoring unit is calculated, enabling precise fault localization.

A 16×2 LCD display is used to show the real-time cable status and fault location, while a buzzer provides an immediate alert when a fault is detected. A switch driver unit is included to simulate different fault conditions for testing and demonstration purposes.
Additionally, the system is integrated with an IoT module that enables real-time transmission of fault information to a remote server or mobile application. This allows operators to monitor the cable condition from any location.

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By combining Arduino-based sensing, real-time data processing, and IoT communication, the proposed system offers a fast, accurate, and reliable solution for underground cable fault detection. This approach significantly reduces fault detection time, minimizes power outages, and improves maintenance efficiency in urban power distribution networks.

B. Proposed Design

The proposed block diagram illustrates the overall architecture of the IoT-based underground cable fault detection system. An Arduino UNO microcontroller serves as the central processing unit of the system and is responsible for data acquisition, fault analysis, and control operations. It is interfaced with a 16×2 LCD display for local monitoring and an ESP8266 Wi-Fi module for IoTbased communication.

The Arduino UNO is powered by a regulated power supply to ensure stable operation of all components. A fault simulation and sensing unit connected to the Arduino represents the underground cable network. This unit enables the system to detect different types of faults by monitoring variations in electrical parameters such as voltage and current.

When a fault occurs, the Arduino analyzes the sensed data to determine the fault condition and its approximate location. The detected fault information is displayed in real time on the LCD panel. Simultaneously, the ESP8266 module transmits this data through the Internet to a remote server or mobile application, enabling continuous remote monitoring.

By integrating embedded control, sensing, and IoT connectivity, the proposed system provides a fast, reliable, and automated solution for detecting and locating underground cable faults. This design improves maintenance response time and enhances the reliability of underground power distribution networks.

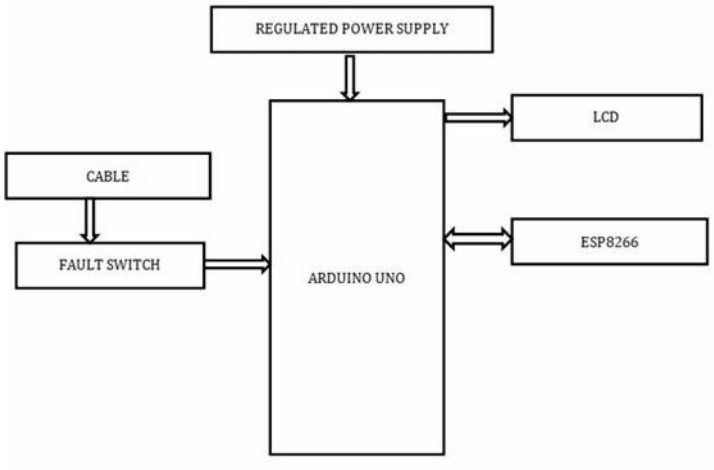


Fig. 1. Block Diagram

C. Components Used

1) Arduino UNO

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The Arduino UNO serves as the central controller of the IoT-based underground cable fault detection system. It interfaces with the fault simulation switch, the ESP8266 Wi-Fi module, and the 16×2 LCD display. Powered by a regulated supply, the Arduino continuously processes voltage and current data to detect faults and determine their locations in real time. Its compact size, ease of programming, and reliable performance make it suitable for underground cable monitoring applications.

2) ESP8266 Wi-Fi Module

The ESP8266 module enables wireless communication between the Arduino system and the Internet. It transmits fault information and cable status data to a remote server or mobile application, allowing operators to monitor the system from any location. Its low cost, compact size, and built-in TCP/IP stack make it ideal for IoT-based underground cable monitoring.

3) 16×2 LCD Display

The LCD display provides real-time visual feedback on the system's operating condition. It displays essential information such as fault occurrence, fault type, and fault distance. The 16×2 display format ensures clear and readable output, helping maintenance personnel quickly understand the status of the underground cable.

4) Fault Switch

The fault switch is used to simulate different fault conditions in the underground cable network. When activated, it generates artificial fault scenarios that help in testing and validating the detection system. This allows verification of the Arduino's ability to accurately identify and locate faults under various conditions.

5) Battery

The battery supplies portable power to the fault detection system, enabling operation in remote or off-grid locations. It provides uninterrupted power to components such as the Arduino UNO, ESP8266 module, and LCD display. Its compact and rechargeable design enhances the mobility and flexibility of the system.

6) Power Adapter

The power adapter converts AC power from a wall outlet into a suitable DC voltage for electronic components. It powers the Arduino, ESP8266, and LCD, ensuring stable and continuous operation of the system. Its plug-and-play design makes installation simple and reliable.

D. Operational Procedure

Underground power cables are continuously exposed to harsh environmental conditions such as moisture, temperature variations, and mechanical damage, especially in metropolitan regions where drainage leaks and frequent excavation occur. These conditions may lead to insulation failure, conductor breaks, or small cracks, eventually causing electrical faults. Among all fault types, shortcircuit faults are the most common and require fast and accurate detection to avoid major power interruptions.

The proposed underground cable fault detection system uses electrical parameter measurement and mathematical modeling to detect short-circuit faults. As shown in Fig. 2, the cable is energized through

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a circuit breaker and Relay-A using a voltage source (V_s). Relay-B is located at a known distance (d) from the source. The objective is to calculate the unknown fault distance (x) from the source based on the electrical characteristics of the cable.
The cable is modeled as a distributed network with resistance (r) and inductance (l) per unit length. The voltage at any point along the cable can be expressed as:

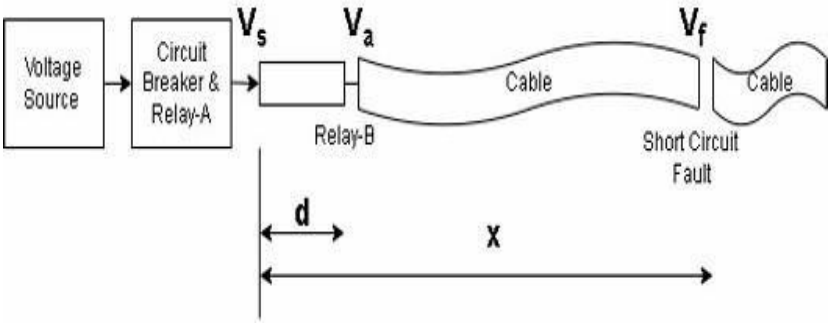


Fig.2. short circuit fault distance measurement

$$V = V_f + xrI + xl \frac{dI}{dt} \tag{1}$$

where (V_s) is the source voltage, (V_f) is the voltage at the fault location, and (I_s) is the current supplied by the source.
For long cables, impedance is proportional to the length of the cable. Therefore, the ratio of impedances equals the ratio of distances:

$$\frac{Z_x}{Z_d} = \frac{R_x}{R_d} = \frac{x}{d} \tag{2}$$

Expressing resistance in terms of voltage and current yields:

$$\frac{x}{d} = \frac{I_s (V_s - V_f)}{I_s (V_s - V_a)} \tag{3}$$

For short-circuit faults, the fault voltage (V_f) becomes zero and the impedance becomes purely resistive. Therefore, the fault distance is calculated as:

$$x = \frac{V_s}{V_s - V_a} \times d \tag{4}$$

Thus, the unknown fault distance (x) is computed using the known reference distance (d).
In the practical implementation, the Arduino UNO is interfaced with current sensors, voltage sensing circuits, relays, an LCD, an ESP8266 Wi-Fi module, and a fault switch. The Analog-to-Digital Converter (ADC) of the Arduino continuously monitors voltage and current variations along the cable. When a fault is introduced using the fault switch, abnormal electrical changes are detected and processed by the Arduino to calculate the fault distance.

The detected fault information is displayed locally on a 16×2 LCD and simultaneously transmitted to a remote monitoring platform through the ESP8266 Wi-Fi module. A buzzer is activated to alert

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maintenance personnel. The system operates using either a regulated power supply or a battery, ensuring reliable operation in both urban and rural environments.

The flow diagram shown in Fig. 3 illustrates the complete operational sequence of the system, including module initialization, fault detection, fault distance computation, LCD display, alarm generation, and cloud data upload.

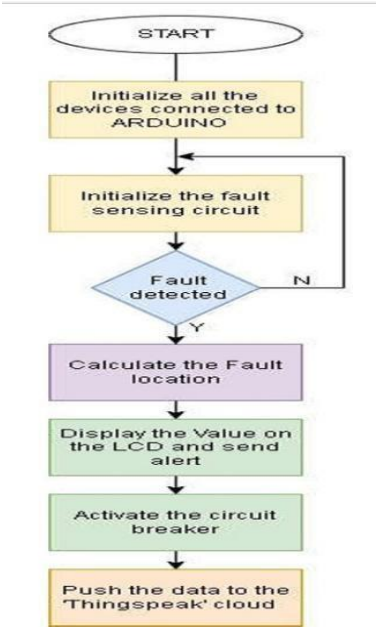


Fig.3.operationalflowchart

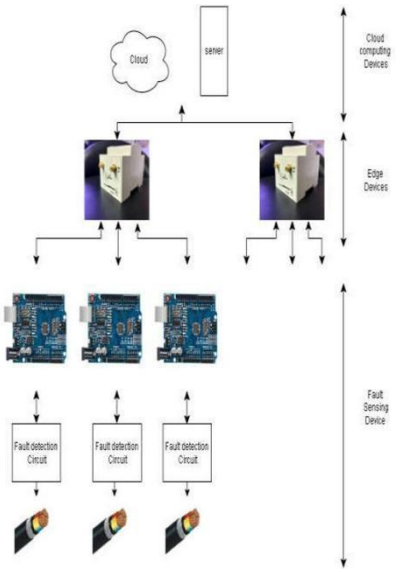


Fig. 4. Integrating Cable Fault Detection Boards Together

To address the electrical needs of dense populations, extensive underground cable networks are installed in large metropolitan areas. It is necessary to integrate Internet of Things (IoT) technology with edge computing for real-time and localized data processing to identify issues across such large cable systems.

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Multiple edge computing units can be installed at different points throughout the network to efficiently monitor cable conditions. These edge devices collectively provide comprehensive fault surveillance across the city. The edge computing units are connected to a central controller or cloud-based platform to enable centralized monitoring and data processing.

This integrated architecture ensures improved reliability, faster response times, and efficient fault detection in urban power distribution systems.

IV. EXPARIMENTAL RESULTS

The simulated fault conditions are tested using the experimental setup shown in Fig. 5. When the system is powered on, the LCD display initially shows a welcome message, as illustrated in Fig. 6. To simulate different fault scenarios, faults are introduced through a dedicated resistive network connected to the underground cable model.

When no fault is present in the cable, the LCD displays “NF” (No Fault), indicating that the system is operating normally. When a fault is introduced, the LCD indicates the type of fault using the symbol “R”, which represents a resistive fault condition, as shown in Fig. 7.

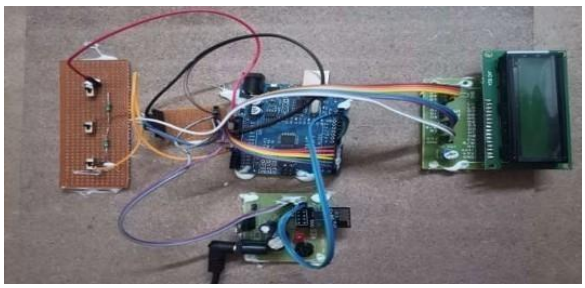


Fig. 5. Equipment and Wire Connections

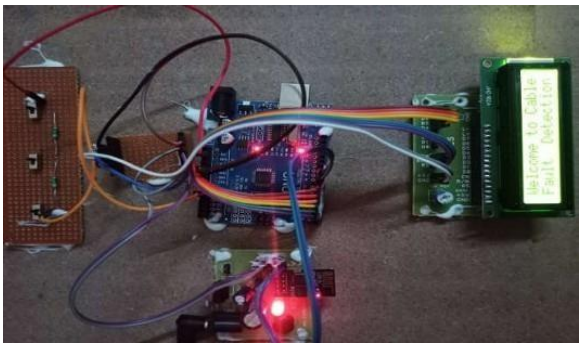


Fig. 6. Equipment and Wire Connections with Welcome Message on LCD

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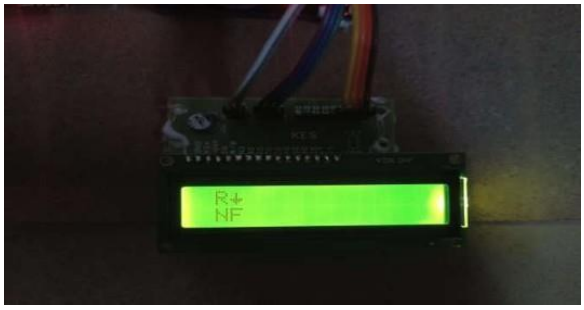


Fig. 7. No Fault Indication

When a fault occurs in the cable model, the system calculates the approximate distance of the fault from the monitoring unit using the measured electrical parameters. The experimental results demonstrate that the system successfully identifies faults at different distances along the cable.
For example, the resistive fault readings obtained at 9 km and 6 km from the test setup are shown in Fig. 8 and Fig. 9, respectively.

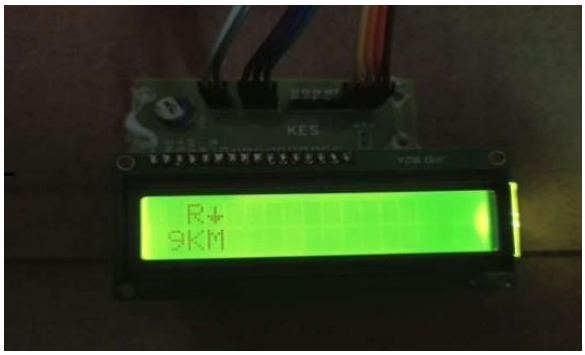


Fig. 8. Fault Indication at 9 km Distance

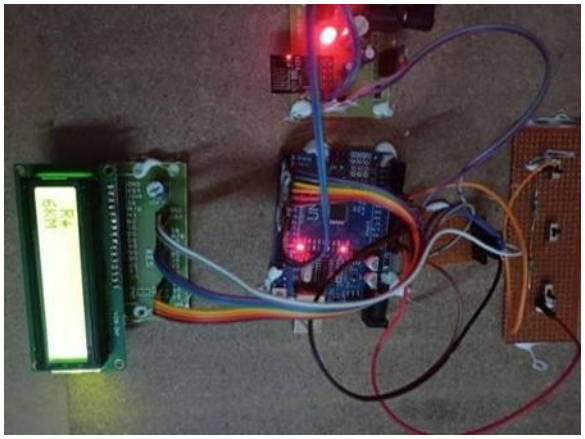


Fig. 9. Fault Indication at 6 km Distance

Additional experiments were conducted to verify the accuracy of the system under different conditions. The results obtained from the hardware setup are displayed on the LCD as shown in the following figures.

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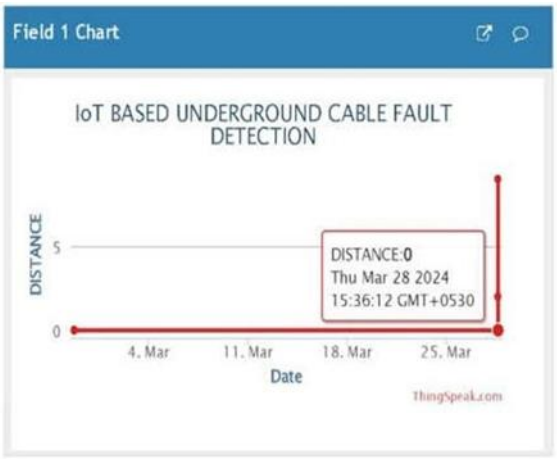


Fig. 10. No Fault Condition

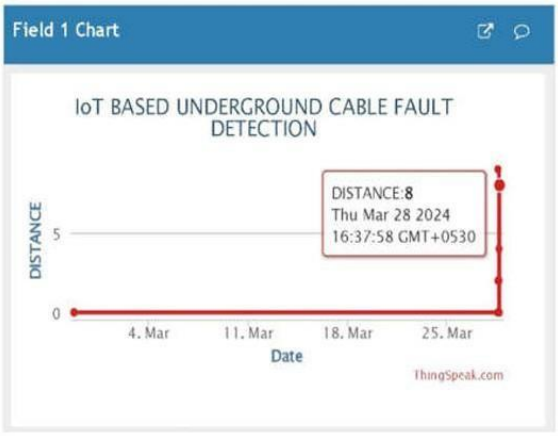


Fig. 11. Fault at a Distance of 8 km

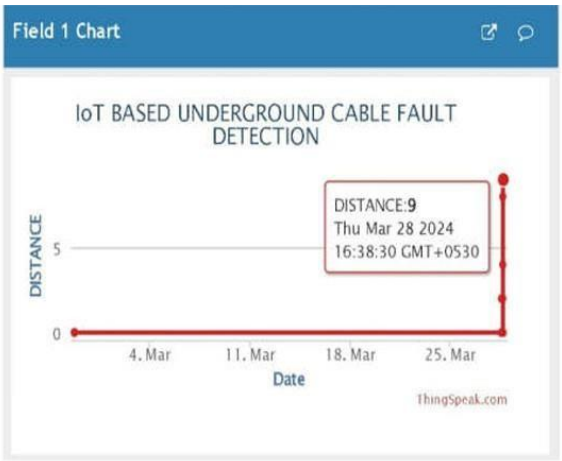


Fig. 12. Fault at a Distance of 9 km

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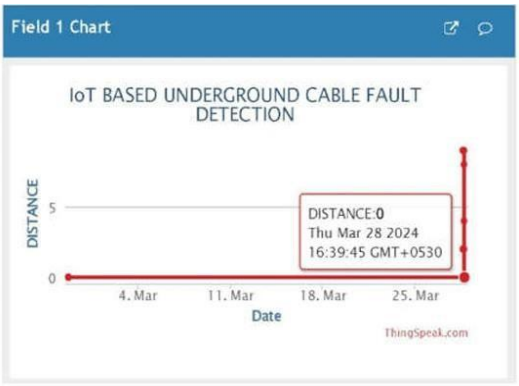


Fig. 13. No Fault Condition

To enable remote monitoring, the system transmits fault data to the Thing Speak cloud platform, which provides a convenient interface for storing, visualizing, and analyzing data from IoT devices. Figures 10 through 13 illustrate the visualization of short-circuit fault data at different distances and time intervals on the Thing Speak platform.

The fault location determined by the experimental setup is transmitted to the Thing Speak cloud for monitoring purposes. When no fault is detected, the LCD displays 0 km, which is also reflected in the cloud visualization as shown in Figures 10 and 13. When faults occur at distances of 8 km and 9 km, the system records and displays these values on the cloud platform, as illustrated in Figures 11 and 12. By integrating multiple such monitoring units across a distribution network, the concerned authorities can significantly improve the quality of service provided to underground cable consumers. Furthermore, the implementation of a publisher–subscriber architecture enables efficient and secure access to fault data for authorized users.

V. CONCLUSION

The Internet of Things (IoT)-based underground cable fault monitoring system provides a reliable and efficient solution for detecting and locating faults in underground cable networks. The proposed technique enables accurate fault localization by utilizing a voltage divider network to calculate the unknown fault distance based on a known reference distance.

The integration of embedded devices, such as a microcontroller with Wi-Fi connectivity, enables real-time monitoring and online transmission of fault data. This significantly improves the efficiency of fault diagnosis and maintenance operations. The system accurately identifies fault locations and transmits this information to the relevant authorities, enabling prompt repair or cable replacement. As a result, troubleshooting becomes easier and the power restoration process is accelerated.

The inclusion of date and time logging improves accountability and traceability, which enhances maintenance planning and fault analysis. In addition, the system continuously stores cable condition data on a cloud platform, enabling long-term performance evaluation and cable health monitoring. This capability supports the prediction of potential failures and allows preventive maintenance using appropriate protection equipment.

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Overall, the IoT-based underground cable fault detection system represents a significant advancement in modern fault monitoring technology. Its ability to improve system reliability, accelerate maintenance procedures, and minimize downtime makes it a valuable tool for modern power infrastructure management.

REFERENCES:

[1] R. K. Mansingh, R. Raghul, et al., "Underground Cable Fault Detection Using Raspberry Pi and Arduino," *International Journal of Emerging Technologies in Engineering Research (IJETER)*, vol. 5, no. 4, 2017.

[2] P. A. Hukeri and M. P. Ghewari, "Review Paper on IoT-Based Technology," *International Research Journal of Engineering and Technology (IRJET)*, vol. 4, no. 1, 2017.

[3] E. C. Bascom, D. W. Von Dollen, and H. W. Ng, "Computerized Underground Cable Fault Location Expertise," in *Proceedings of the IEEE/PES Transmission and Distribution Conference*, IEEE, 1994.

[4] R. Salat and S. Osowski, "Accurate Fault Location in Power Transmission Lines Using Support Vector Machine," *IEEE Transactions on Power Systems*, vol. 19, no. 2, pp. 979–986, 2004.

[5] M. F. Islam, A. M. T. Oo, and S. A. Azad, "Locating Underground Cable Faults: A Review and Guideline for New Development," in *22nd Australasian Universities Power Engineering Conference (AUPEC)*, IEEE, 2012.

[6] M. F. Badillo et al., "Simulation and Analysis of Underground Power Cable Faults," in *International Meeting of Electrical Engineering Research*, Ensenada, Mexico, 2012.

[7] A. Pandey and N. H. Younan, "Underground Cable Fault Detection and Identification Using Fourier Analysis," in *Proceedings of IEEE Conference*, 2010.

[8] C. Zhang et al., "On-Line Incipient Fault Detection in Underground Cables Based on Single-End Sheath Currents," in *IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC)*, 2016.

[9] R. Schulze and P. Schegner, "Two-Terminal Fault Location on Unsymmetrical Transmission Lines," in *IEEE PES General Meeting*, 2010.

[10] X. Sun et al., "Underground Power Cable Detection and Inspection Technology Based on Magnetic Field Sensing at Ground Surface Level," *IEEE Transactions on Magnetics*, vol. 50, no. 7, pp. 1–5, 2014.

[11] M. Paul and R. K. Kakoti, "Underground Cable Fault Locator," *International Advanced Research Journal in Science, Engineering and Technology (IARJSET)*, vol. 3, no. 9, pp. 79–81, 2016.

[12] V. V. Teresa et al., "IoT-Based Underground Cable Fault Detection," in *International Conference on Augmented Intelligence and Sustainable Systems (ICAISS)*, IEEE, 2022.

[13] W. Zhao, Y. H. Song, and W. R. Chen, "Improved GPS Traveling-Wave Fault Locator for Power Cables Using Wavelet Analysis," *International Journal of Electrical Power & Energy Systems*, vol. 23, no. 5, pp. 403–411, 2001.

[14] M. Gilany and D. K. Ibrahim, "Traveling-Wave-Based Fault-Location Scheme for Multi-End Aged Underground Cable Systems," *IEEE Transactions on Power Delivery*, vol. 22, no. 1, pp. 82–89, 2006.

[15] X. Yang et al., "Distributed Parameter Approach for Underground Power Cable Fault Location," *IEEE Transactions on Power Systems*, vol. 23, no. 4, pp. 1809–1816, 2008.