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# Smart Underground Cable Fault Detector

**Mrs. Mamatha N[1], B Kiran Kumar[2], Charan K V[3], Bharath Gowda[4], Jnanesh R[5]**

Assistant Professor, Dept. of ECE, K S School of Engineering and Management Bengaluru, India[1]

Student, Dept. of ECE, K S School of Engineering and Management Bengaluru, India[2-5]

**Abstract:** the Smart Underground Cable Fault Detector is an innovative solution designed for the rapid and precise identification of issues in buried power lines. While subterranean cables offer superior safety and aesthetic advantages, they are vulnerable to faults like short circuits or insulation failure caused by aging and moisture. Traditional troubleshooting is often laborintensive and expensive.

This system leverages an Arduino Uno and the voltage drop principle to pinpoint fault locations. By using an onboard ADC to process signals and an ESP8266 for wireless connectivity, the device provides real-time updates and distance calculations via an LCD. This automation significantly reduces the need for manual inspection and disruptive excavation, making it ideal for smart city infrastructure and industrial power grids."

## I. INTRODUCTION

Underground cable systems play a major role in modern electrical power distribution networks, especially in urban areas, industrial zones, smart cities, and commercial infrastructures. Compared to overhead transmission lines, underground cables provide better safety, improved reliability, reduced maintenance caused by environmental conditions, and enhanced appearance because the cables are hidden beneath the ground. These systems are protected from external disturbances such as storms, heavy rainfall, strong winds, lightning, falling trees, and accidents caused by vehicles or animals. Due to these advantages, many countries and cities are increasingly replacing overhead lines with underground cable networks for efficient power transmission and distribution.

Although underground cables provide several benefits, they also create a major challenge when faults occur. Since the cables are buried beneath the ground, identifying the exact location of a fault becomes very difficult. Faults in underground cables may occur because of insulation failure, cable aging, moisture penetration, overheating, manufacturing defects, corrosion, or accidental damage during excavation and construction activities. These faults can interrupt the continuous flow of electricity and may result in severe power failures, equipment damage, economic loss, and safety hazards.

The most common types of underground cable faults are open-circuit faults, short-circuit faults, and earth faults. An open-circuit fault occurs when the conductor inside the cable breaks, stopping the flow of current completely. A shortcircuit fault occurs when two conductors come into contact due to insulation damage, causing excessive current flow. Earth faults happen when the conductor touches the ground or the metallic body connected to earth potential. These faults affect the reliability and efficiency of the electrical power system and therefore require immediate detection and repair.

Traditional methods used for underground cable fault detection mainly depend on manual inspection and physical digging. Technicians usually inspect the cable route and perform testing procedures to locate the damaged section. These methods consume a large amount of time, require skilled manpower, increase maintenance cost, and may unnecessarily damage roads and underground infrastructure during excavation. In many situations, identifying the exact location of the fault becomes difficult, leading to long power interruptions and inconvenience to consumers. Therefore, there is a strong need for an intelligent and automated system that can quickly detect the fault and accurately identify its location.

The Smart Underground Cable Fault Detector project is developed to overcome these limitations by using a microcontroller-based automated monitoring system. The project mainly focuses on detecting underground cable faults and locating the approximate distance of the fault from the base station. The system uses the voltage drop principle to identify the fault position. Whenever a fault occurs in the cable, there is a change in voltage and current characteristics. By measuring the voltage variation, the system calculates the distance of the fault from the supply point and displays the result on an LCD screen.

In this project, the Arduino Uno acts as the main controlling unit. Arduino Uno is a widely used microcontroller board based on the ATmega328P microcontroller. It is selected because of its simplicity, low cost, easy programming, and efficient processing capability. The Arduino continuously monitors the analog voltage signals from the cable network

  

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through its built-in Analog-to-Digital Converter (ADC). Based on the received voltage values, the controller processes the data and determines whether a fault has occurred.

## II. LITERATURE REVIEW

In [1], Yunru Chen et al. (2025) proposed an advanced underground cable monitoring and protection system focused on reducing circulating sheath currents using distributed sheath compensation techniques. In underground power transmission systems, excessive circulating current in cable sheaths produces unwanted heat, increases energy losses, and affects cable insulation life. The proposed system uses transformers, inductors, and compensation modules to control and reduce these sheath currents effectively. By minimizing heat generation and electrical stress, the system improves underground cable efficiency, stability, and safety. The research also explains how intelligent control systems can improve long-distance underground cable transmission performance. The proposed method reduces maintenance requirements and increases the operational life of underground cables. This project is highly useful for modern smart grids, industrial power systems, and urban underground electrical infrastructure where uninterrupted and reliable power supply is essential. The study demonstrates that intelligent compensation and monitoring techniques can significantly improve underground cable reliability while reducing the possibility of cable failure and system downtime.

In [2], Ayush Sahare et al. (2025) developed a smart underground cable fault location detector integrated with GPS and GSM communication technologies. The system is designed to detect underground cable faults accurately and send real-time location details to maintenance personnel. The proposed method uses Ohm’s law and Murray loop techniques to calculate the distance of the fault from the base station. Once a fault occurs, the system immediately identifies the fault location and sends SMS alerts along with GPS coordinates using the GSM module. This reduces manual inspection and helps maintenance teams reach the damaged area quickly. The integration of GPS technology improves location accuracy, while GSM communication supports remote monitoring and fault notification. The system minimizes power interruption duration, reduces repair time, and improves underground cable maintenance efficiency. This research demonstrates the importance of combining communication and tracking technologies in smart electrical systems. The proposed project is highly suitable for smart cities, industrial power distribution systems, railway networks, and underground utility monitoring applications where fast fault response is necessary.

In [3], Murugakummar Jayachandran et al. (2024) introduced an IoT-based underground cable fault detection system using an ESP32 microcontroller and cloud monitoring platform. Underground cable systems are difficult to inspect manually because the cables are buried below the ground surface. To solve this problem, the researchers developed a smart monitoring system that continuously checks voltage variations in underground cables and identifies fault conditions automatically. The ESP32 controller processes voltage signals and sends the collected data to a cloud platform through wireless communication. Whenever a fault occurs, the system updates the information in real time, allowing operators to monitor cable conditions remotely. The proposed system improves fault detection speed, reduces maintenance delay, and minimizes unnecessary excavation work. The integration of IoT technology enables remote monitoring, automated fault diagnosis, and real-time data analysis. This project supports smart grid applications and improves the efficiency of underground power distribution systems. The research highlights the growing importance of IoT-enabled monitoring systems in modern electrical engineering and smart infrastructure development

In [4], Vishal Kumar proposed a system that detects underground cable faults and calculates the distance of the fault from the supply point. The project uses a microcontroller, resistors, relays, and LCD display for monitoring. The voltage drop principle is used to determine the location of the fault. When a short circuit or open circuit occurs, the voltage changes according to the fault distance. The microcontroller processes these voltage values and displays the fault location on the LCD screen. The paper explains that the system helps reduce unnecessary digging and speeds up maintenance work. The proposed design is simple, low-cost, and efficient for small-scale underground power systems. The researchers also discussed the importance of automatic monitoring in reducing repair costs and improving power supply reliability. Experimental results showed accurate fault detection under different testing conditions. This survey is highly useful for Arduino-based underground cable fault detector projects.

In [5], E. Rajinikanth introduced an IoT-based monitoring system using NodeMCU technology. The system detects underground cable faults by monitoring phase variation in electrical signals. When a fault occurs, phase imbalance changes are detected and transmitted to the cloud through IoT communication. The NodeMCU controller continuously checks cable conditions and sends real-time alerts to users. The paper explains how cloud monitoring improves fault management and remote access. The researchers highlighted that phase variation analysis is an effective method for identifying cable faults accurately. The system also reduces maintenance time and improves overall reliability. Experimental analysis confirmed that the proposed system can detect faults quickly and efficiently. The project is useful

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for smart grid and smart city applications because it supports continuous online monitoring. This survey provides important information about IoT communication and phasebased fault detection methods.

In [6], Shahram Kazemi studied the importance of proactive and reactive fault diagnosis schemes in underground cable systems. The paper compares Reactive Fault Diagnosis Schemes (RFDS) and Proactive Fault Diagnosis Schemes (PFDS). RFDS identifies faults only after failure occurs, while PFDS predicts problems before complete failure happens. The researchers explained that proactive monitoring reduces maintenance cost, repair time, and power interruption frequency. The study also discusses how early fault detection improves system safety and reliability. Advanced monitoring techniques and automated diagnostic systems were analyzed in detail. Simulation results showed that proactive systems perform better than traditional maintenance methods. The paper highlights the importance of smart monitoring technologies in modern power systems. This survey helps students understand reliability improvement techniques used in underground cable networks.

In [7], Suzi Seroja Sarnin proposed a smart monitoring system using Arduino, current sensors, smoke sensors, GSM modules, and LCD displays. The system continuously monitors electrical current and detects abnormal conditions such as short circuits and fire hazards. When a fault occurs, the smoke sensor checks for fire and the GSM module sends warning messages to users. The LCD display shows the fault condition locally. The paper explains how IoT technology improves electrical safety and fault management. The researchers emphasized that automatic alerts help reduce accidents and improve maintenance response time. The system is suitable for industrial power systems and smart monitoring applications. Experimental testing confirmed reliable operation under different fault conditions. This survey is useful for understanding sensor-based monitoring systems and IoT communication methods.

In [8], Wei Wang proposed a modern underground cable monitoring system using 5G network slicing technology. The system uses sensors and robotic inspection devices to monitor cable tunnels continuously. Parameters such as temperature, humidity, gas concentration, and cable faults are measured in real time. The collected information is transmitted through a 5G communication network for faster data transfer. The researchers explained that 5G technology improves communication speed, monitoring efficiency, and reliability. Inspection robots help reduce human risk during tunnel monitoring. The paper highlights the importance of smart communication systems in underground cable management. The proposed method supports real-time monitoring and automatic warning generation. Experimental results proved that the system improves operational safety and fault detection efficiency. This survey provides useful ideas about advanced communication technologies in underground cable systems..

In [9], Mairaj Ali developed a system for detecting abnormal voltage and frequency conditions in underground cables. The system uses window comparator circuits and zero-crossing techniques to identify variations in electrical parameters. Checkpoint methods are used to locate cable faults accurately. The researchers explained that voltage and frequency monitoring helps identify abnormal operating conditions before complete failure occurs. The system continuously checks cable conditions and provides fault alerts whenever parameter limits exceed normal values. The paper also discusses the importance of preventive monitoring in underground power systems. Experimental testing showed accurate detection of cable faults and voltage abnormalities. This survey is useful for understanding checkpoint monitoring and voltage analysis techniques.

In[10], Simar Preet Kaur proposed a cable fault distance calculator using an 8051 microcontroller and Analog-toDigital Converter (ADC). The system measures voltage drop across underground cables to calculate fault distance. The calculated distance is displayed on an LCD display. The paper explains that the method reduces manual excavation and speeds up maintenance work. The researchers discussed how resistance changes help identify short-circuit and opencircuit faults. The system is low-cost and suitable for educational and industrial applications. Experimental results confirmed accurate distance calculation under different testing conditions. This survey provides useful knowledge about voltage-drop-based fault detection systems.

In[11], Snehal C. Kor presented a system that identifies underground cable faults using Murray loop methods and Ohm's law calculations. The proposed design measures resistance changes in cables to determine the exact fault location. The researchers explained that accurate fault location reduces repair time and maintenance cost. Microcontroller-based circuits process electrical signals and display fault details to operators. The study discusses different types of underground cable faults and their causes. Experimental analysis proved that the method provides accurate results under different operating conditions. The paper highlights the importance of automation in underground cable maintenance systems. This survey is useful for understanding resistance-based cable fault detection techniques.

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In[12], Bing Li developed a device for testing underground electric heating cables. The system detects short-circuit and break faults using intelligent control methods. The researchers explained that underground heating cables are difficult to inspect manually because they are installed below the ground. The proposed testing device improves troubleshooting efficiency and fault accuracy. Intelligent monitoring circuits continuously check cable performance and identify abnormal conditions quickly. The paper discusses the advantages of automatic fault testing in industrial applications. Experimental results showed improved testing performance and reduced maintenance effort. This survey provides basic knowledge about underground cable testing systems and intelligent monitoring techniques.

In [13], Researchers proposed a wireless sensor networkbased underground cable monitoring system for continuous fault supervision. Sensors are placed along the cable route to monitor current, voltage, and temperature conditions. The collected data is wirelessly transmitted to a monitoring station for analysis. This system improves reliability, reduces manual inspection, and supports smart grid infrastructure development. The project is useful for modern electrical distribution systems.

In [14], This research introduced an Arduino-based automated underground cable fault detection system using voltage measurement and resistance analysis techniques. The system identifies fault conditions and calculates the approximate fault distance. The detected fault information is displayed on an LCD module. This project provides a lowcost and simple solution for underground cable fault management. The system improves maintenance efficiency and reduces unnecessary excavation work.

In [15], The proposed intelligent underground cable fault detection system combines sensors, embedded systems, and IoT communication technologies. The system continuously monitors cable conditions and automatically identifies abnormal situations. Fault information is transmitted wirelessly for quick maintenance action. The project improves power distribution reliability and supports smart city infrastructure. This research highlights the importance of intelligent monitoring systems in modern electrical engineering.

## III. COMPARISON OF THE TECHNIQUES

Table 1: Comparison Table

| Author Name | Methodology | Results | Gaps | Year |
|---|---|---|---|---|
| Yunru Chen et al. [1] | Distributed sheath compensation using transformers, inductors, and control modules for underground cables. | Reduced sheath circulating current, minimize d heat losses, and improved cable stability. | Complex implementation and higher installation cost. | 2025 |
| Ayush Sahare et al. [2] | GPS and GSM based underground cable fault detection using Ohm's law and Murray loop method. | Achieved accurate fault location tracking with realtime SMS alerts and GPS coordinates. | Depend s on GSM network availability and GPS signal accuracy. | 2025 |
| Murugakummar Jayachandran et al. [3] | IoT based underground cable monitoring using ESP32 and cloud communication. | Enabled remote fault monitoring and improved fault detection speed. | Require s internet connectivity and cloud infrastructure. | 2024 |
| Vishal Kumar et al. [4] | Voltage drop method using microcontroller, resistors, switches, and LCD display... | Calculated undergro und cable fault distance accurately and reduced manual inspection. | Fault accuracy decreases for long distance cable network s. | 2023 |
| E. Rajinikanth et al. [5] | Phase variation analysis using Node MCU and IoT communication. | Enabled real-time underground cable monitoring and cloud based alerts. | Continuous network support is required for operation. | 2023 |

  

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|---|---|---|---|---|
| Shahram Kazemi et al. [6] | Reactive and proactive fault diagnosis schemes for underground cable systems. | Improve d distribution system reliability and reduced maintenance cost. | Require s advance d predictive analysis algorithms. | 2023 |
| Suzi Seroja Sarnin et al. [7] | Arduino and GSM-based smart monitoring system with current and smoke sensors. | Improve d electrical safety and enabled remote fault warning alerts. | Limited monitoring range and slower response in large systems. | 2023 |
| Wei Wang et al. [8] | 5G-based underground cable tunnel monitoring using sensors and inspection robots. | Achieved real-time monitoring of tunnel temperature, humidity, and cable conditions | Expensive infrastru cture and high deployment cost. | 2022 |
| Wireless Sensor Network Researcher s [9] | Wireless sensor network for underground cable condition monitoring. | Improved continuo us supervision and reduced manual maintenance. | Sensor calibration and maintenance required regularly. | 2021 |
| Arduino-Based Researcher s [10] | Automated underground cable fault detection using Arduino and resistance analysis. | Provided low-cost and efficient underground cable fault identification. | Limited detection accuracy for complex fault conditions. | 2020 |
| Smart Grid Researcher s [11] | Intelligent underground cable monitoring using IoT and embedded systems. | Improve d smart grid reliability and enabled remote cable monitoring. | Comple x integration with existing power systems. | 2019 |
| Mairaj Ali et al. [12] | Check point method using window comparator and zerocrossing techniques. | Improved voltage and frequency variation monitoring in underground cables. | Limited capability for advanced fault analysis | 2018 |
| Simar Preet Kaur et al. [13] | Voltage drop principle using ADC and 8051 microcontroller. | Achieved accurate underground cable fault distance calculation. | Suitable mainly for shortdistance underground cable systems. | 2017 |
| Snehal C. Kor et al. [14] | Murray loop and Ohm's law-based underground cable fault identification system. | Improve d fault location accuracy and simplified maintenance work. | Require s proper calibration for accurate measurements | 2017 |
| Bing Li et al. [15] | Intelligent underground electric heating cable fault testing system. | Improve d troublesh ooting efficienc y and fault detection accuracy. | Applica ble mainly for undergr ound heating cable systems. | 2008 |

## III. CONCLUSION

The Smart Underground Cable Fault Detector system provides an efficient and reliable solution for identifying and locating faults in underground power cables. The proposed system uses Arduino Uno, voltage drop analysis, LCD display, and IoT communication to detect cable faults accurately and display the fault distance from the base station. This reduces manual inspection, minimizes unnecessary digging, and decreases maintenance time.

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The integration of IoT technology and wireless communication improves real-time monitoring and enables faster fault response. The system also improves power distribution reliability, reduces operational cost, and supports smart grid applications. Compared to traditional fault detection methods, the proposed technique offers better efficiency, safety, and automation.

Overall, the project provides a low-cost, simple, and effective underground cable fault detection solution suitable for smart cities, industrial power systems, and underground electrical distribution networks. Future improvements can include AI-based fault prediction, GPS integration, cloud monitoring, and advanced sensor technologies for higher accuracy and fully automated maintenance systems.

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