

Underground Cable Fault Detection using IOT

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Abstract - Underground power cables are commonly employed for use in urban regions because of safety and reliability benefits. However, it is difficult and time-consuming to identify faults in underground cables. Conventional techniques for identifying faults in underground cables involve manual inspection and the use of equipment. Recently, IoT-based monitoring techniques have been proposed for use in underground cables for real-time fault detection. This paper discusses different techniques for underground cable fault detection, namely Time Domain Reflectometry (TDR), and techniques with IoT.

Keywords: Underground Cable Fault Detection, Internet of Things (IoT), Time Domain Reflectometry (TDR), Smart Grid, Real-Time Monitoring, Fault Localisation, Power Distribution Systems.

1. INTRODUCTION

Underground power cables are a vital part of electrical power distribution systems, especially in urban areas where safety, reliability, and aesthetics are major concerns. Although the use of underground cables minimises exposure to environmental disturbances compared to overhead lines, detecting and identifying faults in the cable remains a major challenge due to their inaccessibility. Various types of faults that may occur in underground cables include open-circuit, short-circuit, and earth faults, which can be caused by insulation failure, moisture, mechanical damage, and ageing effects. These types of faults can disrupt the supply of electrical power and increase maintenance costs for electrical distribution networks. Although conventional techniques such as bridge techniques and time-domain reflectometry can be used to detect and localise faults in electrical cables, they require specialised equipment and skilled personnel, and take considerable time to perform the tests. However, with the introduction of Internet of Things (IoT) technology, intelligent monitoring systems have been developed to allow continuous monitoring of cable parameters and to detect faults in real time, thus improving the efficiency and reliability of electrical distribution networks.

2. LITERATURE SURVEY

[1]. P. Choudhury et al., "Arduino-Based Underground Cable Fault Detection System," International Journal of Emerging Trends in Electrical Engineering, 2021.

The paper suggests a fault detection and identification system for underground electrical cables using an Arduino-based approach, addressing the issue of determining fault locations buried underground. The approach is based on an Arduino

board that detects voltage changes on a resistor network simulating the underground cable and then uses these changes in voltage as changes in resistance caused by faults such as open circuit, short circuit, or insulation fault. The changes are then used to calculate and display the fault location on an LCD screen, making it easier for technicians to find the fault location without having to dig up the entire cable line. The basic idea is based on electrical resistance and Ohm's law principles, where a small DC voltage is applied, and its voltage drop is measured and analysed for fault identification. This approach is much simpler and less costly compared to existing approaches that involve costly equipment and human involvement. The authors also suggest the possible integration of IoT or GPS technology for remote transmission of fault information for better efficiency in maintenance operations.

[2]. L. Goswami, M. K. Kaushik, R. Sikka, V. Anand, K. Prasad Sharma and M. Singh Solanki, "IoT-Based Fault Detection of Underground Cables through Node MCU Module," 2020 International Conference on Computer Science, Engineering and Applications (ICCSEA), Gunupur, India, 2020.

In the paper "IoT-Based Fault Detection of Underground Cables through Node MCU Module," Goswami et al. have suggested an IoT-based method of detecting faults in underground cables. This method utilises a Node MCU module, which is a Wi-Fi module based on the ESP8266. This method has been suggested in response to the challenges posed in the detection of faults in underground cables. IoT, along with sensor and microcontroller technologies, has been utilised in the suggested method. This method can be used to monitor the status of underground cables, and the Node MCU modules are used for this purpose. These modules are connected with sensing elements, which are used to transform the signals of electrical parameters into internet data. These Node MCU modules are wirelessly connected, and the status of underground cables can be viewed remotely through cloud services. This method of fault detection in underground cables is based on real-time detection, monitoring through Wi-Fi, and high accuracy. Internet connectivity and cloud services have been utilised in the suggested method,

which can be used to improve the overall efficiency of fault management in urban power distribution systems.

[3]. Pandey, Abishek. "Nicolas H. Younan, Underground cable fault detection and identification using Fourier analysis." 2010 IEEE Conference

In the research paper "Underground Cable Fault Detection and Identification via Fourier Analysis," Abishek Pandey and Nicolas H. Younan discuss the application of digital signal processing techniques in the identification of underground cable faults. Specifically, the authors are interested in applying the Fourier Transform technique to voltage and current signals obtained from underground cable systems. By applying the Fourier Transform technique to the signals, the authors are able to identify the presence of faults in the cable system. By transforming the signals from the time domain to the frequency domain, the authors are able to identify the presence of different types of faults, such as open-circuit faults and short-circuit faults. By applying the Fourier Transform technique, the authors are able to compare the effectiveness of this technique with other digital signal processing techniques, such as the short-time Fourier transform and the wavelet transform, in the identification of cable faults. Overall, the research paper is aimed at moving away from conventional methods of cable fault identification and towards real-time monitoring of cable faults.

[4]. Bascom, E. C., D. W. Von Dollen, and H. W. Ng. "Computerised underground cable fault location expertise." Proceedings of IEEE/PES Transmission and Distribution Conference. IEEE, 1994.

The paper titled "Computerised Underground Cable Fault Location Expertise" discusses an expert system designed for underground power cables' fault location and diagnosis. Understanding that underground cables' faults are hard and expensive to identify because they are underground and inaccessible, the paper explains the creation of an intelligent decision-support tool called FAULT. This intelligent decision-support tool was designed to help field workers identify cable faults and determine appropriate methods for locating cable faults. Based on practices and survey information, the intelligent decision-support tool is an integration of different traditional methods for faults' location, conditions of cable failures, and optimised methods for fault identification and resolution. Through its design, the intelligent decision-support

tool is expected to increase the accuracy and efficiency of faults' location and resolution, reducing human error and improving the process of faults' location and resolution, as opposed to traditional methods of faults' location and resolution.

[5]. Mansingh, RK Raghul, et al. "Underground Cable Fault Detection using Raspberry Pi and Arduino." International Journal of Emerging Technologies in Engineering Research (IJETER) 5.4 (2017)

The research paper "Underground Cable Fault Detection using Raspberry Pi and Arduino" suggests a model using both Raspberry Pi and Arduino for the detection and location of faults in underground cables. The Arduino microcontroller is employed in this research to sense the parameters from the cable, such as voltage and current, and detect any abnormalities in these parameters, which can indicate different types of faults, such as open-circuit faults and short-circuit faults, in the cable. The parameters sensed by the Arduino microcontroller are sent to the Raspberry Pi, which is used to process this data and make decisions regarding the faults in the cable. The results are then displayed using the interface. The integration of both microcontrollers has enhanced the flexibility of the model, making it more efficient and accurate in the detection and diagnosis of faults in the cable, and has also improved the interaction between the user and the machine using a GUI.

3. PROPOSED SYSTEM

The proposed Underground Cable Fault Detection System based on IoT technology is designed to detect, identify, and locate faults in underground power cables. The underground power cable is electrically modelled as a resistive network, where the resistance value is directly proportional to the length of the cable. For laboratory testing, a lumped parameter resistive model is built by interconnecting series resistors to represent the actual cable. Fault points are introduced at regular intervals to represent open circuit faults, short circuit faults, and line-to-ground faults. Voltage and current sensors are used to continuously measure the electrical parameters of the underground cable. The measured analogue signals are then sent to signal conditioning circuits, comprising voltage divider circuits and low-pass filters, to remove noise and ensure stable measurements. The conditioned analogue signals are then sent to the Analogue-to-Digital Converter (ADC) of the microcontroller for digital signal processing.

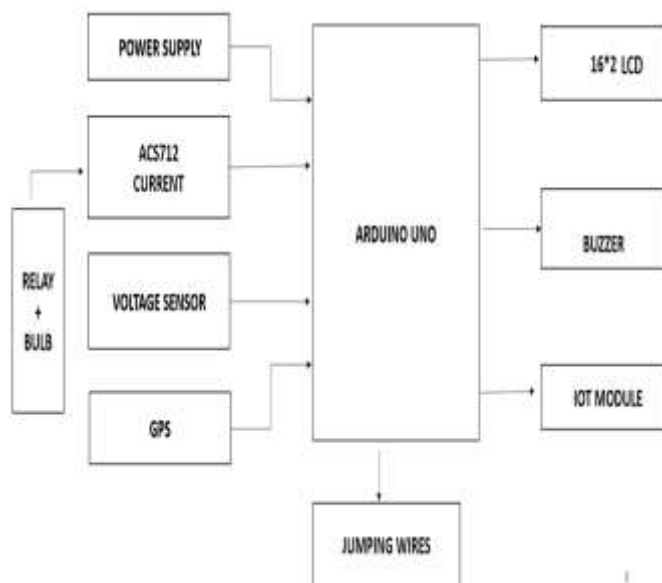
The fault detection system relies on impedance change and voltage drop analysis, which is derived from Ohm's Law. In normal working conditions, the voltage drop along the cable is uniform and directly proportional to the cable length. However, when a fault occurs, an impedance change is introduced, leading to irregular voltage and current changes. The microcontroller is programmed to continuously monitor the system and compare actual readings with predetermined threshold values. Depending on the deviation, the system identifies the nature of the fault. The distance to the point of fault is calculated based on proportional voltage, which is assumed to have equal resistance per unit length of the cable. The embedded software is programmed using Embedded C and has a modular structure that includes data acquisition, fault analysis, calculation, and communication modules. The system runs in continuous monitoring mode with periodic sampling.

For remote monitoring, the IoT communication module provides wireless connectivity via standard TCP/IP protocols. The data related to faults, including voltage, current, type of fault, and calculated distance, is sent to a cloud server for real-time visualisation and storage. The cloud platform supports data logging, historical analysis, and automatic alert generation for abnormal conditions. Alerts can be sent to the concerned maintenance personnel through web interfaces or mobile apps. The proposed system is tested experimentally for various simulated fault conditions to assess the accuracy of detection, location, and communication. Calibration processes are carried out to reduce errors and improve system stability. This approach ensures the development of An automated, scalable, and economical solution for underground cable fault monitoring in the context of contemporary power distribution systems.

Hardware Description

Components	Type	Ratings in DC
Arduino	Arduino uno	5V
IoT module	ESP8266	5V
Power supply	DC	5V
LCD	16x2 Display	5V
Relay	Singe-channel	5V
Sensor	Voltage sensor	Up to 25V

Block Diagram



Outputs:



Fig 1:- Fault Detected

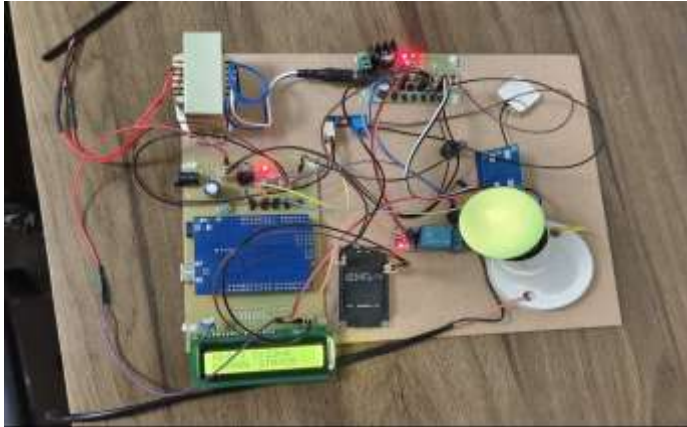


Fig 2: - Normal Status

4. CONCLUSIONS

The Underground Cable Fault Detection using an IoT system provides a sophisticated and feasible solution to one of the most prominent problems in power distribution networks, which is accurate and immediate fault detection. Because underground cables are buried beneath the earth's surface, it is difficult, time-consuming, and costly to identify faults in them using conventional techniques. The proposed system resolves this problem by employing real-time monitoring and automated fault detection through the use of sensors and a microcontroller-based processing unit. The inclusion of IoT technology in the system provides remote monitoring and immediate notification of fault conditions. Once a fault, such as a short circuit or open circuit, takes place, the system identifies the change in the electrical parameters, determines the location of the fault, and sends the data to a cloud platform. This greatly minimises the need for manual inspections, reduces downtime, and optimises maintenance activities. Additionally, the system is cost-effective, scalable, and adaptable for use in both urban and rural power distribution networks. The system optimises the overall reliability, security, and efficiency of underground cable networks. In the future, the model can be developed with more sophisticated fault analysis algorithms, machine learning algorithms, and smart grid infrastructure integration for improved accuracy and predictive maintenance capabilities. Thus, the proposed IoT-based underground cable fault detection system contributes to the development of intelligent, automated, and reliable power distribution systems.

REFERENCES

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- [3]. Pandey, Abishek. "Nicolas H. Younan, Underground cable fault detection and identification using Fourier analysis." 2010 IEEE Conference.
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