International Journal of Research in Engineering, Science and Management
Volume 5, Issue 6, June 2022
https://www.ijresm.com | ISSN (Online): 2581-5792

Cable Fault Detection Methods: A Review

Vijay Mane[1*], Prajakta Mansawale[2], Sakshi Yawale[3], Amberish Deshmukh[4]

[1]Associate Professor, Department of Electronics & Telecommunication Engineering, Vishwakarma Institute of Technology, Pune, India

[2,3,4]Department of Electronics & Telecommunication Engineering, Vishwakarma Institute of Technology, Pune, India

***Abstract*: In the growth of power system grids, underground cables are now commonly used. Because of some subsurface environments, wear and tear, and rodents, underground cables contain a more range of problems. For Detecting the source of a fault is challenging since the entire line must be dug to look for defects in the cable line. Repairmen know which parts have problems, and only that area needs to be dug up to find the source of the problem. It also saves time and money by allowing subterranean cable lines to be maintained more quickly. Electrical cables in rural places go underground rather than over the headlines. When a fault arises in an underground cable, pinpointing the exact site of the defect and repairing it might be difficult.**

***Keywords*: Fault, underground, detection, operator.**

1. Introduction

In this study, we looked at a fault localization approach for underground cables as well as the many types of cables that are employed in fault localization models. The goal of this work is to use a fault location model to pinpoint the exact site of a fault. Cables were meant to be placed above the head until the last decade, and there is now no subterranean cable that is higher than the old way. Storms, snow, severe rains, and pollutants have no effect on underground wires. However, it is difficult to discover a problem in underground cable when it happens in subsurface lines. Because the world has become more digitised, this model can now detect the exact location of a person.

2. Types of Fault Detection

A. Different types of faults occur in power lines and cables

- short circuit to another conductor in the cable,
- short circuit to earth,
- high resistance to earth and open circuit.

There are several other approaches for fault detection. But these are four methods that are getting prominently used for the fault detection

These are as listed below.

1. A frame
2. Thumper
3. Time Domain Reflectometer (TDR)
4. Bridge methods

1) A frame method

Current (DC) into the faulty cable and earth termination to detect a ground fault. As shown in Figure, the DC pulse will travel through the conductor and travel back to the ground stake via the earth from the earth fault site. The flow of pulsed DC via the ground results in a very small DC voltage. A sensitive voltmeter is used to measure the strength and direction of the DC voltage in different portions of the earth along the cable path. By examining the results of the voltage measurements made along the course, the location of the cable defect can be determined.

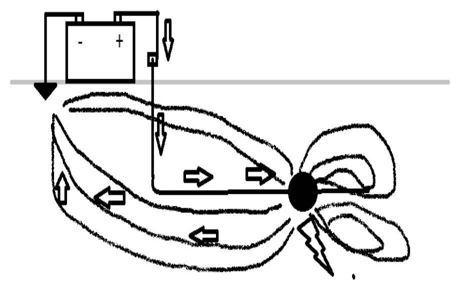


Fig. 1. Functional diagram of a frame method

A Frame is a dependable but not the fastest method because the operator must walk along the entire length of the line from the transmitter to the ground fault. This strategy might have an issue if the return DC discovers a quicker way to get back to the transmitter's earth stake than through the ground. Less current flows through the ground when it is sandy, paved, or both because of the high resistance. Defect detection is challenging in this circumstance because the voltmeter may occasionally be unable to detect the voltage.

2) Thumper method

With the help of a high-voltage surge generator called Thumper, a damaged underground wire creates a high-current arc that causes a loud noise that can be heard above ground. High current thump at voltage levels up to 25 kV is used to produce loud noise underground that may be heard from the surface. The thumper method, like A Frame, calls for an operator to move along the cable's course and listen for sound coming from above ground in order to find defects. It could be challenging to discern this sound due to various ground conditions, nearby traffic, and noises.

3) Time Domain Reflectometry (TDR) method

In the Time Domain Reflectometry (TDR) approach, a low-energy signal is passed down the cable, and the ideal cable with homogeneous characteristic impedance emits the signal in a

*Corresponding author: vijay.mane@vit.edu

specific time and with a specified profile. The timing and profile of the signal are changed whenever the cable's impedance changes as a result of a malfunction. Due to the impedance change, some of the signal is bounced back to the source. The reflected signal strengthens the original signal when characteristic impedance at the fault location increases, while it works against the original signal when characteristic impedance decreases. The distance to the fault in temporal units is graphically represented on the Time Domain Reflectometry (TDR) panel. It is possible to approximate the real distance by multiplying the time by the signal velocity. The basic block diagram of a TDR is displayed in Figure 2. As a result, it is possible to integrate the low voltage TDR and thumper techniques into a single system that records and stores a low voltage TDR pulse of the cable being tested in a display memory. The damaged area can then be heated up using the thumper by sending a high-voltage pulse there. While the arc is burning at the troublesome area, the TDR is used to send the same low voltage pulse; the new pulse will be overlapped on the original trace. Due of the arc's low impedance, the TDR pulse reflects there like a short circuit.

Figure shows a sample test that stacks two signal traces on top of one another. The illustration's dashed cursor denotes the launch point, whereas the solid cursor stands in for the defective point. These two cursors allow the system to calculate the fault's distance directly. TDR and a thumper combination reduce serious cable insulation damage, although the risk is still present. Open circuit faults can be found using the TDR method. The issue will be similar to that of a high-resistance earth fault if the fault has a low series resistance.

4) Bridge method

Bridge approaches for locating faults in subterranean cables use a modified Wheatstone circuit, in which direct current is used to measure resistance and the distance of the fault is calculated as a percentage of the entire line length. For estimating the distance to the fault, Murray and Glaser bridges employ a similar technique. The following is a brief summary of these bridges. Wheatstone bridge circuit (Figure 3).

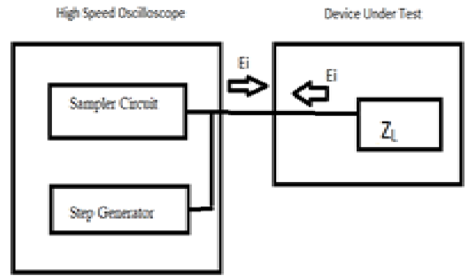


Fig. 2. Functional block diagram of TDR

The Wheatstone bridge circuit is shown in Figure 3, where R1, R2, R3 are known resistors whereas Rx is an unknown resistance. When the galvanometer displays no current flow, the unknown resistor Rx value can be calculated from the other known resistor value using the equation below.

$$Rx = \frac{R2+R3}{R1}$$

$$R1 = \frac{R \times R3}{R3+R4}$$

$$R2 = \frac{R \times R4}{R3+R4}$$

$$R1 + R2 = R$$

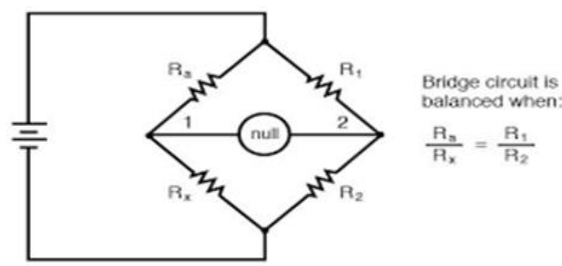


Fig. 3. Wheatstone bridge circuit

Table 1

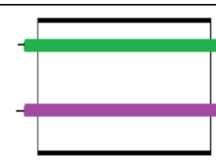
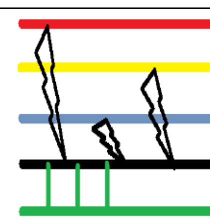
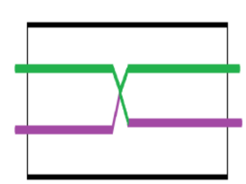
Open circuit	The capacitance of two wires is measured to detect an open circuit, and cable capacitance varies with wire length. When two cables are open, the capacitance is reduced, and a failure develops.	
Earth Fault	When any conductor makes contact with the ground, an earth fault occurs. It happens when the conductor's outer sheath is destroyed by chemical reactions with the soil, vibrations, or mechanical crystallization, and it's the same as a short circuit.	
Short Circuit	The resistance between two cables is measured to detect a short circuit. And the resistance value indicates the exact position of the defect.	

Figure depicts a Murray bridge loop for locating cable faults. A healthy conductor must be attached to terminal T1 in the measuring circuit in addition to the problematic conductor. The resistance of the external loop wires in the circuit linking the resistances at the front and the conductors at the cable end should be near zero. For the balance condition of the galvanometer in the Murray Bridge loop. The conductor resistances to the fault location are calculated using the formulae below.

$$Lx = \frac{\alpha}{100} \times L0$$

3. Faults in Underground Cables: Types and Detection

- Open circuit fault.
- Earth Faults.
- Short circuit fault.

4. Other Methods of Fault Detection

1) Identification of underground cable fault location and development

Two approaches for pinpointing the exact position of underground cable faults from the base station are presented in this paper. Ohm's law is one technique, and the Murray loop method is another. The Murray approach employs the wheatstone bridge to locate the malfunction at the base station and communicates the information to the operator's mobile phone. When using the ohm's law method, when a fault develops, the voltage drop varies depending on cable length, and the current varies accordingly. These approaches can use a voltage converter, microcontroller, and potentiometer to find the location.[1]

2) Automatic underground cable fault locator using GSM

This paper proposed a system that can detect not only short circuit faults, but also low voltage and high voltage faults. The proposed system is based on the law of ohms. This method locates the fault and provides the information to the operator via GSM; the benefit of this system is that it cuts the power supply to the faulted region for safety reasons. The sort of fault that was discovered is also displayed on the LCD display, and a buzzer will sound to inform the operator.[2]

3) IoT based diagnosing of fault detection in power line transmission using GOOGLE firebase database

This paper proposed a methodology for detecting transmission line shortfalls when the node MCU is connected to the transformer. If the node MCU receives power, the following signal will be sent to the Google Firebase database; this is based on the number transformer and its related node MCU. If all of the signals go to the Google Firebase database, the transmission line is in good condition; if the data does not travel through the database, the data with the problem will be delivered to a page via an IoT gadget called a node MCU. [3]

4) IoT based fault detection of underground cables via Node MCU module

This article presented an IoT-based system for detecting underground cable faults in kilometres from the base station. Arduino, microcontroller, LCD, RF transmitter and receiver, and voltage sensors make up this system. The voltage will be changed if a fault occurs, and this will be applied to the programmed Arduino, which will display the fault in the distance. The fault distance, phase, and time will be displayed on the LCD, which is connected to the microcontroller. The internet of things (IoT) is used to show information on a computer. [4]

5) Identification and classification of faults in underground cables

This paper includes fault detection using thermal imaging. Infrared cameras can be used to detect subterranean cable defects, and CCD cameras, or charge coupled devices, can be utilized to capture the surrounding problematic components. Also. As an automated decision support system for the categorization of defective and non-faulty conductors, a model constructed using Convolutional Neural Networks (CNN) with LetNet architecture is used. [5]

6) Underground cable fault detection

This paper proposes utilizing the Raspberry Pi and the Internet of Things to locate underground cable faults. For discovering cable defects, they employed CT Theory, or Current Transformer Theory. They also employed a microcontroller to calculate the distance between base station and faults, which was then displayed via IoT devices. If a cable short circuit occurs, the voltage drop will vary depending on the length of the cable; also, current varies, so the current transformer will calculate the varying current and the signal conditioner will manipulate the change in voltage. These details will be sent to the access point and displayed on IoT devices.[6]

7) Underground cable fault detector

This paper proposed an Arduino-based system that will discover the fault between the phases and the distance from the bottom station of the fault in kilometres for all three RYB phases. To create faults, they employed fault switches and resistors to identify the cable location. The underground fault will be presented on an LCD display that is connected to the Arduino. This technology can identify problems up to 5 kilometres away. [7]

5. Conclusion

This paper presented a survey on various methods for the detection of faults in cable.

References

[1] M. R. Hans, S. C. Kor and A. S. Patil, "Identification of underground cable fault location and development," 2017 International Conference on Data Management, Analytics and Innovation (ICDMAI), 2017, pp. 5-8.

[2] Thomas, Summi & A.Vimenthani, & Kaleeswari,. (2017). Automatic underground cable fault locator using GSM. International Journal of Advanced Research Trends in Engineering and Technology, vol. 4. 260-265.

[3] 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), 2020, pp. 415-420.

[4] 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), 2020, pp. 1-6.

[5] R. Rengaraj, G. R. Venkatakrishnan, S. Shalini, R. Subitsha, S. Suganthi and S Sushmita Carolyn, “Identification and classification of faults in underground cables – A review,” IOP Conference Series: Materials Science and Engineering, Volume 1166, International Conference on Materials Science and Manufacturing Technology (ICMSMT 2021), Coimbatore, India R Rengaraj et al 2021 IOP Conf. Ser.: Mater. Sci. Eng. 1166 012018, 8th-9th April 2021.

[6] Roshani Shingrut, Shubham Shelar, Dakshata Mokal, Shekar Mhatre, Sharvari Sane, 2020, Underground Cable Fault Detection, International Journal of Engineering Research & Technology, vol. 9, no. 2, February 2020.

[7] Jignesh Patel, Shubham Pawar, Pratik Sutar, Smitesh Gaychor, “Underground Cable Fault Detector,” International Journal of Engineering Research & Technology, vol. 10, no. 9, September 2021.

[8] T. N. Aminu, N. A. Algeelani, S. A. Algailani and A. Ahmed Salem, "Arduino based Underground Cable Fault Distance Locator: Hardware Design," 2021 2nd International Conference on Smart Computing and Electronic Enterprise (ICSCEE), 2021, pp. 265-269.

[9] R. M. Asif, S. R. Hassan, A. U. Rehman, A. U. Rehman, B. Masood and Z. A. Sher, "Smart Underground Wireless Cable Fault Detection and Monitoring System," 2020 International Conference on Engineering and Emerging Technologies (ICEET), 2020, pp. 1-5.

[10] Shingrut, Roshani & Shelar, Shubham & Mokal, Shekar & Sane, (2020). Underground Cable Fault Detection. International Journal of Engineering Research.

[11] G. R. Mirza, A. K. Maheshwari, M. A. Mahar, A. S. Larik and G. H. Talpur, "Design and fabrication of underground fault distance locator using Arduino and GSM," 2017 International Conference on Open-Source Systems & Technologies (ICOSST), 2017, pp. 30-34.