

Automatic Cable Fault Distance Locator using Arduino

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Abstract: *This paper presents the method of design of a cable fault location sensor for underground cable fault detection. The aim was to detect the fault location from transmitting or receiving station up to few meters accuracy using an Arduino based kit. The underground cable-based supply system is a common practice in urban areas. As explained in the paper, the system uses the principle of a Varley loop to determine the exact distance of the fault in the underground cable up to the accuracy of a meter. When any fault, e.g. short circuit and earth fault occurs, the length of the fault of the cable can be determined from the fault resistance using the bridge in the Varley loop. A microcontroller is used to make the necessary calculations and display the fault distance after that. After necessary calibration and testing, an accuracy of about 85% is achieved in locating the fault using the method.*

Keywords: Arduino; ADC; Varley loop; Underground Cable Fault.

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1. Introduction

For the low voltage and medium voltage distribution lines, underground cables have been used for many decades worldwide. To reduce the effects of distribution networks on the environment, underground high voltage cables are used more and more now. Underground cables have been widely used in power distribution networks due to the advantages of underground connection, involving more security than overhead lines in bad weather, less liable to damage by storms or lightning. It is less expensive for a shorter distance, eco-friendly and required less maintenance [1].

But, if any fault occurs in an underground cable, then it is difficult to locate the fault. Therefore, this paper explains one such method developed to detect the location of a fault in a digital way. There is a great requirement of locating the fault point in an underground cable in order to facilitate quicker repair, improvement of the system reliability and reduced outage period [2].

From the works of literature reviewed, it is seen that different designs are proposed by different authors for using various methods to locate the faults in underground cables. Variety of methods such as the techniques using Megger, Optical sensing, Electromagnetic Field and Varley

loop sensing are being used for fault detection and pinpointing. The accuracy levels and complexity of the set-up used vary along with the cost of the equipment in various such methods. The earliest techniques recorded in pieces of the literature suggest the use of Megger based techniques for the purpose of locating the fault. The use of optical and electromagnetic methods is relatively new, mainly developed during the last decade [3, 4].

The automatic underground fault locator systems have a higher level of acceptance as compared to manual ones [5]. The automatic fault locator has perceived benefits of protection against any underground faults, i.e., short circuit and open circuit faults. The present system, as described in subsequent sections, is therefore designed to give the exact distance reading from the feeder end to where the fault occurs in underground cable automatically. In addition, it can be taken to any location for operation, whenever the fault occurs and is basically made to serve for the need for a simple and cheap cable fault locator.

2. Theoretical Background

In the present work, the Varley loop based testing method is used for locating short-circuit and earth faults in underground cables. This test employs the principle of the Wheatstone bridge [8].

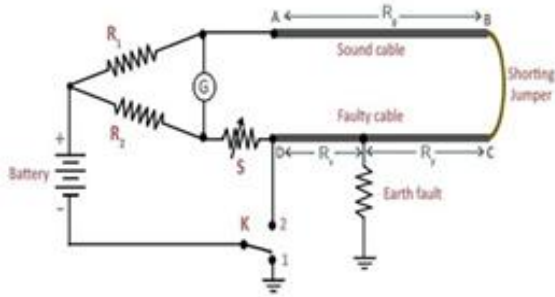


Figure 1: Varley loop method for earthed fault

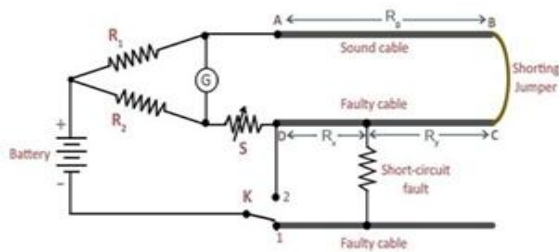


Figure 2: Varley loop method for short circuit fault

To locate fault using the Varley loop, connections are made as shown in the circuit diagram of Figure 1 and Fig. 2. Resistors R_1 and R_2 are fixed, and the resistor S is variable. A stepper motor is to be used to vary the resistance to bring the bridge to a balanced condition. The balanced resistance value will be given to the microcontroller for applying that value to the program to be developed. The program will automatically calculate the distance of fault, based on the algorithm to be developed during the project.

3. System Designs

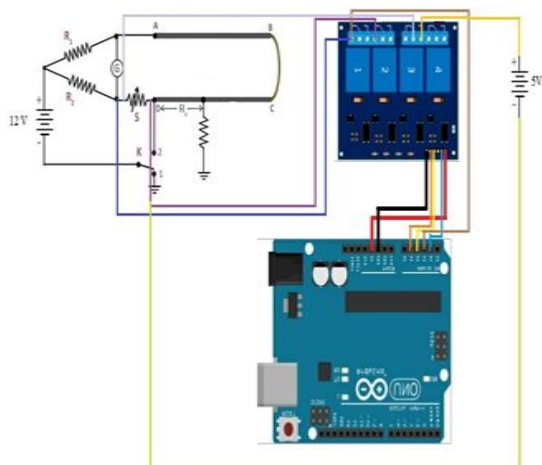


Figure 3: Circuit diagram of automatic cable fault distance locator

The fault detector system is designed to utilize the bridge balance technique. In this test, the switch K is first thrown to position 1. Then the variable resistor S is varied until the galvanometer shows zero value (i.e., the bridge is balanced).

Let us say; the bridge is balanced for the value of S equal to S_1 . Then,

$$\frac{R_1}{R_2} = \frac{R_g + R_y}{R_x + S_1}$$

Let, $R_g + R_y = R_3$

$$\frac{R_1 + R_2}{R_2} = \frac{R_3 + R_x + S_1}{R_x + S_1}$$

$$R_x + S_1 = \frac{R_2(R_3 + R_x + S_1)}{R_1 + R_2}$$

$$R_x = \frac{R_2(R_3 + R_x) - R_1 S_1}{R_1 + R_2} \dots \dots \dots \text{eq. (i)}$$

Now, the switch K is thrown to the position 2, and the bridge is balanced by varying the resistor S . Say, the bridge is balanced at the value of resistor S is equal to S_2 . Then,

$$\frac{R_1}{R_2} = \frac{R_3 + R_x}{S_2}$$

$$R_1 S_2 = R_2 (R_3 + R_x) \dots \dots \dots \text{eq. (ii)}$$

Now, putting the result of eq.(ii) in eq.(i),

$$R_x = \frac{R_1 (S_2 - S_1)}{R_1 + R_2}$$

Since the values of R_1 , R_2 , S_1 and S_2 are known, R_x can be calculated. When R_x is known, the distance from the test end to the fault point L_x can be calculated as,

$$L_x = R_x / r$$

Where, r = resistance of the cable per meter.

Now, when the bridge is in a balanced condition, the relay module consisting of 3 relays will be interfacing with the Varley loop circuit. The relay 1 and relay 2, which is connected between the two ends of the terminal of variable resistor S , trip when the galvanometer reads zero value. Therefore,

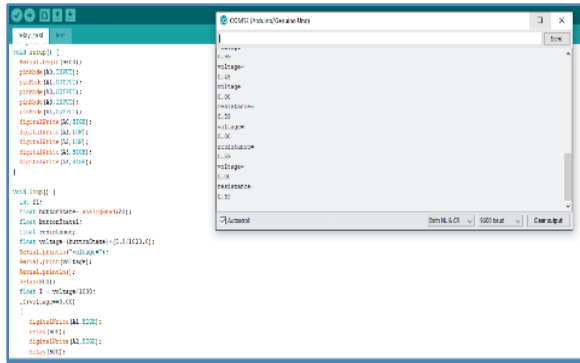


Figure 6: Output result during a balanced condition

During the testing of the project, it was found that if the unknown resistance value is very small, then it is difficult to bring the bridge to the balanced condition. The bridge is very sensitive, and the voltage deflects randomly if the unknown resistance is very small. But, through much continuous trial, the voltage could be made stable, by choosing proper ratings of standard arm resistances. After that, the bridge could be interfaced with the Arduino for making the system automatic.

The relay module is interfaced with the microcontroller, and when the voltage across the galvanometer is higher than zero value, the relays do not trip. But, as soon as the Arduino reads zero value, it automatically sends signals for tripping the relays.

5. Conclusion

In the present project, it was intended to study the process of detection of the exact location of circuit fault in the underground cables from the feeder end in few meters by using an Arduino microcontroller. The Arduino microcontroller is used to detect the changes in the output voltage of the bridge circuit. As soon as a fault occurs in the cable, the bridge is balanced at some other resistance than the normal condition. That resistance is then used to produce the voltage across the analog input ports of the microcontroller, and thus the fault location is determined using an algorithm.

The project using the Varley loop test is expected to detect the fault by detecting the resistance, which in turns can be translated into distance using an algorithm. Then the microcontroller is used to display the fault distance from the source end in the LCD display.

References

[1] G. Cheung, Y. Tian and T. Neier, “Technics of locating underground cable faults inside conduits”, *Proc. of 2016 International*

Conference on Condition Monitoring and Diagnosis (CMD), pp. 619-622. IEEE, Xi’an, China, 25-28 Sept. 2016. Doi: 10.1109/CMD.2016.7757954

[2] K. Padmanaban, G. S. Sharon, N. Sudharini and K. Vishnuvarthini, “Detection of Underground Cable Fault Using Arduino”, *International Research Journal of Engineering and Technology (IRJET)*, Vol. 4, Issue 3, March 2017, pp. 2451-2454. Retrieved from http://www.academia.edu/33479505/Detection_of_Underground_cable_fault_using_Arduino

[3] A. Jagtap, J. Patil, B. Patil, D. Patil, A. A. H. Ansari and A. Barhate, “Arduino based Underground Cable Fault Detector”, *International Journal for Research in Engineering Application & Management (IJREAM)*, Vol. 3, Issue 4, May 2017, pp. 88-92. Retrieved from http://www.academia.edu/33635671/Arduino_based_Underground_Cable_Fault_Detection

[4] G. Ojha, A. G. Roy, R. Verma and V. Kumar, “Underground Cable Fault Distance Locator”, *International Journal of Advance Research, Ideas and Innovations in Technology (IJARIIT)*, Vol. 3, Issue 2, March 2017, pp. 550-552. Retrieved from <https://www.ijariit.com/manuscripts/v3i2/V3I2-1364.pdf>

[5] T. Nandini, J. Shalini, T. S. Sangeetha and D. Gnanaprakasam, “Underground Cable Fault Detection using Arduino”, *International Journal of Engineering Science and Computing (IJESC)*, Vol. 7, Issue 4, April 2017, pp. 6460-6462. Retrieved from <http://ijesc.org/upload/47eea5901e73e8ae6aca4d6319d89128.Underground%20Cable%20Fault%20Detection%20using%20Arduino.pdf>

[6] N. Sampathraja, L. A. Kumar, V. Kirubalakshmi, C. Muthumaniyarasi and K. V. Murthy, “IOT Based Underground Cable Fault Detector”, *International Journal of Mechanical Engineering and Technology*, Vol. 8, Issue 8, August 2018, pp. 1299-1309. Retrieved from https://iaeme.com/MasterAdmin/uploadfolder/IJMET_08_08_132/IJMET_08_08_132.pdf

- [7] T. Kedia, A. Lal and A. Verma, "IoT Technology Based Underground Cable Fault Distance Detection System Using ATmega328P Microcontroller", *International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET)*, Vol. 7, Issue 3, March 2018, pp. 3008-3018. Retrieved from https://www.ijirset.com/upload/2018/march/8_2_IoT.pdf
- [8] S. Sahana, B. M. Harish, S. M. Annu, H. V. Vani, T. Sudha and H. K. P. Kumar, "Analysis of Fault Detection and Its Location Using Microcontroller For Underground Cables", *International Research Journal of Engineering and Technology (IRJET)*, Vol. 4, Issue 6, June 2018, pp. 1873-1878. Retrieved from <https://www.irjet.net/archives/V4/i6/IRJET-V4I6358.pdf>
- [9] J. Althaf, M. Imthiaz and R. Raj, "Underground Cable Fault Detection Using Robot", *International Journal of Electrical and Computer Engineering (IJECE)*, Vol. 3, Issue 2, April 2013, pp. 145-151. Retrieved from <https://www.iaescore.com/journals/index.php/IJECE/article/viewFile/5469/5008>
- [10] T. A. Kawady, A. M. I. Taalab and M. El-Sad, "An Accurate Fault Locator for Underground Distribution Networks Using Modified Apparent-Impedance Calculation", *10th IET International Conference on Developments in Power System Protection (DPSP 2010) - Managing the Change*, Manchester, UK, 29 March-1 April, 2010. Doi: <https://doi.org/10.1049/cp.2010.0302>
- [11] D. Dharani. A and Sowmya. T, "Development of a Prototype Underground Cable Fault Detector", *International Journal of Electrical, Electronics and Computer System (IJECS)*, Vol. 2, Issue 7, 2014, pp. 17-21. Retrieved from http://www.irdindia.in/journal_ijeecs/pdf/vol2_iss7/4.pdf
- [12] T. Kedia, V. Sahare, K. K. Bauri, R. K. Sahu, S. Kumar and A. Lal, "Underground Cable Fault Distance Detector Using ATmega328 Microcontroller", *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)*, Vol. 6, Issue 10, October 2017, pp. 8018-8026. Retrieved from

http://www.ijareeie.com/upload/2017/october/19_3_Final%20Research%20Report.pdf

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