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Underground Cable Fault Detection System

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Abstract—*Power cables that are used to deliver electrical power are placed underground in order to avoid unnecessary interference. This makes it very difficult to determine the exact location of the faults that occur. A fault might occur due to a multitude of reasons such as digging, earthquake, construction work, etc. The repairing process related to that particular cable is difficult due to unknown location of the fault in the cable. In this paper we intend to demonstrate the working of a self-made hardware model illustrating the detection of faults in underground power cables using Ohm's law. The potential drop is measured across regular intervals of the cable. As soon as the fault occurs, the potential drop (voltage) across each interval varies in accordance with the Ohm's law. Arduino-Uno micro-controller (IC AT Mega 328P) has been used in the hardware model.*

1. INTRODUCTION

Power cables that are used to deliver electrical power are placed underground in order to avoid unnecessary interference. This makes it very difficult to determine the exact location of the faults that occur. The objective of this paper is to demonstrate a self-made hardware model that determines the distance of the cable fault from the base station in kilometers and display it over the internet. Underground power cable system is a common practice followed in major urban areas.

A fault might occur due to a multitude of reasons such as digging, earthquake, construction work, etc. The repairing process related to that particular cable is difficult due to unknown location of the fault in the cable.

This impediment is tackled with the help of optical fibre system. A bunch of optical fibres is placed along with the power cables. The optical fibre system constantly measures various parameters (such as voltage, current and temperature of the cable) at multiple checkpoints located at regular intervals on the power cable. As soon as a fault occurs, the values of the parameters of the surrounding checkpoints change "abnormally". The data corresponding to the particular location of the checkpoints surrounding the fault is obtained. Hence the approximate distance of the cable fault is located using this method. After the approximate location has been identified, high voltage pulses are transmitted over the faulty cable to determine the exact location of the fault.

In our model we intend to demonstrate the methodology employed to find out the exact location of the fault and to send data in graphical format to a dedicated website together with on board LCD display using a GSM module.

Instead of using optical fibres, the model uses the standard theory of Ohms law, i.e., when a low DC voltage is applied at the feeder end through a series resistor (cable lines), then the current would vary depending upon the location of the fault in the cable as the resistance is proportional to the distance. Hence the potential drop would also vary across each resistor. These potential drop variations are used to determine the location of the fault.

2. RELATED WORK

An extensive fault location model for underground power cable in distribution system using voltage and current measurements at the sending-end has already been proposed in a paper published in November 2008. The paper presents an analysis of an equivalent circuit that models a faulted underground cable system using distributed parameter approach. Analysis of sequence networks in three-phase network by applying the boundary conditions is also presented. Using the analysis, the location of the fault is determined with the help of current and voltage equations. Further analysis of extension to multi-section is also presented along with case studies of variations with fault distance and resistance, which also includes evaluation of its robustness to load uncertainty [1]. Another paper, published in February 1997, explains how injecting a series of chirped pulse streams into the faulted cable, shortly after the occurrence of the cable fault using a pulse generator unit can be used for an accurate calculation of the location of the cable fault. It has been termed as 'fault distance locator'. The delay times between the reflected pulses and sent pulses by a correlation process which is specially designed to eliminate noise effects caused due to arcing voltage is observed. The delay times thus obtained are used to provide an accurate calculation of the fault distance. By injecting pre-fault signals, or, 'reference pulse signals' periodically into the cable before the occurrence of the fault, accuracy is further increased. Information regarding the speed of propagation of cable is provided by this pulse signal [2]. Another paper, published in August 2000, proposed a better approach to cable-fault location system, essentially consisting of synchronized sampling technique, wavelet analysis and travelling wave principle. Along with the introduction to three major techniques and an outline of the new scheme, this paper presents a detailed wavelet analysis of faulty transient waveforms and hence determines the best wavelet levels for this particular application. Then, Alternative Transient Program (ATP) is used to simulate an underground cable system under various fault conditions in order to fully evaluate the approach. Numerical results with error less than 2% of the length of cable have been obtained showing that this is a reliable scheme [3]. A paper, published in January 2007, presented a wavelet-based fault-location scheme for aged cable systems when synchronized digital fault recorded data are available at the two terminals of the cable. The wavelet singularity detection theory is used as a powerful signal processing tool to estimate the location of the fault in multiend-aged cable systems. Arrival of the first and second voltage travelling waves can be identified at both the ends of the power cable. The wavelet processing scheme is applied on the modal co-ordinates instead of the phase co-ordinates. The proposed scheme can also be used to remove the effect of change in propagation velocity of travelling wave on the cable fault location calculations. This can also be used to solve the problem associated with changing parameters of the cable with age, such as relative permittivity. Alternate Transients Program for extensive simulation studies to analyze the characteristics of the proposed cable fault location scheme. The results show an accepted degree of accuracy [4].

3. WORK DONE

Regular conducting wire along with resistors is used to represent the power cable. Four switches and the resistors have been inserted at regular intervals on the wire. These switches are used to create faults. Power supply of +5V is provided from one end of the cable and an LED is attached to the other as shown in Fig. 1.

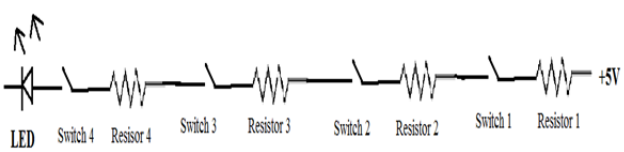

Fig. 1: Schematic of the conducting wire

Initially, all the switches are closed and the LED is ‘ON’. Potential drop across each resistor is measured. As soon as a fault is created by opening a switch, potential across resistors succeeding the opened switch becomes 0 and potential across resistors preceding the opened switch becomes +5V. The LED turns ‘OFF’.

The potential across each resistor is fed to a micro-controller. In the near future, we intend to interface an LCD with micro-controller displaying the potential values across each resistor and also interface a GSM module in order to constantly upload the same values to a dedicated server. The practical implementation of the circuit is shown in the Fig. 2.

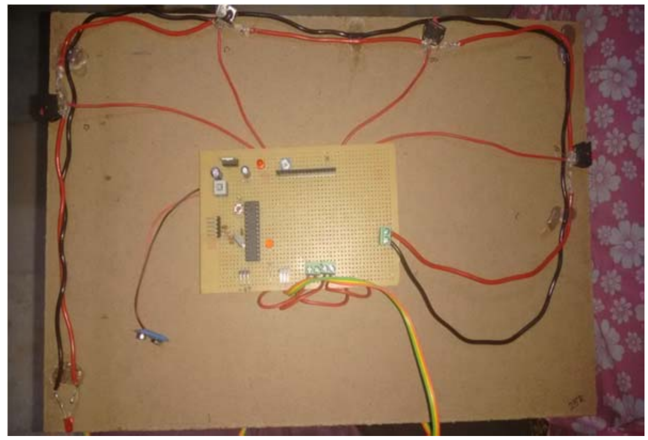

Fig. 2: Practical implementation of the circuit

4. OBSERVATIONS

The value of voltage across each resistor is given in table 1.

Table 1: Resistances and their corresponding voltages

RESISTANCE	VOLTAGE
R1	4.4 V
R2	3.9 V
R3	3.3 V
R4	2.0 V

5. FUTURE WORK

Along with potential, temperature will also be measured across each resistor. The LCD will be interfaced with the micro-controller and the values of the potential and temperature across each resistor will be displayed on the LCD screen. The schematic is shown in the Fig. 3.

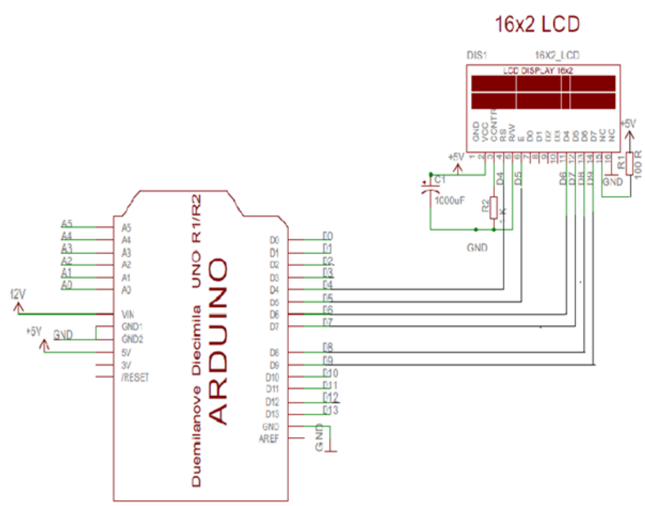

Fig. 3: Schematic of the LCD interfaced with micro-controller

A GSM module will also be interfaced with the micro-controller. The GSM module will upload the values of the potential and temperature across each resistor to a dedicated website. The micro-controller used is Arduino-Uno (IC ATMega 328P).

6. CONCLUSION

A self-made hardware model illustrating the concept of underground cable fault detection system has been demonstrated. After the interfacing of LCD and GSM module, we will be able to constantly monitor the potential and temperature across each resistor through the dedicated website. As soon as a fault is created, the corresponding changed values of potential and temperature will be updated on the website.

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