Estimation of Open & Short Circuit Fault Distances in the Underground Cable using Arduino & GSM Module

[1]S. Madhavi, [2]D. Durga Bhavani, [3]Ch. Harika, [4]B. Vineela, [5]P.V.S. Sruthi Mrunalini
[1,2,3,4,5]Dept. of Electronics and Communication Engg., BVRIT Hyderabad College of Engg. for Women, Hyderabad, Telangana, India

Abstract
Cables are playing a major role in the transmission of either power or information. Initially the transmission was carried with overhead cables which were threaded in the air. With the increase in population and environmental constraints such as snow, storms, heavy rain falls, etc., the performance of the overhead cables has been greatly affected. These problems have been eliminated by using underground cables. However the problem with the underground cables is that once a fault occurs it is very difficult to identify the exact location of the fault as they are buried underground. The primary aim of our paper is to design a circuit that helps to identify the open and short-circuit faults in the underground cables using Arduino and also find the distance of the these faults accurately from the base station. In addition to this GSM module has been implemented by which the information can be sent to the concerned person in the form of a text message specifying the exact type of the fault as well as its location from the base station.

Keywords
Fault, Short Circuit, Open Circuit, Arduino, GSM

I. Introduction.

Cable is a group of an insulated wire having a protective casing and is used for transmitting power or communication signals. Basically, cables are of two types. They are overhead cables and underground cables. An overhead cable is one which is used for the transmission of information, lain on utility poles. The main advantage of overhead cables is that when a fault occurs, it is easy to identify the fault but the disadvantage in these cables is that it easily gets affected due to the environmental factors such as snow, storms, heavy rain falls, etc.,[3] Underground cables are designed to avoid the disadvantage caused in overhead cables. But once the fault occurs in an underground cable, identification and repairing of those faults is difficult and also time taking as they are buried underground. In spite of the disadvantages the usage of underground cable system for transmission of power and communication signals in large cities are widely increasing because of its own advantages and efficiency [6].
Generally one comes across different types of faults such as short-circuit, open circuit and earth faults in the underground cables , and the process of fault tracking without knowing the location related to that particular cable is very difficult.

A .Short Circuit Fault

Short circuit fault [8] occurs when any two conductors with insulation failure [2] in a cable come in contact. In this situation, the current instead of flowing through the main cable it flows from one cable to another cable.

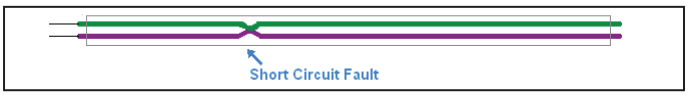

Fig. 1: Short Circuit Fault

B. Open Circuit Fault

Open circuit fault [8] occurs when there is a break in a conductor. In this situation, the current stops flowing through the conductor [1].

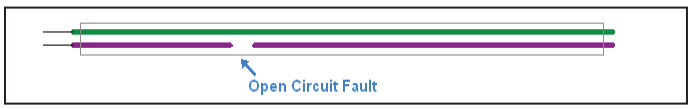

Fig. 2: Open Circuit Fault

C. Earth Faults

Earth fault occurs when the cable insulation gets damaged. In this case all the conductors in the cable come in contact with the earth and due to this the current do not flow through the load [9].

Until now, many have implemented circuits for identifying short-circuit faults and earth faults. In this paper, we have extended the circuit for identifying open circuit fault along with short-circuits faults. In order to get on with the digitization that is happening in the world currently, the location of the fault has been shown digitally using the GSM technology.

II. Methodology and Implementation

The methodology used in this work is represented in the form of blocks as shown below in fig. 3 and has been implemented using the Proteus Software.

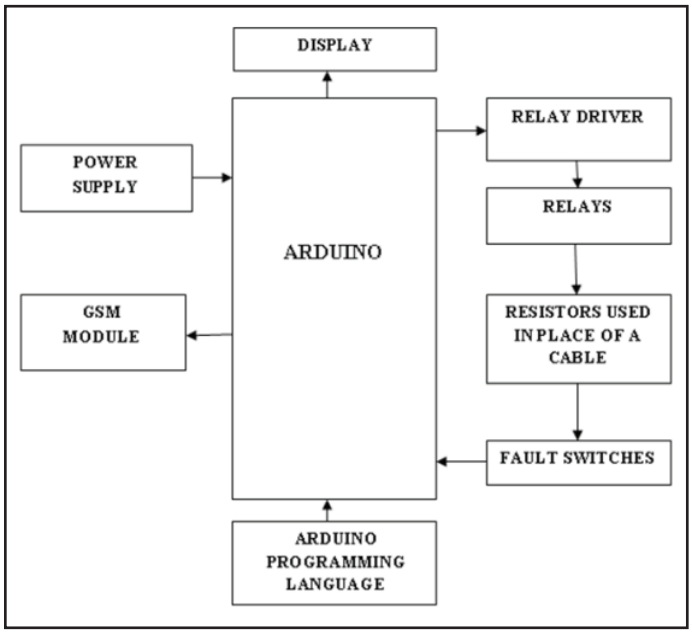

Fig. 3: Block Diagram

The Arduino plays a major role in the transmission of the information to the relay driver and then to the respective relays. The relays try to identify the fault location with the help of switches and that information is fed back to the Arduino board. This information will be sent to LCD display as well as the GSM

module thus displaying the required information.
As Arduino is highly compatible with the C programming language, the programming has been carried out using the basic C++ language. The compiled code is dumped into the Arduino board present in the Proteus software to run the project.
The Proteus Design Suite is a windows application and is an Electronic Design Automation (EDA) tool that includes schematic capture, simulation and PCB Layout modules. This is be used as testing environment to check the performance of the circuit .Once tested successfully and found everything is fine it can be implemented with the hardware. Simulation of the circuit starts after clicking on the run button present at the bottom of the Proteus window.

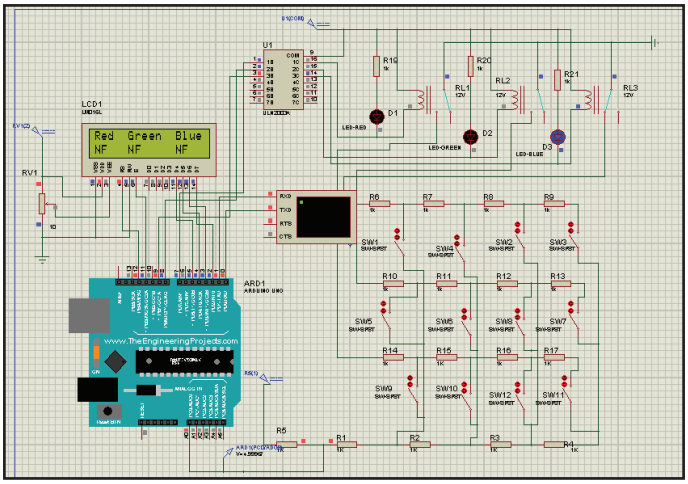

Fig. 4: Schematic View in Proteus

Fig. 4 is the schematic view of the work simulated in Proteus. The voltage that is required in order to make the circuit work is 12V. The work has been carried out assuming a 3 core cable i.e. one that comes with 3 conductors and the 3 conductors are indicated as red, green and blue. Generally the resistance of a faultless cable will be different from a fault cable. Keeping this in view resistors were used in the place of a cable and some switches were taken to create faults [4]. When a fault occurs the resistance of the cable changes and with the principle of voltage divider rule, distance can be calculated. Hence four resistors have been considered for each conductor and each resistor represents a distance of 2km and the maximum distance is 8km. If a fault is created, using the voltage divider principle the switch divides the voltage at that particular location and sends it to the microcontroller atmega8, which is an integral part of the Arduino board. Code has been written to detect this voltage that comes in the form of analog signal. The ADC which is inbuilt in the Arduino board converts the analog value to digital, and finally gives the distance value in the digital form and displayed on the LCD [5].
The connection between the conductors and the Arduino has been carried through the help of relay drivers and relay driver are connected to the three relays that are red, green and blue. Once operated relays are continuously scanned [7] and each relay scans its respective colored conductor. If there is no fault in any of the three conductors it displays as "NF" i.e. No Fault. If a fault is created at green conductor at 4kms, it displays in the LCD that there is an open circuit fault in the green conductor at 4kms. If a fault is created at the same location in two different conductors then it displays that short-circuit fault has been occurred between those two conductors at that particular location. Same message will be sent as a text message by using GSM technology.

III. Results

Different outputs have been considered for the testing of the output results. A few of them are as shown below:

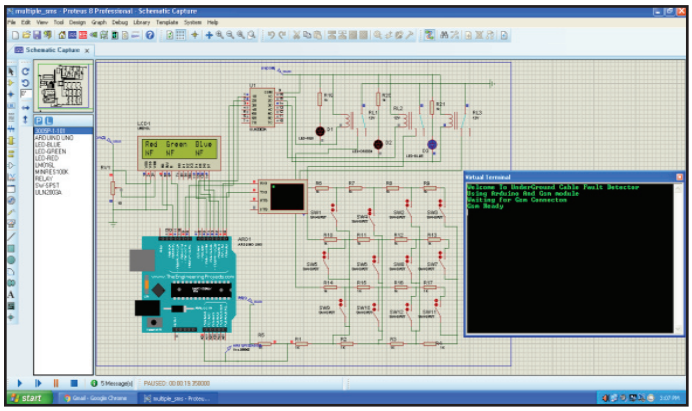

Fig. 5: Screen Indicating NF Condition

This is the initial screen which will be available when there are no faults. As there are no faults, in the LCD display module under each category there will be a "NF" displayed which indicates that there is no fault in the cable.

A. Open Circuit Fault

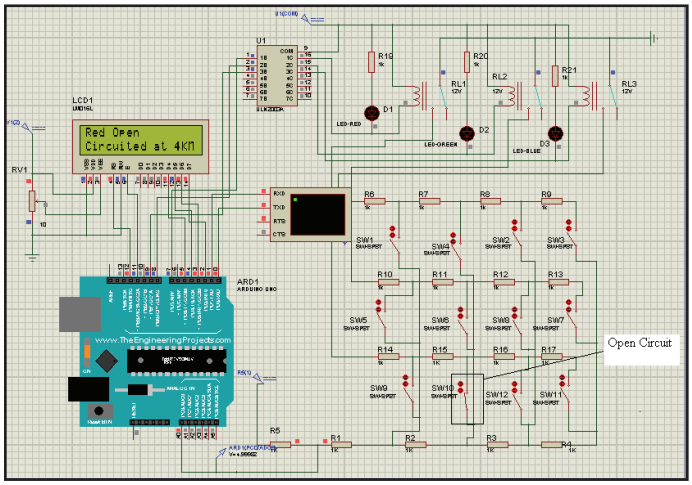

Fig. 6: Screen Indicating Open Circuit Fault

Fig. 6 indicates that there is fault in one of the conductors. It is clearly observed that there is a misalignment near one of the resistors in the first line. And this line is considered as red line. As there is no other misplacement in any of the other lines this is considered as an Open fault as it is freely hanging. Hence on the LCD display screen the message will be displayed as "Red Open Circuited at 4km" from the base station.

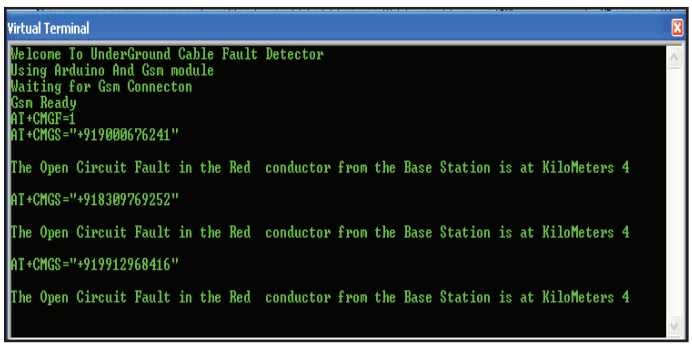

Fig. 7: GSM Screen Indicating for Open Circuit Fault

The Fig. 7 above is the output which is obtained in the GSM module when there is a fault in the conductor of a cable as described in the previous case. The message "The Open Circuit Fault in the Red conductor from the Base Station is at 4 kilometers", will be sent as a text message to the concerned persons mobile.

B. Open Circuit Faults at 2 Different Locations

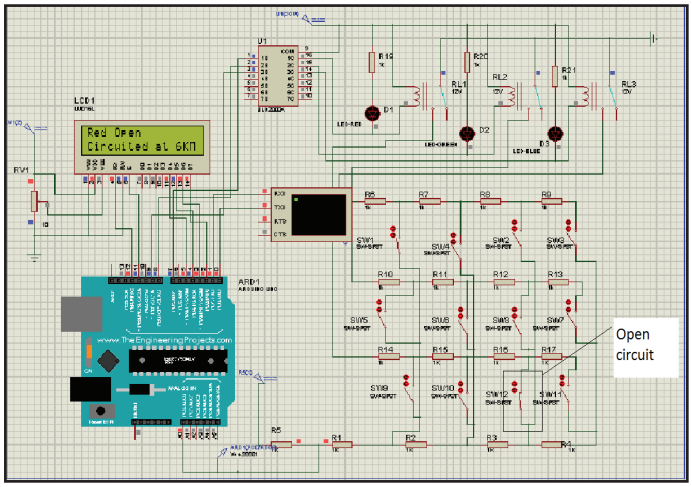

Fig. 8: Screen Indicating Open Circuit Faults at 2 Different Locations

Here, in the above screen i.e., Fig. 8, there is a misalignment at two different positions in two different lines. There is a misalignment in the position of the resistor which is present at the third position from the Ardunio board in the 1st line i.e. red line. And there is a misalignment in the position of the resistor which is present at the first position from the Ardunio board in the 3rd line i.e. blue line. As such in the circuit, first the red colored relay scans the red conductor to check whether there is any fault in it. When it comes across the faulty resistor, the message "Red Open Circuited at 6 KM" will be displayed on the LCD display.

The scanning will be further continued by the green and blue relays to check the condition of green and blue conductors respectively. The green relay does not find any fault in the green conductor. But during the scanning process of the blue conductor by the blue relay, it comes across the faulty resistor, that is present at the first position from the Arduino board, and the message "Blue Open Circuited at 2 KM" will be displayed on the LCD display as shown in the fig. 9.

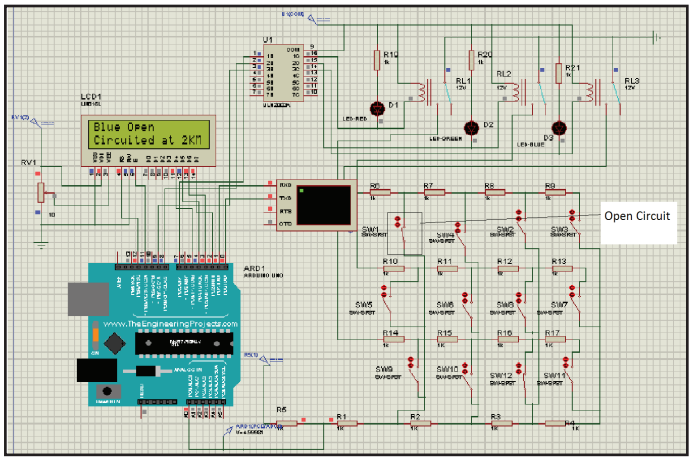

Fig. 9: Screen Indicating Open Circuit Fault at 2 Different Locations

The Fig. 10 is the screen that is obtained in the GSM module when the red relay completes the scanning of the red conductor.

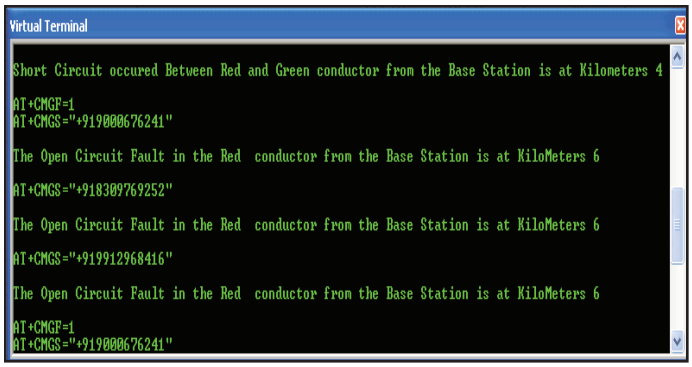

Fig. 10: GSM Screen Indicating Open circuit faults in red conductor.

The fig. 11 is the screen that is obtained in the GSM module after the scanning of all the conductors.

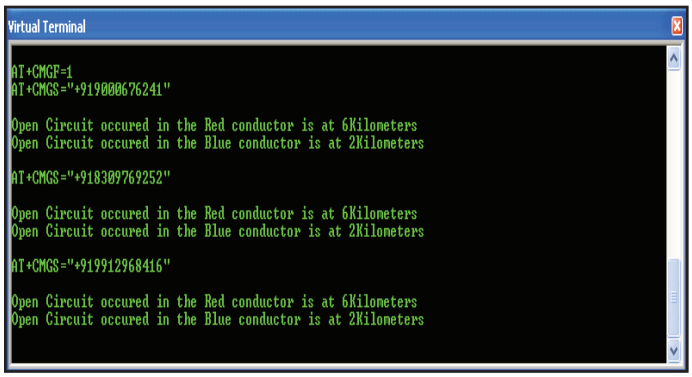

Fig. 11: GSM Screen Indicating Open Circuit Fault in Red and Blue Conductors.

C. Short Circuit Faults

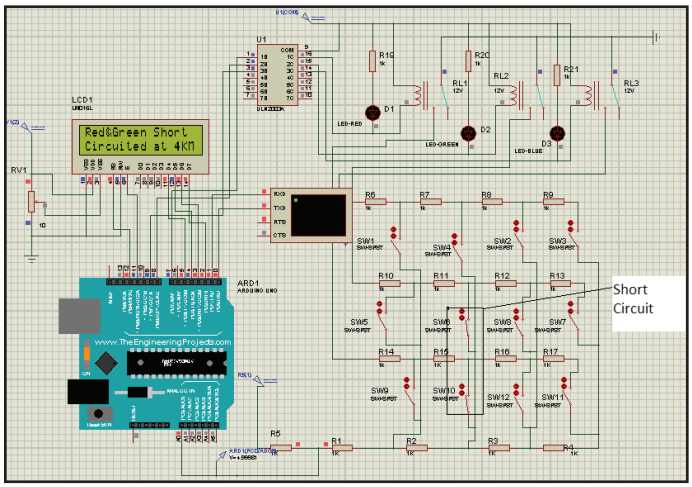

Fig. 12: Screen Indicating Short Circuit Fault at 4KM

Here, in the fig. 12 there are two misalignments in the position of the resistors which are present in the red and green lines at the second position from the Arduino board. As the distance of the fault present in both the conductors is same, this fault is treated as short circuit fault. The red relay first checks whether there is any fault in the red cable and if there is any fault in it, fault will be displayed and when the green relay comes across the fault in green conductor at the same location, then the message "Red & Green Short Circuited at 4 KM" is displayed on the LCD display.

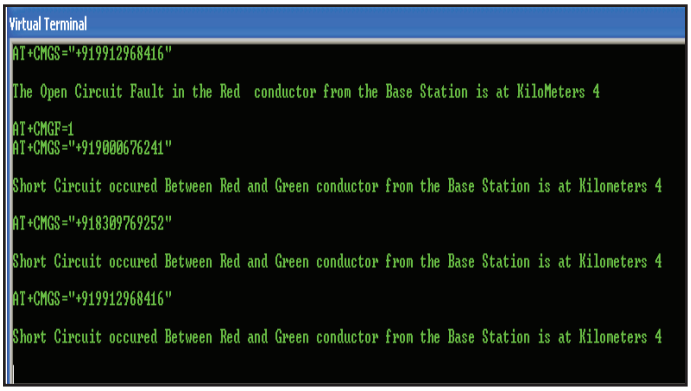

Fig. 13: GSM Screen for Short Circuit Fault at 4KM

The fig. 13 is the output obtained in the GSM module when there is a short circuit fault between red and green conductors at a location of 4 kilometers from the base station.

D. Short Circuit Faults in 3 Conductors

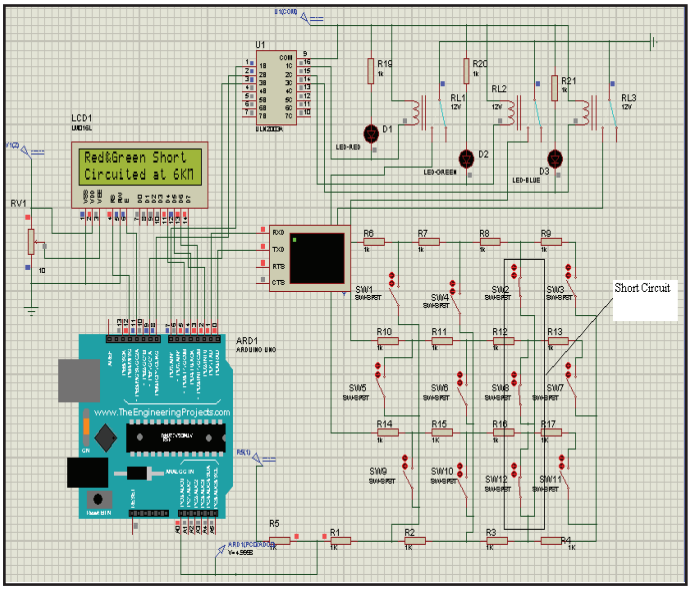

Fig. 14: Screen for Short Circuit Fault in 3 Conductors

In fig. 14 all the three conductors have faults. All the three conductors are scanned serially. First the red relay scans the red conductor. When it comes across the fault that is present in the red conductor, the message will be displaced in the display. Now, the green relay starts scanning. Once it comes across the fault in the green conductor it identifies the distance and finds that both the red and green are having the fault at the same location. From this one can come to the conclusion that this is a short circuit fault as both the conductors are having the fault at the same position. Thus the message "Red & Green Short Circuited at 6KM" will be displayed.

Now the blue relay starts scanning the blue conductor after the green conductor completes its scanning process. Now, when the blue relay comes across the fault that is present in the blue conductor at the same location as that of the green conductor, the message "Green & Blue Short Circuited at 6KM" will be displayed which means that all the three conductors are short circuited at that particular location as shown in the fig. 15.

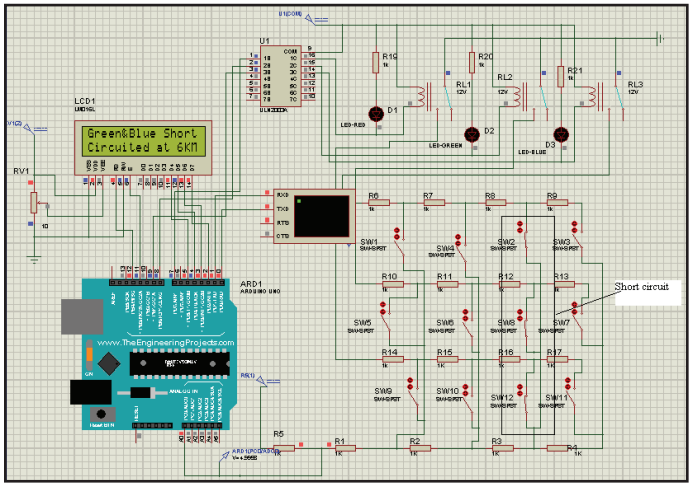

Fig. 15: Screen for Short Circuit Fault in 3 Conductors

The fig. 16 is the screen that is obtained in the GSM module when the red relay and the green relays completes the scanning of the red conductor and the green conductor and finds the short circuit faults between them.

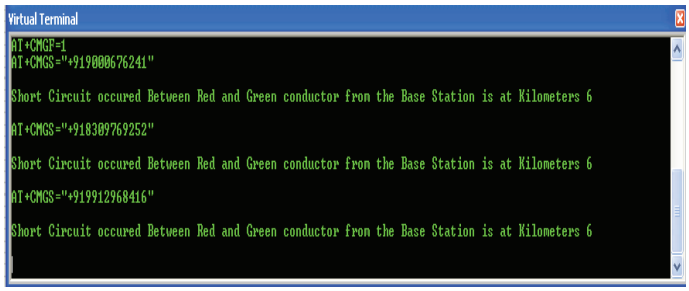

Fig. 16: GSM Screen for Short Circuit Fault in 3 Conductors

The fig. 17 is the screen that is obtained in the GSM module when scanning of the blue conductor happens after completion of the scanning by green relay and finds the short circuit fault between the green and the blue relay.

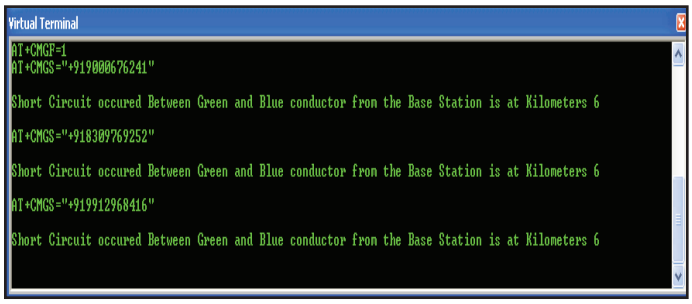

Fig. 17: GSM Screen for Short Circuit Fault in 3 Conductors

Thus the fault location and the type of the fault can be easily identified with the circuit designed.

IV. Conclusion

These days many of the countries are opting for underground cables instead of overhead cables for transmission due to their advantages over overhead cables. The major problem with underground cables is identification of the fault once it occurs as they are laid under the ground.

This project helps to identify the type of fault as well as its location. By using GSM, the message displaying the type of the fault present in the conductor along with its location from the base station will be sent to the concerned person.

V. Future Scope

In this paper we have estimated the location of short circuit faults and open circuit faults in the underground cable from base station in km by using Arduino. In future, we are planning to detect earth fault as well and implement everything in hardware version.

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S.Madhavi received degree in Electronics & Telecommunication Engineering from AMIETE, New Delhi, India and Dual M. Tech degree in GIS and Embedded Systems from JNTUH, and BVRIT Narsapur Hyderabad respectively Telangana, India. Having 5 years of teaching experience and 2 years of Industrial experience, currently she is working as Asst. Professor in the department of Electronics and Communication Engineering, BVRIT Hyderabad College of Engineering for Women, Hyderabad, Telangana, India. Her research interests include Satellite Communication, Embedded Systems.

D. Durga Bhavani is a Final year student of department of Electronics and Communication Engineering, BVRIT Hyderabad College of Engineering for Women, Hyderabad, Telangana, India. She is a member of ISTE and IETE. Her area of interest includes Communication.

Ch. Harika is a Final year student of Department of Electronics and Communication Engineering, BVRIT Hyderabad College of Engineering for Women, Hyderabad, Telangana, India. She is a member of ISTE and IETE. Her area of interest includes Embedded Systems.

B. Vineela is a Final year student of department of Electronics and Communication Engineering, BVRIT Hyderabad College of Engineering for Women, Hyderabad, Telangana, India. She is a member of ISTE and IETE. Her area of interest includes Communication.

P.V.S. Sruthi Mrunalini is a Final year student of department of Electronics and Communication Engineering, BVRIT Hyderabad College of Engineering for Women, Hyderabad, Telangana, India. She is a member of ISTE and IETE. Her area of interest includes Communication.