A

Project Report

On

"ARDUINO BASED UNDERGROUND CABLE FAULT LOCATOR"

Submitted In Partial Fulfillment Of The Requirement ForThe Degree Of

BACHELOR OF ENGINEERING
IN
ELECTRICAL ENGINEERING

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JAWAHARLAL DARDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, YAVATMAL

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CERTIFICATE

This is to certify that the Project report entitled

"ARDUINO BASED UNDERGROUND CABLE FAULT LOCATOR"

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DECLARATION

We, hereby declare that the Seminar "**ARDUINO BASED UNDERGROUND CABLE FAULT LOCATOR"** submitted here has been carried out by us in the Department of Electrical Engineering of Jawaharlal Darda Institute of Engineering and Technology, Yavatmal. The work is original and has not been submitted earlier as a whole or in part for the award of any degree at this or any other Institution.

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CONTENTS

LIST OF ABBREVIATIONS

Sr. No.	**Abbreviation**	**Illustration**
1	AC	Alternating Current
2	DC	Direct Current
3	LCD	Liquid Crystal Display
4	ADC	Analog to Digital Convertor
5	SPST	Single Pole Single Throw
6	CRT	Cathode Ray Tube
7	DVD	Digital Versatile Disc
8	CD	Compact Disc
9	GND	Ground

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Underground cables are widely employed at many places where it is difficult to install overhead lines e.g. near airports, densely populated areas, factories etc., but installation and maintenance cost of underground cables is 3 times more as compared to the overhead lines because of extreme underground conditions that causes frequent faults in the cables and fault location detection is difficult and time consuming as well. Fault occurrence is unstoppable because the natural underground conditions are completely out of human's control hence it is important to fix the fault before it causes extra damage to the whole cable. In order to start the maintenance of a faulty cable, it is required to find the exact fault location so that maintenance work becomes easy and less time consuming as compared to the conventional methods like 'thumping', 'sectionalizing', 'TDR' etc. In case of underground transmission lines, short circuit faults (LL, LLL, LLG, etc.) are very rare unlike the overhead lines since the cables R, Y and B are already dug inside the Earth (underground) with enough distance and soil cavity in between each of them. The most common fault that tends to occur is due to the wire breakage at any point that causes the 'line to ground fault' or 'earth fault' as the broken line is already touching the ground.

This project is based on locating the fault occurred due to wire breakage in the system of underground transmission cables. In this project titling 'arduino based underground cable's fault locator system' the existing system has to be installed with an additional cable called as sensor cable. Sensor cable is the series network of a fixed number of resistors that can sense the current and voltage fluctuations in the faulty cables and transfer this change to itself. The continuous outputs from the sensor cable at either normal or fault condition is given as an input to the microcontroller. This system uses arduino microcontroller which can perform the functions of controlling all the activities of the system, reading inputs from the sensors and turning it into the desired output. The arduino microcontroller is programmed in such way that on receiving the input from the sensor cable, it analyses the resistance values for all the three cables. Resistance values play a major role for detecting the fault location on the desired cable. As we know that fault occurrence is directly related with the change in resistance values, resistance either increases or decreases than the normal value in case of fault condition. According to the program dumped in the microcontroller it performs required operation on the above resistance values to find out the fault location in the system. Fault location is the distance in kilometres from the base station to the fault point. This project not only shows the fault location but also the name of the cable in which fault has occurred.

Implementation of this project will be proven more advantageous over the conventional methods mentioned above (sectionalizing, thumping, TDR, etc.) as all these conventional methods required the whole cable to be dig out in order to locate the fault point and carry out the maintenance work whereas use of this project will give the exact range in which the fault lies and hence only desired distance is needed to be dig out for the maintenance purpose.

INTRODUCTION

CHAPTER 1
INTRODUCTION

The purpose of electricity transmission system is to move generated electrical power from generating station to the load canters. Some of the transmission lines plays the major role of every power systems. The last cables of the decades where made to put the overhead and is currently put to the underground cable that is superior to the previous method. Because the underground cable are not affected by adverse weather conditions, such as storm, snow, heavy rain as well as pollution. Use of underground power cable is expanding due to safety considerations and enhanced reliability in the distribution systems in recent times. Due to safety reasons and high power requirements in densely populated areas, use of underground cable has seen a sharp hike. With regard to this, cost of power delivery, and accurate fault location for the transmission of electric lines is of vital importance in restoring the power services and reducing outage time as much as possible.

1.1 TYPES OF FAULTS

Before fixing any fault in cables, the fault has to be identified first. There are many ways to find the cable fault location. Detecting the cable fault in the underground can be categorized as an open circuit faults, short circuit faults and earth faults. Which it may occur in the transmission lines.

Short Circuit Fault:A short circuit fault occurs when there is an insulation failure between phase conductors or between phase conductor(s) and earth or both. An insulation failure results into formation of a short circuit path that triggers a short-circuit conditions in the circuit. Or due to the contact of two or more conductor together. The short circuit fault is of two types one is symmetrical fault and other is unsymmetrical fault. The symmetrical fault occurs due to the short circuit of all three phase together whereas unsymmetrical fault occurs due to the short circuit of any one phase or two phases together out of three phases

Open Circuit Fault: An open-circuit fault occurs if a circuit is interrupted by some failure. If the circuit is not closed that is called open circuit fault. This type of fault occurs due to breaking of conductors, cracks or disjoint of conductors completely.

Earth Fault: An earth fault is an inadvertent contact between an energized conductor and earth or equipment frame. The return path of the fault current is through the grounding system and any personnel or equipment that becomes part of that system.

When the faults occur in the underground cables then we cannot detect the faults in the cables normally. As underground cables are buried deep inside the ground (soil) so it is not possible to detect abnormalities in them. If we think that we found the location of the fault but not exactly then we have to dig the entire area and check the cables. If there fault does not occurs then we have a wastage of lots of money and also the manpower. While the fault occurs for some reason at that time the repair process related to that particular cable is difficult due to not knowing the exact location of fault. So if we want to ignore this problem then we have to find the exact location of the faults in the underground cables.

In accordance to find out the easiest way to find the fault location in underground cables we proposed this project. In this digitalized world we are detecting the fault location in the digital form .This project is to determine the distance of underground cable fault from the base station in kilometres and displayed over the LCD panel. In this project we use Ohm's Law to find the fault location .In this proposed fault detector, the dc voltage is supplied to the feeder through the number of series resistor. If there is a short circuit or open circuit is present in the conductor, the current flowing through the circuit will change its magnitude which is detected by the cable fault detector. For operating the microcontroller and other electronic device installed in the proposed system will be work with the help of ADC converter. The ADC will convert the AC voltage into DC voltage for the processing of microcontroller. The detector will detect any type of underground fault and display on the LCD panel. In the event of short circuit (Line to Earth) fault, the voltage accordingly. It is then fed to an ADC to develop precise digital data that is directed to the programmed Arduino to display the same in kilometres on LCD.

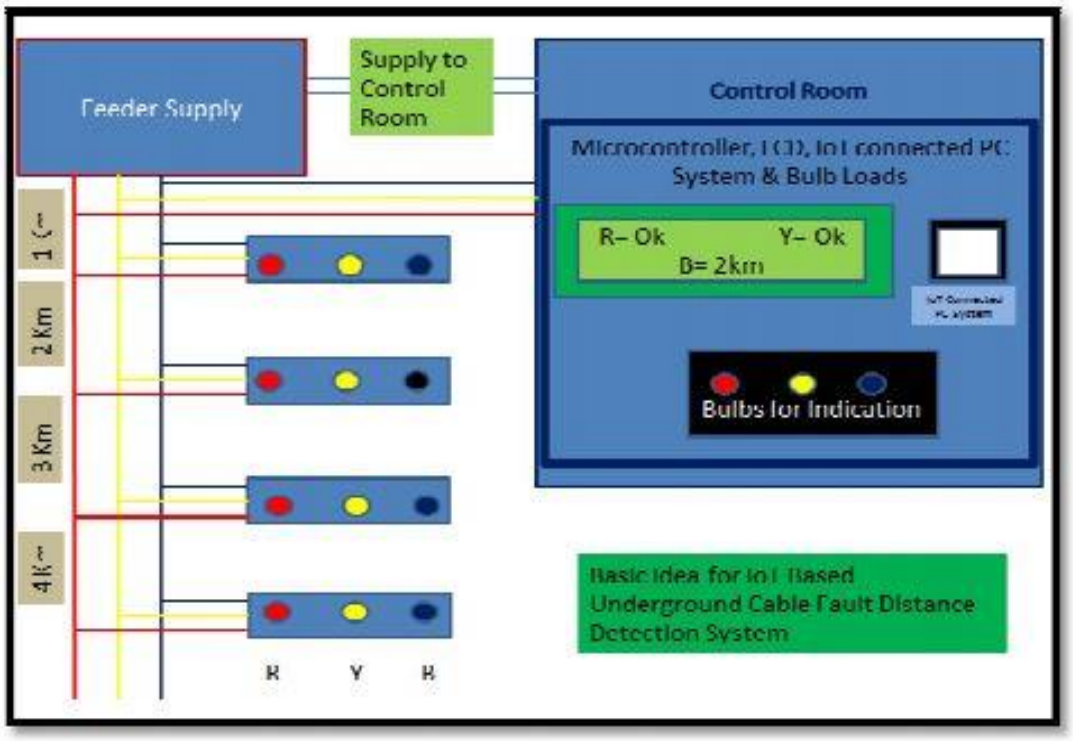

Fig.1. Basic Idea Schematic Diagram

1.2 EXISTING METHODS TO DETECT UNDERGROUND FAULTS

1. Thumping

A cable thumper is basically a portable high voltage surge generator. It is used to inject a high voltage DC surge (about 25 kV) into the faulty cable. If you supply a sufficiently high voltage to the faulty cable, the open-circuit fault will break down creating a high-current arc. This high current arc makes a characteristic thumping sound at the exact location of the fault.

To find the location of cable fault using the thumping method, a thumper is set to thump repeatedly and then walking along the cable route to hear the thumping sound. The higher the dc voltage applied, the louder will be the resulting thump. This method is useful for relatively shorter cables. For longer cables, the thumping method becomes impracticable (imagine walking along a cable that runs several kilometres to hear the thump).

Advantages And Limitations Of Cable Thumping

A major advantage of cable thumping is that it can locate open circuit faults very accurately. Also, this method is easy to apply as well as easy to learn.

Though the thumping method provides very accurate fault location, it has its own drawbacks. Applying this method for longer cables is extremely time-consuming. It may take hours or even days to walk along the cable to locate the fault. Moreover, during that time, the cable is exposed to high voltage surges. So while the existing fault is located, the high voltage surges may weaken the insulation of the cable. If you are proficient in cable thumping, you can limit the damage to the cable insulation by reducing the power sent through the cable to the minimum required to conduct the test. While moderate thumping may not cause noticeable damage, frequent thumping may degrade the cable insulation to an unacceptable condition. Also, this technique cannot find faults that do not arc-over (i.e. short circuit faults).

2. Time Domain Reflectometer (TDR)

Fig.2. Megger Time Domain Reflectometer

A Time Domain Reflectometer (TDR) sends a short-duration low energy signal (of about 50 V) at a high repetition rate into the cable. This signal reflects back from the point of change in impedance in the cable (such as a fault). TDR works on the similar principle as that of a RADAR. A TDR measures the time taken by the signal to reflect back from the point of change in impedance (or the point of fault). The reflections are traced on a graphical display with amplitude on y-axis and the elapsed time on x-axis. The elapsed time is directly related to the distance to the fault location. If the injected signal encounters an open circuit (high impedance), it results in high amplitude upward deflection on the trace. While in case of a short-circuit fault, the trace will show a high amplitude negative deflection.

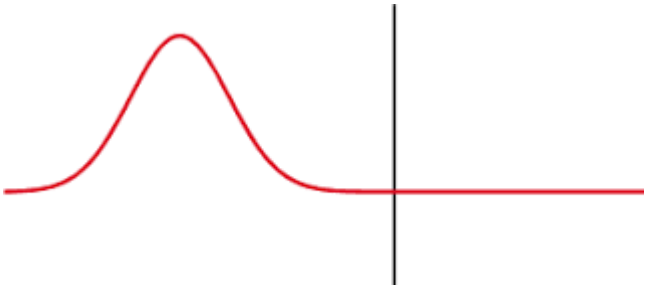

Fig.3. Signal transmitted through and reflected back from a fault

Advantages And Disadvantages Of TDR

As a TDR sends a low energy signal into the cable, it causes no degradation of the cable insulation. This is a major advantage of using TDR to find the location of a fault in an underground cable. A TDR works well for open-circuit faults as well as conductor to conductor shorts.

A weakness of TDR is that it cannot pinpoint the exact location of faults. It gives an approximate distance to the location of fault. Sometimes, this information alone is sufficient and other times it only serves to allow more precise thumping. When the TDR sends a test pulse, reflections that may occur during the time of outgoing test pulse may be obscured from the user. This can happen with the faults at near end and called as blind spots. Also, a TDR cannot see high resistance (generally above 200 Ohms) ground fault. If there is surrounding electrical noise, it may interface with the TDR signal.

3. High Voltage Radar Methods

As the low-voltage TDR is unable to identify high resistance ground faults, its effectiveness in finding underground cable faults is limited. To overcome this limitation of TDR, following are some popular high voltage radar methods. (i) Arc reflection method, (ii) surge pulse reflection method and (iii) voltage decay reflection method.

4. Arc Reflection Method

The arc reflection method uses a TDR with a filter and thumper. The thumper (or surge generator) is used to create an arc across the shunt fault which creates a momentary short-circuit so that the TDR can show a downward deflection effectively. The arc reflection filter protects the TDR from high voltage surge generated by the thumper and routes the low-voltage signal down the cable.

5. Surge Pulse Reflection Method

This method uses a current coupler, a thumper and a storage oscilloscope (analyzer). This method is used for long run cables and on faults that are difficult to arc over which do not show up using arc reflection method. In this method, a thumper is directly connected to the cable without a filter which can limit both the voltage and current applied to the fault. The thumper injects a high voltage pulse into the cable creating an arc at the fault, which subsequently causes a reflection of energy back to the thumper. The reflection repeats back and forth between the fault and the thumper till its energy gets depleted. The current coupler senses the surge reflections which are then captured and displayed by the storage oscilloscope.

6. Voltage Decay Reflection Method

This method uses a voltage coupler, a dielectric test set (high-voltage dc test set or proof tester) and a storage oscilloscope (analyzer). This method is used for transmission class cables when the generation of arc at the fault requires breakdown voltage greater than that a typical thumper or surge generator can provide. Here, the voltage coupler senses the reflections produced by the flashover of dc voltage at the fault and the analyzer captures and displays them.

LITETRATURE SURVEY

CHAPTER 2

LITERATURE SURVEY

1. [Samuel A. Isaac, Olajube Ayobami , Awelewa Ayokunle, Utibe Bassey, "Arduino Microcontroller Based Underground Cable Fault Detector"]

In this paper author presented idea of locating the exact position of any kind of faults by using microcontroller based underground cable fault distance locator powered by Arduino is designed to detect and pinpoint location of faults in underground cable lines. A basic ohm's law is employed to achieve the variation of current with respect to resistance that determines the position of the fault. This device has a power supply unit, cable unit, control unit, tripping unit and display unit. The main parts of underground cables, it's insulting materials, applications are mentioned in this paper. Ageing phenomenon and different kinds of faults occurring on underground cable are listed also previous fault detection methods are tabulated.

2. [AkashJagtap, JayeshPatil, BhushanPatil, DipakPatil, Aqib AlHusan Ansari, Atul Bharate, "Arduino Based underground cable fault detector"]

As it is difficult to locate faults occurred in underground cable lines, author of this paper proposed a fault localization model for the underground cable lines with Arduino. The purpose of this paper is to determine the distance from the base station's underground cable fault in kilometers. The Arduino is programmed such that it contains ohms laws V=IR , according to sensed fault current value in the circuit programmed Arduino will give output fault location in the form of km values.

3. [G.SasidharAchari, Mohana, "Arduino Based Underground Cable Fault Detector"]

Underground cabling framework is an increasingly regular practice in numerous urban zones. Despite the fact that the blame happens for reasons unknown, around then, the fix procedure for this specific link is troublesome in view of not knowing the accurate area of the link breakdown. This paper features the system which uses Arduino controller to pinpoint the cautious accuse region with low maintenance of task.

4. [NilamPawar, Rutuja Nirhali, Snehal Kolhe, Swati Darade, Ritesh Patil, "Design of Arduino based Underground Cable Fault Detector"]

The proposed system is to find out the precise location of the fault. The system become cost effective and compact as the components such as a LCD, regulators, relays, relay driver IC etc. are integrated with Arduino. Arduino is compiled with C language and program is uploaded in the Arduino board. When power is on Arduino start its programming cycle and send signal to relay driver to operates the relay. When Arduino performs its program cycle then all three phases are scanned with a delay of 500ms. During scan if any switch is closed (fault is created manually) current is changed and it causes drop in voltage. The drop in voltage is recorded and fed to the analog pins of Arduino and it is programmed with c language. Processes and executes input data and converts analog data into digital data using ADC. Digital data is display on the LCD with its phase and location of fault.

5. [P. Harichandana, M. Venkataramana, K. Satyanarayan, P. Yogendra, Srinivasaacharya, "Detection of Underground cable fault using Arduino and GSM module"]

The main objective of this project is to detect the faults and abnormalities occurring in underground cables using an arduino. The basic idea behind the working of this project is ohms law .At the feeder end, when a DC voltage is applied, based on the location of fault in the cable, the value of current also changes. So in case of a short circuit fault like L-G or L-L fault the change in voltage value measured across the resistor is then fed to the in-built ADC of the arduino. This value is processed by the arduino and the fault is calculated in terms of distance from the base station .This value is sent to the LCD interfaced to the arduino board and it displays exact location of the fault from the base station in kilometers for all the three phases. This project is arranged with a set of resistors which represent the length of the cable. At every known kilometer fault switches are placed to induce faults manually. Finally the fault distance can be determined.

6. [Baskhemlang Rynjah, Ferdinand Lyngdoh, Marqueen Mary Sun, Bikramjit Goswami, "Automatic Cable Fault Distance Locator using Arduino"]

This paper emphasizes on 'Varley loop based testing' method for locating short circuit and earth faults in underground cables. This test employs the principle of Wheatstone bridge. In this method, resistance value is measured which directly corresponds to the distance of fault. Connections of Wheatstone bridge are done such that two resistances are fixed and one is variable. There is a requirement of stepper motor to vary the resistance to bring the bridge to balanced condition. The value at which balanced condition is obtained is given as an input to the microcontroller to process the data and give desired fault location on LCD. Use of stepper motor makes the assembly bulky and expensive.

***7.* [Saranya.A, Ajitkumar.P, Ravikumar.A, Vignesh.C, "Underground Cable Fault Detection Using Arduino"]**

In this paper, authors propose the 'current sensing' method of fault detection. The current varies depending upon the length of the cable from the place of fault occurred. This system uses additional three components to form a power supply that includes adapter modules, capacitor and 7805 IC. Adopter modules convert 230 V into 12 V and 1 amp for each cable, capacitor filters out the AC ripples and 7805 IC converts 12 V DC into 5 V regulated DC that is to be fed to the microcontroller and LCD. In short, for this system to be installed there is more requirement of components and there connections as well.

8. [Shweta Desai, KetanWalunjkar, VipulBhoyar, Priyanka Maske, Shantanu Singh "Underground Cable Fault Detection Using ARDUINO, GSM, GPS"]

This method uses arduino microcontroller, relays, GSM and GPS as the main components of fault locator circuit kit. This method uses three relays, out of which first two relays contain NO FAULT whereas third relay has fault into it, this is all programmed into the microcontroller. Third relay is connected to the current sensor CT of range 5 amps which senses the current in the faulty cable. In this method, authors could detect only short circuit faults, by detecting the location of open circuit fault. To detect the open circuit fault, capacitor is used in the AC circuit which can measure the changes in the impedance of underground cables and accordingly calculate the distance of fault with the help of microcontroller. GSM and GPS modules are used to send SMS of fault distance to the authorized person at the base station.

9. [Roshani Shingrut, Dakshata Mokal , Shubham Shelar, Shekar Mhatre, Dr. Sharvari Sane, "Underground Cable Fault Detection"]

In this method, a dummy cable is considered to find out fault distances. The dummy cable is formed by connecting three similar resistors in series, assuming that every cable has its internal resistance. The main component of this underground cable fault detection circuit is low value resistance measurement. It is constructed using a constant current source of 100 mA. The dummy cables used in the system are connected to the relays using motor drivers to boost the supply. The limitation of this project is that the use of dummy cable provides assumptions in fault location process instead of providing exact and real data.

10. [Aditya Sharma, Himanshu Sharma, MdIrfan Ahmed, "Arduino Based Underground Overhead Cable Fault Detection"]

In this method, the authors have used both underground as well as overhead cables. Fault creation is carried out with the help of switches and the cables are made by connecting a set of resistances in series for all 4 cables. Each set consists of four resistors and each resistor represents the resistance of any cable for a specific distance. At fault occurrence, the voltage drop at the ADC varies according to the current flow which is inversely proportional to the resistance value representing the length of cable in meters. This varying voltage is fed to the ADC to develop 8 bit data at the microcontroller's analog port. Hence, in this method, the microcontroller is programmed such that it senses the change in voltage drop values.

11. [Ayush Shukla, Himanshu Sable, Sagardayal Bhagat, Ravindra, "Underground Cable Fault Detection System Using GSM & GPS"]

This method uses the combination of arduino microcontroller, GPS and GSM module for calculating and passing the fault distance. Looking at certain limitations of similar proposed systems, the authors of this paper have thrown a light on using dual power supply for the system. It means that this system is capable of running on AC mains supply and a DC battery pack. This project uses the simple concept of ohms law where a low DC voltage is applied at the supply end through series resistor. The current would change depending upon the length of fault at the cable. For any short circuit fault, the series resistor voltage drop changes according to the fault which is then fed to the ADC of a programmed microcontroller which finally provides the kilometres of fault.

12. [Sat Dev, Maneet Kour, Atul Singh Salaria, ArifUl Rahman, Salender Sharma, Yogeshwar Singh, Sanjeev Kumar Dogra, Mohd. Yousuf, "GSM based Underground Cable Fault Detection "]

In this paper author described detection of the fault in three phases. In this project just connect switch to disconnect the wire in each km segment .with the three phase cable one reference cable are also present to compare with it .The arduino board is there to refer resistance of cable with the fault cable resistance. Fault current sensed by fault detector circuit and this is provided to Arduino. This programmed Arduino process data and displayed it over LCD and location of fault is sent to the concerned authority via GSM module.

13. [Siwani Singh, Shubham Jayant Sarnaik, Akilla Sai Bhargav, Vinod Chavan, "Detection of Underground Cable Fault Using Arduino"]

This paper features detection of faults in 3 phases. It uses internal resistance of cable because as the length of copper wire increases resistance also increases. The arduino board required the reference resistance of cable with the fault cable resistance .consider, a single cable in which 4 resistance are connected with 4 switches and when fault occur the system at 2 km distance. In this project switch is just connect to disconnect the wire in each km segment with the three phase cable one reference cable are also present to compare with it. This project is beneficial to use to detect the fault location. So the fault can easily locate and extinguish.

14. [Saurabh Kumar, Kumari Shradha ,"Open Circuit and Short Circuit Fault Detection of cable"]

Concerns about the reliability of overhead lines, increases in their maintenance and operating costs, and issues of public safety and quality-of-life are leading more and more utilities and municipalities to the realization that converting overhead distribution lines to underground is the best way to provide high quality service to their customers. This paper gives significance of underground cable fault. Circuit has been tested with different resistor values to simulate various fault conditions. It displays exact location of short circuit. In this paper the exact location of short circuit fault at a particular distance in the underground cable from feeder end in km can be located by using arduino 8051. The concept of OHM's law is used so fault can be easily detected.

15.**[Swetali M. Lalge, Snehal M. Adake, Ranjit R. Dhuke, Prof. S. N. Yadav, "Underground Cable Short Circuit Fault Distance Locator"]**

The Project is intended to detect the location of fault in underground cable lines from the base station to exact location in kilometers using an Arduino micro controller kit. In the urban areas, the electrical cable runs in undergrounds instead of overhead lines. Whenever the fault occurs in underground cable it is difficult to detect the exact location of the fault for process of repairing that particular cable. The proposed the system finds the exact location of the fault. This system uses an Arduino micro controller kit to help of the internal ADC device for providing digital data to the micro controller to display the information. It is difficult task to identify the faults in underground cable. By using Arduino controller we can find out exact fault location. This circuit is assemble to detect open circuit fault, short circuit fault. Once fault occur in the cable display unit displays the exact fault location that shows which phase is affected in the cable and how long it is affected.

16.[Henna Sam.E.J, Pavithra.U.H, Ramakrishnan.P.V, RiyashBasha.S and Mr.T.M.Sathish kumar5, "Underground Cable Fault Detection Using IOT"]

Power supply networks are growing continuously and their reliability getting more important than ever. The complexity of the whole network comprises numerous components that can fail and interrupt the power supply for end user. This prototype uses the simple concept of OHMs law. The current would vary depending upon the length of fault of the cable. This prototype is assembled with a set of resistors representing cable length in Kilo meters and fault creation is made by a set of switches at every known Kilo meters (km's) to cross check the accuracy of the same. The fault occurring at what distance and which phase is displayed on a 16X2 LCD interfaced with the microcontroller.

17.[Padmanaban.K, SanjanaSharon.G , Sudharini.N ,Vishnuvarthini.K , "Detection of Underground cable fault using Arduino"]

This paper presents the project on Underground cable fault detection using Arduino and the distance of the fault from the base station in kilometers was displayed for the three individual phases R, Y and B. Circuit can be tested with different resistor values to simulate various fault conditions In this project faults up to a distance of 4km can be detected. When the fault switches are operated to fault condition then the phase corresponding to that particular switch is considered as the faulty phase. So the faulty section can easily be located using the project mentioned in this paper.

18.[R.K.RaghulMansingh, R.Rajesh, S.Ramasubramani, G.Ramkumar, "Underground Cable Fault Detection using Raspberry Pi and Arduino"]

The aim of this project is to determine the underground cable faults. This project uses the simple concept of CT Theory. When any fault like short circuit occurs, voltage drop will vary depending on the length of fault in cable, since the current varies CT is used to calculate the varying .The signal conditioner manipulates the change in voltage and a microcontroller is used to make the necessary calculations so that the fault distance is displayed by IOT devices. This project is to determine underground cable fault using specific application. If the short circuit or any physical damage is occurred then the voltage across cable lines changes .The changes which occurred can be calculated using CT theory.CT Theory provides simple and accurate means of sensing current flow in power conductors. Signal conditioner manipulates the analog signal for the further processing. Arduino is used to send the values to raspberry pi. The processed values are displayed in IOT devices.

19.[S. Madhavi, D. DurgaBhavani, Ch. Harika, B. Vineela, P.V.S. SruthiMrunalini, "*E*stimation of Open & Short Circuit Fault Distances in the Underground Cable using Arduino& GSM Module"]

This paper estimated the location of short circuit faults and open circuit faults in the underground cable from base station in km by using Arduino. The primary aim of this 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.

20.[Emmanuel Gbenga Dada, AbdulkadirHamidu Alkali, Stephen Bassi Joseph, Umar Abba Sanda, "Design and Implementation of Underground Cable Fault Detector"]

A fault in electrical equipment can be defined as a defect in its electrical circuit due to which the current is diverted from the intended path. Faults are generally caused by mechanical failure, accidents, excessive internal, external stresses, and others. When a cable is faulty the resistance of such cable is affected. If left unrectified, it will totally hinder voltage from flowing through the cable. The challenge with the existing methods used for locating faults in underground cables is the inaccuracy in calculating the distance where the fault is located and

the low durability of such equipment. To overcome these challenges, this paper presents a novel underground cable fault detector that has the capacity to measure the resistance of the cable, detect the type of fault in a cable, and also accurately compute the location of the fault using cheap materials. Several tests were conducted using the proposed device, and the results indicated that the proposed method produced satisfactory results in detecting both open circuit and short circuit problems in underground cables within a maximum distance of 2km.

21.[Murugesh P D Damini R , Amitha P , Shweta M , "IoT Based Underground Optical Fiber Cable Fault Detection System"]

This paper deals with how to arising the fault in the cable and how to find the exact location of fault using microcontroller. The various types of fault are arise in the power line but we can use one simple method using for find the fault in the cable .This project is fully automated fault detection system. The embedded technology is used for find the fault. In this paper we detect the exact location of short circuit fault in the underground cable from feeder end in km by using Arduino microcontroller. For this they use simple concept of OHM's law so fault can be easily detected and repaired. This circuit is fabricated to detect open circuit fault, short circuit fault and earth fault. Once fault occur in the cable, the display unit displays the exact fault location that indicates which phase is affected in the cable and how long it is affected. A buzzer system is used to create an alerting signal which is helpful to humans. Buzzer system creates an alerting sound signal, once if the fault occur in the underground cable. This prototype detects the exact location of various faults like earth short and open circuit fault in underground cables from feeder end.

22.[Prof. Karthik R ,Spoorthi , Anup Y ,Sukruth ,"IoT Based Underground Fault Detection"]

This paper features IOT based totally underground cable fault detection system which is useful for find out faults and its region in very easy way .Underground cables were extensively used with the development of strength system grid .Underground cables are susceptible to a wide type of faults because of underground situations, wear and tear, rodents .Detecting fault source is difficult due to the fact whole line is to be dug in order to test fault at cable line. The repairmen understand precisely which component has fault and most effective that vicinity is to be dug to stumble on the fault supply. It saves numerous time, cash and permits to carrier underground cable lines faster. Here author used IOT technology

that permits the government to reveal and take a look at faults over internet the usage of Android App.

23.[Mr. M. Dinesh, Mr. K. Vairaperumal, Mr. P. Senthilkumar, "Design and Detection of Underground Cable Fault Using Raspberry Pi &IoT System"]

This paper proposes fault location model for underground power cable using raspberry pi and the Internet of Things which is based on the internet, which means the information will be transferred through the internet access. The aim of this method is to determine the distance of underground cable fault from base station in kilometers and also find the location of that faulty place. This paper uses the simple concept of Current Transformer Theory (CT Theory). When any fault like short circuit occurs, voltage drop will vary depending on the length of fault in cable; since the current varies Current Transformer is used to calculate the varying current. The signal conditioner manipulates the change in voltage and a microcontroller is used to make the necessary calculations so that the fault distance is displayed by IOT devices. These fault details are after sent to any access point through the internet and displayed.

24.[Mr. N. Sampathraja Dr. L. Ashok Kumar Ms. V. Kirubalakshmi and Ms. C. Muthumaniyarasi , Mr. K. Vishnu Murthy, "IOT Based Underground Cable Fault Detector"]

The project work is intended to detect the location of fault in underground cable lines from the base station in km using a PIC16F877A controller. To locate a fault in the cable, the cable must be tested for faults. This prototype uses the simple concept of Ohms law. The current would vary depending upon the length of fault of the cable. In the urban areas, the electrical cables run in underground instead of overhead lines. Whenever the fault occurs in underground cable it is difficult to detect the exact location of the fault for process of repairing that particular cable. The proposed system finds the exact location of the fault. The prototype is modeled with a set of resistors representing cable length in km and fault creation is made by a set of switches at every known distance to cross check the accuracy of the same. IoT is used to display the information over Internet using the Wi-Fi module ESP8266.A webpage is created using HTML coding and the information about occurrence of fault is displayed in a LCD.

SYSTEM

DEVELOPMENT

CHAPTER 3

SYSTEM DEVELOPMENT

3.1 BLOCK DIAGRAM OF PROPOSED SYSTEM

The below figure shows the block diagram of the "Arduino Based Underground Cables Fault Locator" system .The basic block diagram consist of SMPS, Relay modules, LCD display, Arduino Microcontroller kit as a main components which are assembled in the following way to form a proposed system.

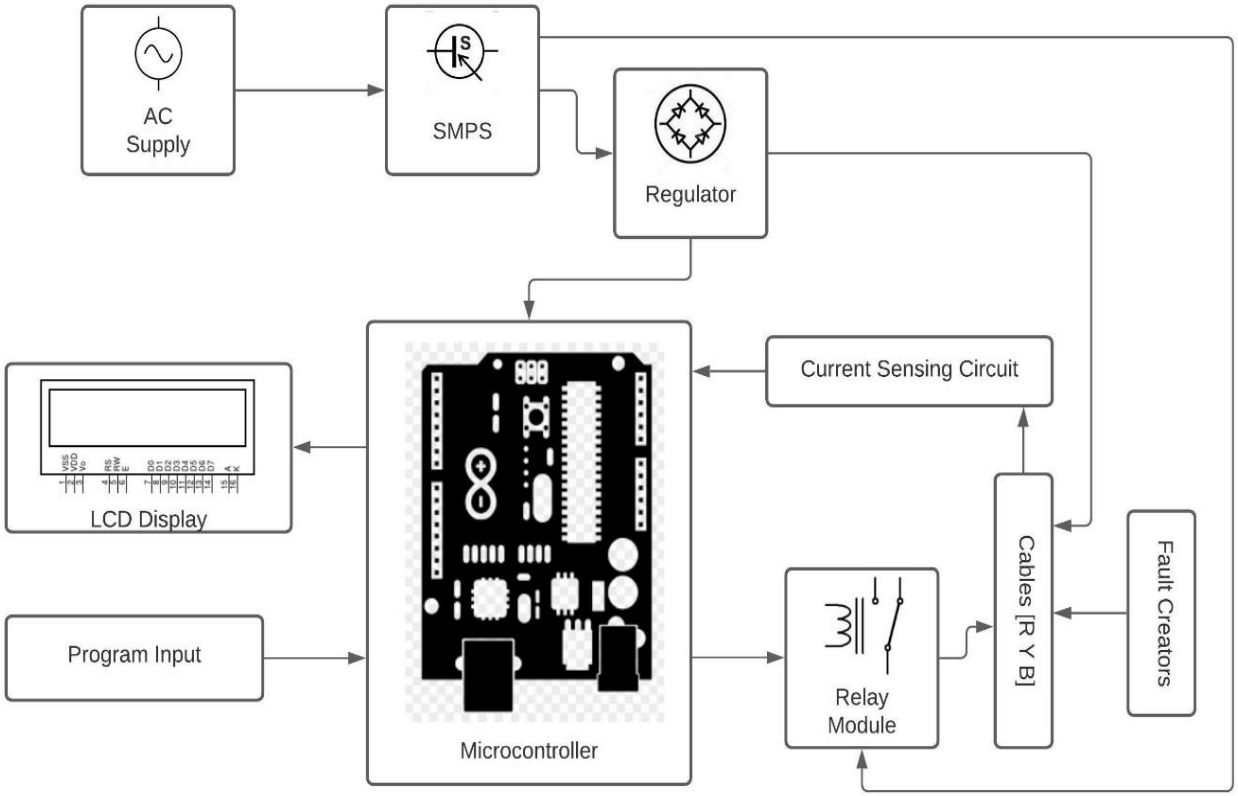

Fig 4. Block Diagram Of Proposed System

3.2 COMPONENTS USED

1. SPST Switches:

Fig.5. SPST Switches

In electrical engineering, a switch is an electrical component that can disconnect or connect the conducting path in an electrical circuit, interrupting the electric current or diverting it from one conductor to another. The most common type of switch is an electromechanical device consisting of one or more sets of movable electrical contacts connected to external circuits. When a pair of contacts is touching current can pass between them, while when the contacts are separated no current can flow.

Switches are made in many different configurations; they may have multiple sets of contacts controlled by the same knob or actuator, and the contacts may operate simultaneously, sequentially, or alternately. A switch may be operated manually, for example, a light switch or a keyboard button, or may function as a sensing element to sense the position of a machine part, liquid level, pressure, or temperature, such as a thermostat. Many specialized forms exist, such as the toggle switch, rotary switch, mercury switch, push-button switch, reversing switch, relay, and circuit breaker. A common use is control of lighting, where multiple switches may be wired into one circuit to allow convenient control of light fixtures. Switches in high-powered circuits must have special construction to prevent destructive arcing when they are opened.

2. 10k Preset:

Fig.6. 10k Preset

A preset is a passive variable resistor that is used to vary the voltage and current in the circuit as per need.

This is a three terminal PCB mount friendly device which gives variable voltage from centre pin in the range of voltage difference applied on the two outer pins, as it is rotated.

Features:

- Track Resistance: 10Kohm
- No. of Turns: 1
- Resistance Tolerance: ± 10%
- Temperature Coefficient: ± 100ppm/°C
- Potentiometer Mounting: Through Hole
- Adjustment Type: Top
- Contact Resistance Variation +: 1%
- Full Power Rating Temperature: 85°C
- Operating Temperature Range: -55°C to +125°C

3. Resistors:

Fig.7. Resistors

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High-power resistors that can dissipate many watts of electrical power as heat, may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

4. Liquid Cristal Display (LCD):

LCD 16×2 Pin Configuration and Its Working

Nowadays, we always use the devices which are made up of LCDs such as CD players, DVD players, digital watches, computers, etc. These are commonly used in the screen industries to replace the utilization of CRTs. Cathode Ray Tubes use huge power when compared with LCDs, and CRTs heavier as well as bigger. These devices are thinner as well power consumption is extremely less. The LCD 16×2 working principle is, it blocks the light rather than dissipate. This article discusses an overview of LCD 16X2, pin configuration and its working.

What is the LCD 16×2?

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.

Fig.8. 16X2 LCD

LCD 16×2 Pin Diagram

The 16×2 LCD pin out is shown below:

- Pin1 (Ground/Source Pin): This is a GND pin of display, used to connect the GND terminal of the microcontroller unit or power source.
- Pin2 (VCC/Source Pin): This is the voltage supply pin of the display, used to connect the supply pin of the power source.

Pin3 (V0/VEE/Control Pin): This pin regulates the difference of the display, used to connect a changeable POT that can supply 0 to 5V.

- Pin4 (Register Select/Control Pin): This pin toggles among command or data register, used to connect a microcontroller unit pin and obtains either 0 or 1(0 = data mode, and 1 = command mode).
- Pin5 (Read/Write/Control Pin): This pin toggles the display among the read or writes operation, and it is connected to a microcontroller unit pin to get either 0 or 1 (0 = Write Operation, and 1 = Read Operation).
- Pin 6 (Enable/Control Pin): This pin should be held high to execute Read/Write process, and it is connected to the microcontroller unit & constantly held high.
- Pins 7-14 (Data Pins): These pins are used to send data to the display. These pins are connected in two-wire modes like 4-wire mode and 8-wire mode. In 4-wire mode, only four pins are connected to the microcontroller unit like 0 to 3, whereas in 8-wire mode, 8-pins are connected to microcontroller unit like 0 to 7.
- Pin15 (+ve pin of the LED): This pin is connected to +5V
- Pin 16 (-ve pin of the LED): This pin is connected to GND.

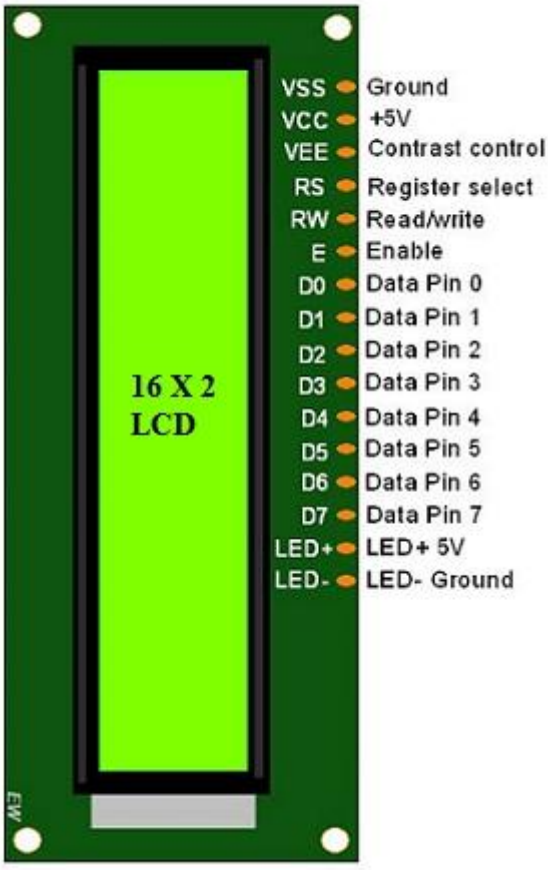

Fig.9. LCD-16×2-Pin-Diagram

Features of LCD 16×2

The features of this LCD mainly include the following.

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit
- These are obtainable in Blue & Green Backlight
- It displays a few custom generated characters

5. Relay Modules:

Fig.10. Relay Modules

A power relay module is an electrical switch that is operated by an electromagnet. The electromagnet is activated by a separate low-power signal from a micro controller. When activated, the electromagnet pulls to either open or close an electrical circuit.

A simple relay consists of wire coil wrapped around a soft iron core, or solenoid, an iron yoke that delivers a low reluctance path for magnetic flux, a movable iron armature and one or more sets of contacts. The movable armature is hinged to the yoke and linked to one or more set of the moving contacts. Held in place by a spring, the armature leaves a gap in the magnetic circuit when the relay is de-energized. While in this position, one of the two sets of contacts is closed while the other set remains open.

When electrical current is passed through a coil, it generates a magnetic field that in turn activates the armature. This movement of the movable contacts makes or breaks a connection with the fixed contact. When the relay is de-energized, the sets of contacts that were closed, open and breaks the connection and vice versa if the contacts were open. When switching off the current to the coil, the armature is returned, by force, to its relaxed position. This force is usually provided by a spring, but gravity can also be used in certain applications. Most power relays are manufactured to operate in a quick manner.

For distribution of power in high current applications, GEP Power Products is the industry leader in high power relay module design and manufacturing.

Rated up to 70 amps, GEP's power relay modules are designed for seamless integration in high power distribution applications. The convenient integral mounting brackets provide easy installation and accessibility. With endless options such as terminal position assurance available for wire retention, GEP Power Products' power distribution solutions and off-road industry knowledge are second to none.

6. SWITCH MODE POWER SUPPLY (SMPS):

Fig.11. SMPS

Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power, see AC adapter) to DC loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as *duty cycles*). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies can also be substantially smaller and lighter than a linear supply because the transformer can be much smaller. This is because it operates on the switching frequency which ranges from several 100 KHz to several MHz in contrast to the 50-60Hz which is typical for the mains AC frequency. Despite the reduction in size, the power supply topology itself and the requirement for electromagnetic interference suppression in commercial designs result in a usually much greater component count and corresponding circuit complexity.

7. Arduino:

Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices. It's hardware products are licensed under a CC-BY-SA license, while software is licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL),[1] permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially from the official website or through authorized distributors.

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ('shields') or breadboards (for prototyping) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs. The microcontrollers can be programmed using the C and C++ programming languages, using a standard API which is also known as the "Arduino language". In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) and a command line tool (arduino-cli) developed in Go.

The Arduino project began in 2005 as a tool for students at the Interaction Design Institute Ivrea in Ivrea, Italy,[2] aiming to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats and motion detectors.

Fig.12. Arduino

3.3 WORKING

Following figure shows the circuit arrangement for the Arduino based Underground Cable Fault Location system. In which three R,Y,B cables are connected with a sensor cable after particular interval of length that are the point 2km, 4km, 6km and 8km as shown in below figure.

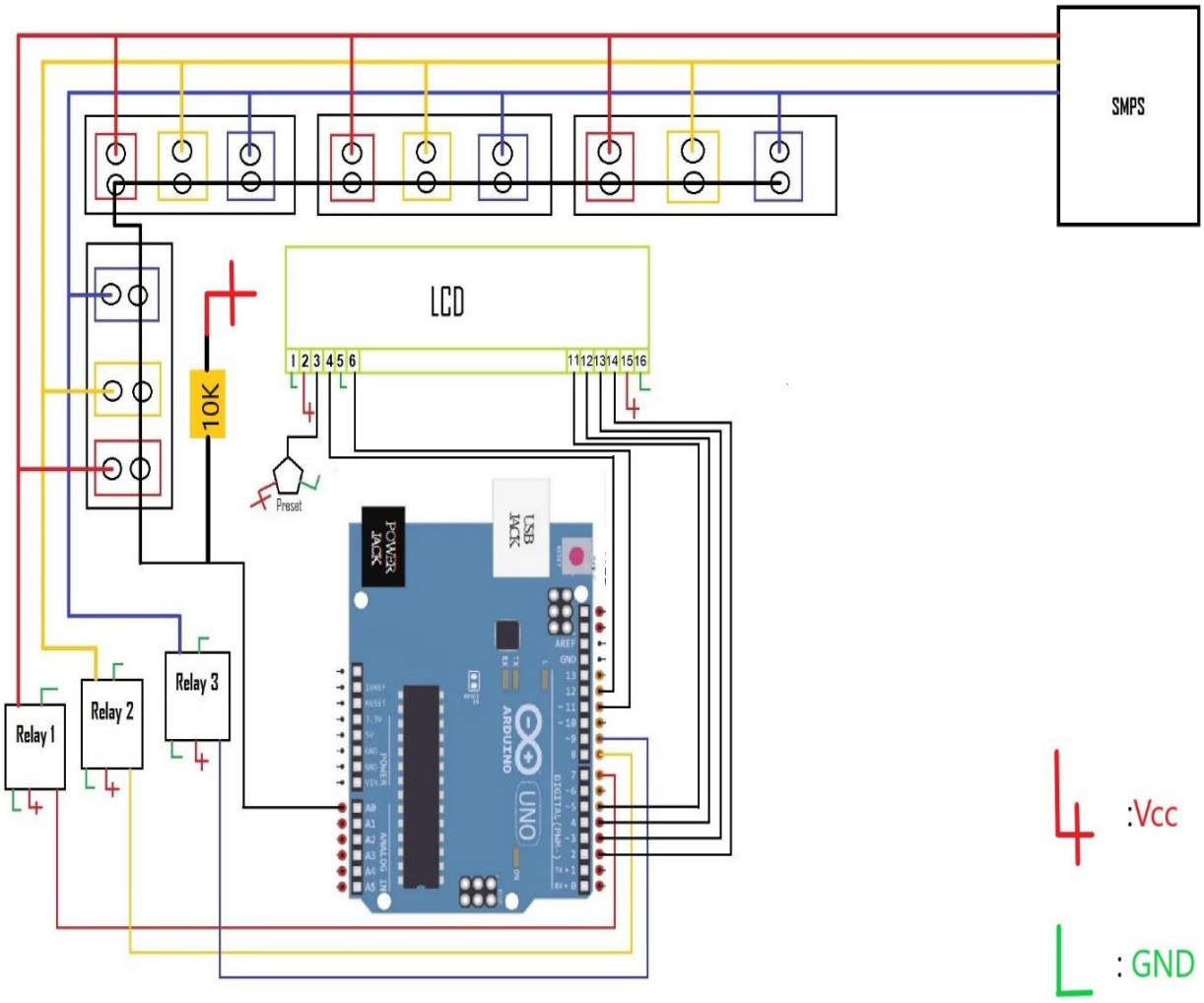

Fig 13. Actual Circuit Diagram Of Proposed System

The working of the proposed system can be done as:

The proposed system is an Arduino based underground cable fault locator and the purpose of this project is to get the exact fault location range of underground cable using microcontroller from the base station in kilometers. The basic principle behind the system is Ohms law. When fault occurs in the cable, the voltage varies which is used to calculate the fault distance w.r.to variation of current. Here we use cables of specific resistances for a particular distance of the cable along with a sensor cable. When the current flows through the

fault sensing circuit module the current would vary depending upon the length of the cable from the place of fault that occurred if there is any short circuit fault with the Single Line to ground fault, or double line to ground fault, or three phases to ground fault. The voltage drops across the series resistors changes accordingly and then the fault signal goes to internal ADC of the microcontroller to develop digital data. Then microcontroller will process the digital data and the output is being displayed in the LCD connected to the microcontroller in kilometers and phase as per the fault conditions.

The power supply given to the system is 230V ac supply. This 230 V supply is fed to the SMPS of the value 12V 3 Amp. Since a constant (5-12) V voltage source is desired for our system, because the Microcontroller (ATmega328), 16x2 LCD (Liquid Crystal Display), Relay Drivers and Relays, Fault Sensing Circuit Module etc.

Since we are using a prototype, the chances of fault occurrence are very less, so we are using the manual switches to create the artificial fault so at to make our system work.


8 Km
6 Km
4 Km
ARDUINO BASED UNDERGROUND CABLE FAULT LOCATOR

3.4 PROGRAM LOGIC

The program works on the principle of change in the values of resistance in the sensor cable, this change directly corresponds to the exact distances at which the fault has occurred. At 'NO FAULT' condition, the current passes through the whole length of the cable having certain resistance whereas at 'FAULT' condition, the current passes from the sensor cable's limited number of resistances depending upon the distance of fault occurrence. The working of program logic is based on the arrangement of hardware as shown in the diagram below:

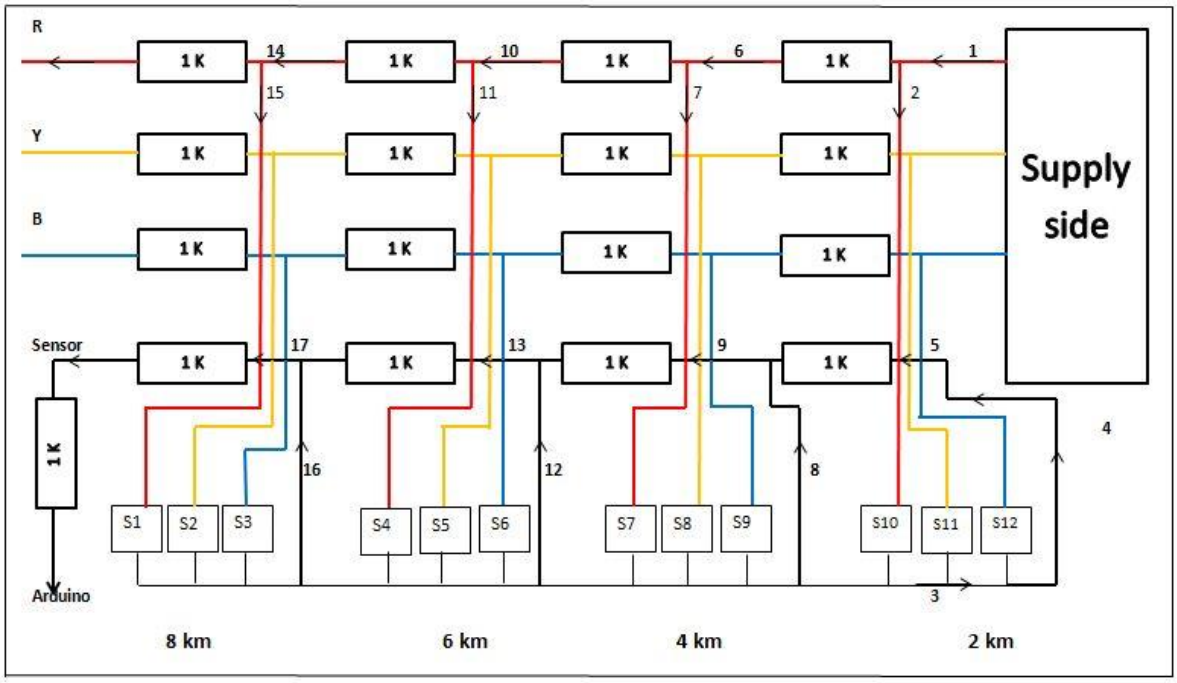

Fig.14. Program Explanation Circuit Diagram

The above diagram consists of three main cables R, Y & B that are connected to the supply at one end and to three separate relays at the receiving end. An additional sensor cable is used which is connected to the respective R, Y & B cables at assumed distances via switches ranging from S1 to S12. All the four cables are divided into 4 equal parts, each part contains equal amount of resistance (consider 1K).

The type of relays used are impedance relays, they can sense the value of resistance in the respective cable to which that particular relay is connected to and hence satisfy the working principle of the system. The outgoing sides of three relays are connected to the arduino pins 7, 8, 9 and the output side of the sensor cable is connected to the A0 pin of the arduino.

If each cable is considered to have the resistance of 1000 ohms then,

- At 'NO FAULT' condition, the current passes straightly from sending end to receiving end normally without branching. The sequence of current flow in this case can be tracked by the arrows 1-6-10-14. The resistance value crossed by the current will be 1000 ohms (total resistance of cable).
- At 'FAULT' condition (at R 2 km) the current gets branched and passes towards the sensor cable via switch S10. The track of current flow in this case will be in the direction of arrows followed by 1-2-3-4-5-9-13-17. This indicates that current crosses 5 resistances while flowing through the sensor cable. The final resistance value reported at arduino will lie between the range of 890 to 920 ohms (due to all 5 resistors)
- At 'FAULT' condition (at R 4 km) the current gets branched and passes towards the sensor cable via switch S7. The track of current flow in this case will be in the direction of arrows followed by 1-6-7-8-9-13-17. This indicates that current crosses only 4 resistances while passing through the sensor cable. The final resistance value reported at arduino will lie between the range of 860 to 880 ohms (due to only 4 resistor)

- At 'FAULT' condition (at R 6 km) the current gets branched and passes towards the sensor cable via switch S4. The track of current flow in this case will be in the direction of arrows followed by 1-6-10-11-12-13-17. This indicates that current crosses only 3 resistances while passing through the sensor cable. The final resistance value reported at arduino will lie between the range of 800 to 825 ohms (due to only 3 resistors)
- At 'FAULT' condition (at R 8 km) the current gets branched and passes towards the sensor cable via switch S1. The track of current flow in this case will be in the direction of arrows followed by 1-6-10-14-15-16-17. This indicates that current crosses only 2 resistances while passing through the sensor cable. The final resistance value reported at arduino will lie between the range of 670 to 688 ohms (due to only 2 resistors)

The above criteria is repeated for remaining two cables ‘Y & B’ as well to locate faults at different distances. The flow of events while finding the exact distances of faults is explained in the below diagram depicting algorithm or flowchart of the program dumped the Arduino.

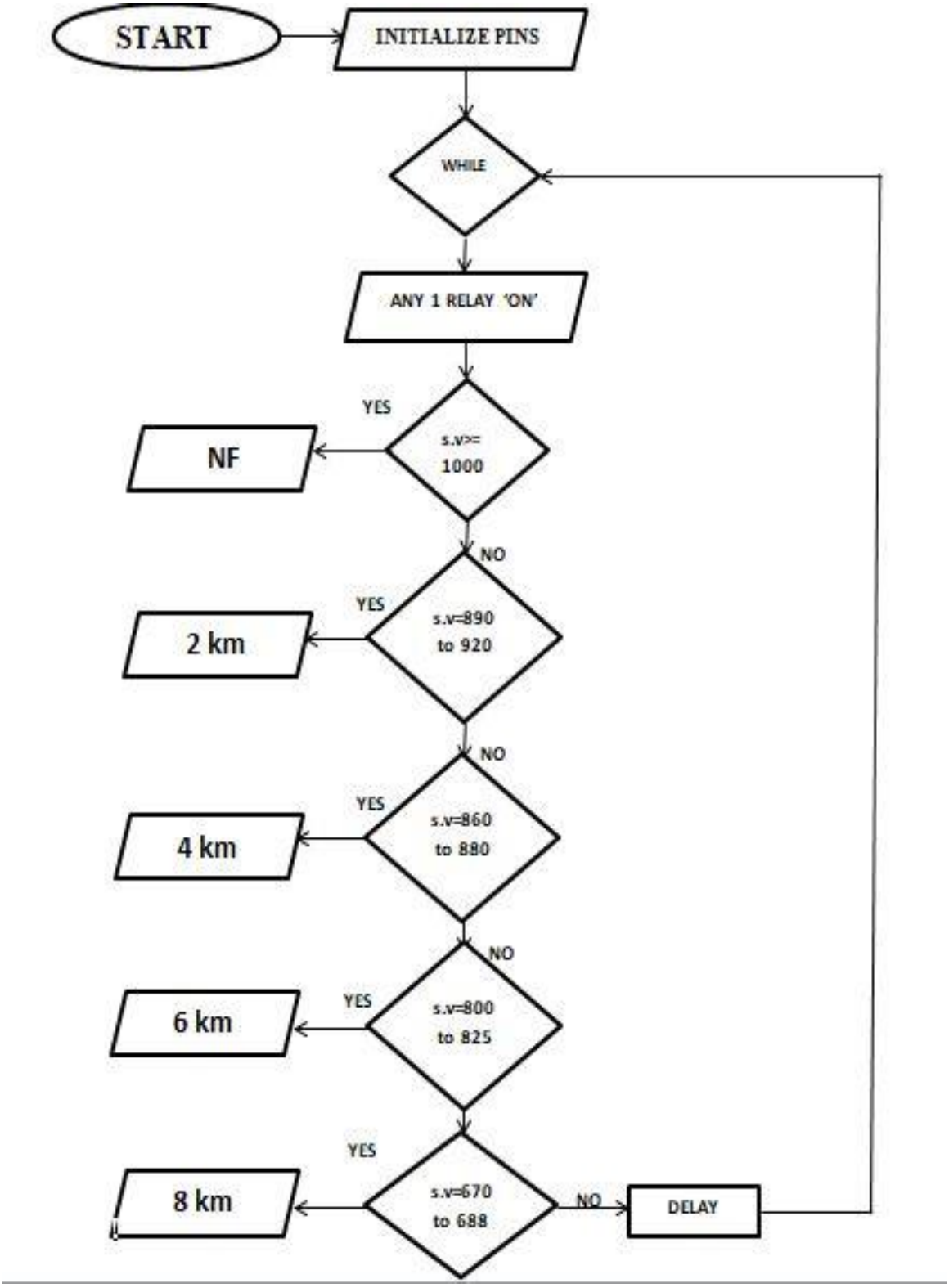

Fig.15. Working Logic Flow Chart

The system turns ON as soon as the supply is provided to the arduino and the cables. It is required to assign the different connections of hardware from relays and sensor cable to arduino and arduino to LCD screen. The 3rd step indicates that at an instant of time only one relay can remain ON, the ON time of each relay is 1 second, the sequence of operation of relays is relay R, relay Y & relay B. In the duration of one second, the arduino will check different conditions for fault at different distances on a particular cable to which the ON relay is connected to. The conditions checked will be according to the sequence shown in the above flowchart.

For sensor value or resistance = 1000 ohms, then LCD shows N.F (NO FAULT) otherwise next condition is checked for sensor value lying between 890-920 ohms then, LCD shows 2 km otherwise next condition is checked for sensor value lying between 860-880 ohms then, LCD shows 4 km else another condition of sensor value lying between 800-825 is checked which if true will print 6 km on LCD screen otherwise last condition is checked for sensor value lying between 670-688 which will print 8 km if gets true otherwise delay is called and all the above process is repeated (by applying a loop) for another cable in the next 1 second duration which is the ON time of next relay.

3.5 ADVANTAGES

1. Detects accurate fault sub-location

It detects the location of fault in underground cable lines from the base station to exact location in kilometres for process of repa**i**ring that particular cable using an Arduino micro controller kit.

2. Reduce Human Efforts

Earlier existing physical methods for fault detection of underground cable, we have to walk along the cable & dig the land until fault get detected it take too much efforts for finding the exact fault which is overcome in the proposed system.

3. Save Time

Previous existing methods takes hours or even days to search the location of fault, this time will be save using this method of fault detection.

4. Applicable to all range of fault cables

Underground cable fault location model are applicable to all types of cable ranging from 1kv to 500 kV& other types of cable fault such as short circuit fault, cable cuts, Resistive fault, sheath faults, partial discharges.

5. Applicable to all types of faults

This system is able to detect all kinds of faults occurring in underground cable lines such as short circuit faults, open circuit faults and earth faults with cable cuts, resistive faults.

6. Higher efficiency and reliability

Power supply networks are growing continuously and their reliability is getting important than ever. With regard to this, cost of power delivery, and accurate fault location for the transmission of electric lines is of vital importance in restoring the power services and reducing outage time as much as possible with higher efficiency. Stability and reliability of the power supply system in the country boost economic growth. Increased reliability during severe weather (wind-related storm dame will be greatly reduced for an underground system.

7. Low maintenance, compact size and easy to handle

Maintenance works are reduced to almost minimum level as only fixed and reduced length of cable is to be dug out. Any additional calculations are also not required as the exact fault range is obtained on the LCD screen, hence is easy to handle.

8. Improved public safety

In densely populated areas, underground cables are more safe than overhead lines, it reduce the risk of accidents in stormy weather. Live-wire contact injuries are also reduced.

9. Cost effective

Implementation of this system can reduce labour cost and hardware cost is also less as the need of conventional apparatus is completely eliminated.

10. Less complexity

The system is a simple assembly of microcontroller, LCD screen and sensor cable. Microcontroller performs all the data processing activities and displays the final result hence hardware becomes less complex.

11. Fewer Fires

External whether conditions cannot affect the system unlike the overhead lines where chances of fire are more due to short circuit faults.

3.6 LIMITATIONS:

1. By implementation in real time may occur high cost as according to desired distances we connect sensor cable with the three phases.

2. This circuit gives only the exact range of fault location instead of exact fault location.

3.7 APPLICATIONS:

1. Fault detection in underground power cable.

2. It is also used in fault detection in communication cable.

3. Monitoring fault in Industrial Lines.

4. Monitoring fault in Residential Lines.

5. Monitoring fault in Overhead Lines.

ANALYSIS

CHAPTER 4

ANALYSIS

The arduino based underground cable fault locator system is designed to give the distance of fault occurrence in the underground cables. In this system, there are 3 cables (R, Y and B) into which faults are inserted artificially with the help of switches. There are total 12 switches used in the system for fault creation, each cable is inserted with 4 switches at different assumed distances of 2 km, 4 km, 6 km and 8 km from the supply side respectively.

The main function of switches is to short circuit the particular cable with the sensor cable at the moment of fault occurrence or at the moment of turning ON the switch. This enables the sensor cable to get the input about fault and transfer this data to the microcontroller. Microcontroller is programmed such that it will analyse the data and print the final result on the LCD screen.

As the system uses 12 switches, they are divided into 4 sets, each set comprises of 3 switches as shown in the diagram below:

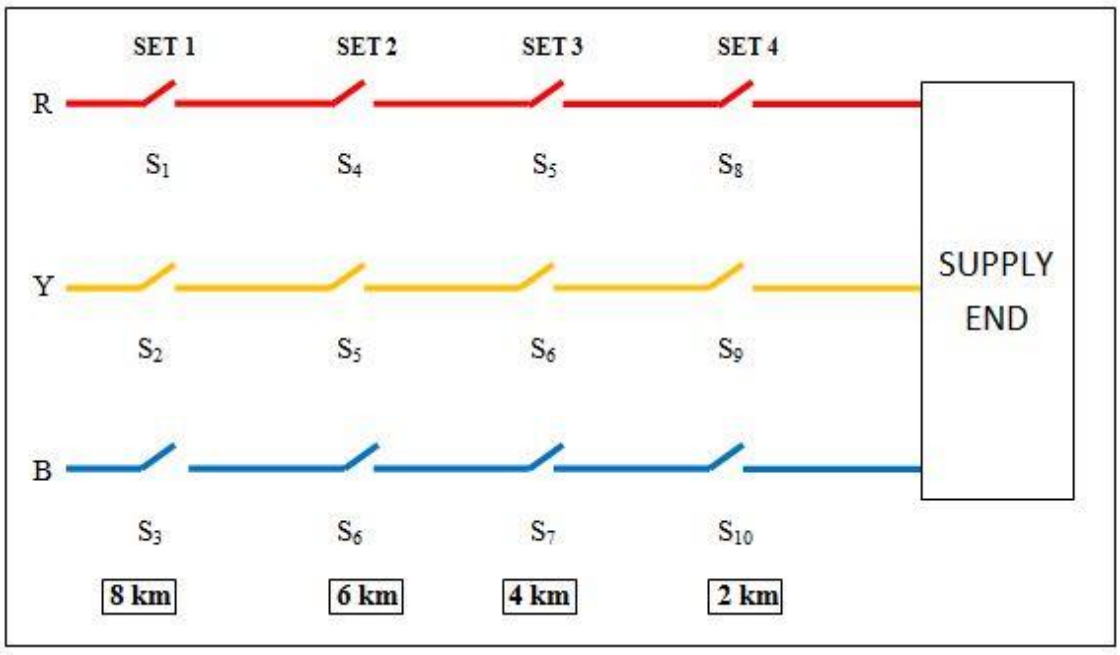

Fig.16. Switches Setting

The above diagram represents the basic design of the prototype. One end of the system is the supply side while another end is the base station that consists of the main circuit including relays, arduino and LCD display. The fault location is the distance in km from the supply end.

The result of this system is classified on the basis of 2 conditions listed below:

1) Single fault on one single line
2) Three/ multiple faults on one single line

1) **Single fault on one single line:**

In this category, fault can be created in two ways:

a) Single fault in the system at an instant : only one fault is created in the whole system at an instant of time

b) Multiple faults in the system at an instant : multiple faults are created in the system at an instant of time

Sr.no	ON switches	Status at R	Status at Y	Status at B
1.	S_1	8km	N.F	N.F
2.	S_2	N.F	8km	N.F
3.	S_3	N.F	N.F	8km
4.	S_4	6km	N.F	N.F
5.	S_5	N.F	6km	N.F
6.	S_6	N.F	N.F	6km
7.	S_7	4km	N.F	N.F
8.	S_8	N.F	4km	N.F
9.	S_9	N.F	N.F	4km
10.	S_{10}	2km	N.F	N.F
11.	S_{11}	N.F	2km	N.F
12.	S_{12}	N.F	N.F	2km

Table1.SingleFaultInTheSystem

Type 1				
Sr. no	ON switches	Status at R	Status at Y	Status at B
1.	S_1 S_5 S_9	8 km	6 km	4 km
2.	S_4 S_8 S_{12}	6 km	4 km	2 km
3.	S_7 S_{11} S_3	4 km	2 km	8 km
4.	S_{10} S_2 S_6	4 km	8 km	6 km

Table2.a. Multiple Faults In The System

Type2				
Sr.no	ON switches	Status at R	Status at Y	Status at B
1.	S_1 S_5 S_9	8km	6km	4km
2.	S_4 S_8 S_{12}	6km	4km	2km
3.	S_7 S_{11} S_3	4km	2km	8km
4.	S_{10} S_2 S_6	4km	8km	6km

Table2.b.MultipleFaultsInTheSystem

Three/ multiple faults on one single line:

In this category, the fault occurs on two different locations on a single cable but for a particular cable, LCD can display only one fault at a time. In this case, the fault that is nearer to the arduino is shown first and once it is fixed another fault becomes visible automatically. It should be noted that LCD screen will continue to show a single fault which is nearer to the microcontroller and not toggling between two different faults. Table 1.3 and 1.4 indicates the step wise display of such faults.

Step 1				
Sr. no	ON switches	Status at R	Status at Y	Status at B
1.	S_1 S_4 S_7 S_6	8 km	N.F	6 km
2.	S_5 S_8 S_{11} S_{10}	2 km	6 km	N.F
3.	S_9 S_{12} S_3 S_2	N.F	8 km	8 km

Table 3.a. Multiple Faults Occurred At One Line

Step 2 (after fixing faults of step 1)				
Sr. no	ON switches	Status at R	Status at Y	Status at B
1.	S_4 S_7	6 km	N.F	N.F
2.	S_8 S_{11}	N.F	4 km	N.F
3.	S_9 S_{12}	N.F	N.F	4 km

Table 3.b. Remaining Faults From Step 1

Step 3 (after fixing faults of step 2)				
Sr. no	ON switches	Status at R	Status at Y	Status at B
1.	S_7	4 km	N.F	N.F
2.	S_{11}	N.F	2 km	N.F
3.	S_{12}	N.F	N.F	2 km

Table3.c.RemainingFaultsFromStep2

CONCLUSION

CHAPTER 5
CONCLUSION

5.1 CONCLUSION

Presently, this system provides the data of fault location at the assumed and designed distances , this data is quite exact and particular to the fault occurrence but, when the fault occurs somewhere between the these assumed distances and not at exact points, the system is capable of providing a range or two points between which this random fault has occurred. The distance between the two points obtained is to be dig out in order to carry out maintenance. This makes it somewhat similar to the conventional methods (i.e. the whole cable had to be dig out), the only difference is, instead of digging out whole cable, here only a range of distance is required to be dug.

Implementation of the proposed project titling “arduino based underground cable’s fault locator system” will be proven more advantageous over the conventional methods such as sectionalizing, thumping, TDR, etc. as all these conventional methods requires the whole cable to be dig out in order to locate the fault point and carry out the maintenance work. When the cable is completely dig out, by using above methods it may take hours, days, weeks or even months to locate the exact fault distance. With increasing time, the labour cost also increases. Whereas use of this project will give the exact range in which the fault lies and hence only desired distance is needed to be dig out for the maintenance purpose. As this system eliminates the need of digging out excessive distance hence it also reduces the cost of labour and also the time taken to locate the fault distance. This makes our proposed system of ‘arduino based underground cable’s fault locator’ a better option for commercial purposes.

5.2 FUTURE SCOPE

For future works and purposes, the system can be turned more precise and accurate. The fault distance obtained on the LCD screen is evaluated in the program logic that means there is certain distance value for every fault occurring in the cables. The accuracy can be improved by increasing the number of connections of sensor cable with respective R, Y and B cables and ensuring that these connections are done at same distances as that mentioned in the program. For instance, at present the system is divided into 4 distance values that are 2 km, 4 km, 6 km and 8km, but for greater accuracy, the program and hardware can be modified with more number of distance values like 1 km, 2 km, 3 km, 4 km, 5km…. so that for faults occurred between any two fixed or assumed points there will be less distance to be dug and fault location can be carried out in lesser time. For even more accuracy, the above distances can be further divided as 0.5 km, 1 km, 1.5 km, 2 km, 2.5 km, 3 km and so on.

For the actual installation, it is required to set up a control room or base station that houses an LCD screen to keep the track of or display the cable faults but installing the LCD might be an unnecessary expense for any small scale industry. In this case GSM module can be employed in the control room, GSM module is a device in which the user can insert his mobile's SIM card and connect the mobile to the GSM device. At the instance of fault occurrence, a text message is sent to the connected mobile device showing the fault location. Use of GSM device also helps keeping a detailed record of all the faults occurred over a particular period of time.

Both the above proposed advancements in the system compulsorily require a base station to be set up. But it is possible to track the faults without a need of setting up a base station. By using IOT (i.e. Internet of Things), it is possible to publish the data (fault location) online over the internet. The websites like 'adafruit', 'thinkable', 'thing speak', etc. are available using which the IOT based project can be implemented. Wi-Fi module is an additional device required to be connected in the system to enable the online transfer of the data. Use of IOT can enable the user to access the fault location data from any corner of the country.

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