DESIGN AND CONSTRUCTION OF AN UNDERGROUND CABLE FAULT DETECTOR USING ARDUINO

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DEDICATION

This project is dedicated to the universe whose gentle air we breathe, the gentle shrubs provides us with food and under the big burning gas we take our warmth. The universe made me discover of recent that my world is shrouded with abundance. I'll forever be grateful to this amazing world.

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DESIGN AND CONSTRUCTION OF AN UNDERGROUND CABLE FAULT DETECTOR USING ARDUINO

Submitted by

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Has satisfied the regulations governing the award of degree of

BACHELOR OF ENGINEERING (B.ENG) IN ELECTRICAL AND ELECTRONICS ENGINEERING,

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ABSTRACT

Fault measurement is an important part of measurement and instrumentation Engineering, thousands of cables are laid underground every year and it is impossible at the time of writing this project to avoid faults in those laid cables, there is a need for the exact fault location to be detected when cables are laid underground. Underground cable fault detectors prevent unnecessary digging out of cables when the faults occur, when the device measures the exact location of the cable fault it saves time and cost of hiring manpower for unnecessary digging out of cables. This project was achieved using an Arduino R3 board and a voltage divider regulator using a voltage divider resistance measurement technique. This project actually measures the resistance in the cable and determines the length of the cable and an abnormal length measurement indicates that there is a fault in the cable. The main advantage of this project is that it is cheaper than other solutions available in the market today. This project is useful in the Telecommunication cables and in every urban area where cables are laid.

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This acknowledgement would not be complete without thanking my classmates for being part of my world.

Thank you all.

CHAPTER ONE

1.0 INTRODUCTION

The goal of this project is to determine disconnected cable from base station in kilometers using an Arduino Uno R3 board. The underground cable framework is a typical practice followed in numerous urban zones. There are numerous electrical, phone and other cables are laid underground. Many time issues happen because of development works. Around then it is hard to uncover fault because engineers cannot determine the correct area of the fault.

Link is a gathering of a protected cables which is used for transmitting force or corresponding signals. Fundamentally, links are of two sorts: overhead links and underground links. An overhead link is one which is used for the transmission of data on utility posts. The principle of favorable position of overhead links is that when a fault happens, it is simple to recognize the fault yet the burden in these links effortlessly gets influenced because of the ecological factors such as snow, storms, overwhelming precipitation falls, etc., Underground links are intended to keep away from the detriment caused in overhead links. Be that as it may, when the fault happens in an underground link, identification what's more, fixing of those shortcomings is difficult and furthermore time taking as they are covered underground. Despite the drawbacks the use of underground link framework for transmission of intensity also, correspondence motions in substantial urban areas are generally expanding due to its own points of interest and efficiency. For the most part one runs over various kinds of issues, for example, cut off, circuit and earth faults in the underground links, what's more, the procedure of fault following without knowing the area identified with that specific link is difficult. [1]

Different types cable faults

1. **Short circuit Fault**

Short out can be controlled by estimating obstruction between two links toward one side (base station). The estimation of opposition discloses to us the correct area of short out.

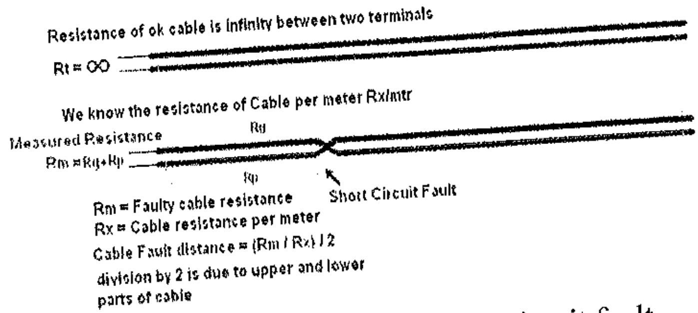


Figure 1.1 Short circuit fault

2. Open Circuit Fault

Open Circuit can be identified by estimating the capacitance between two wires. Capacitance of link changes as per the length. The length of link fluctuates dependent on the area of link cut (open). As the link is open parallel wire capacitance gets diminished dependent on this we can compute the fault area.

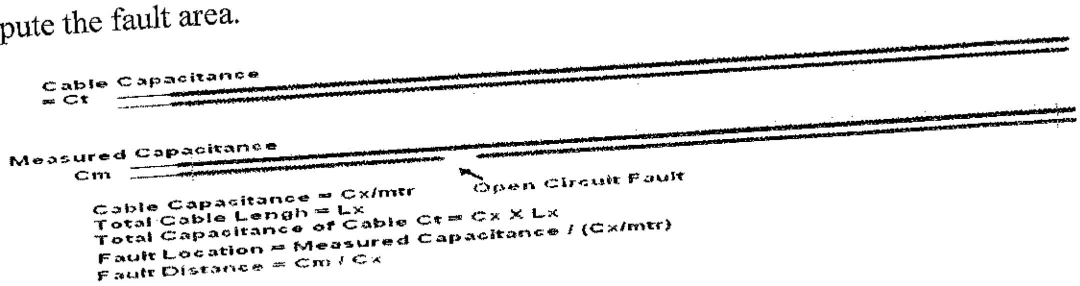


Figure 1.2 Open circuit fault

3. Earth fault

Earth fault happens when the link protection gets harmed. In this case every one of the conductors in the link interact with the earth also, because of this the current don't flow through the heap. Up to this point, many have actualized circuits for recognizing short out flaws and earth shortcomings. In this project, we have broadened the circuit for recognizing open circuit fault alongside short-circuits flaws. [2]

METHODS OF FAULT DETECTION

The methods of fault detection are given below:

1. Disconnected Method

This technique utilizes an exceptional instrument to try out administration of link in the field. Disconnected strategy is ordered into two strategies, for example, tracer technique and terminal strategy.

2. Tracer Method

In this strategy fault of the link can be recognized by strolling on the link lines. Fault area is signified from electromagnetic flag or capable of being heard flag. This strategy is utilized to discover the fault area precisely. [2]

3. Terminal Method

Terminal strategy is utilized to recognize the area of the fault in a link from one end or both the closures without following. This strategy is utilized to discover general regions of the fault to quicken following on covered link. [2]

1.1 BACKGROUND OF THE PROJECT

The background of this project is to locate the correct area of the fault. The undertaking utilizes the standard idea of Ohms law i.e., when a low DC voltage is connected at the feeder end through a Cable lines, at that point current would differ contingent on the area of fault in the link. In the event that there is a short out (Line to Ground), the voltage crosswise over arrangement of cables, which is then encouraged to inbuilt ADC of Arduino board to create exact advanced information for presentation in kilometers.

This project is amassed with an arrangement of resistors speaking to link length in KM's and fault creation is made by an arrangement of resistors at each realized KM to cross check the precision of the equivalent. The fault happening at a specific separation and the individual stage is shown on LCD interfaced to the Arduino board. Further this project upgraded by estimating capacitance of link which can even find the open circuited link. Power Transmission should be possible in both overhead and additionally in underground cables. But not at all like underground links the overhead links have the downside of being effortlessly inclined to the impacts of rainfall, snow, thunder, lightning etc. This requires links with reliability, increased safety, ruggedness what's more, more prominent service. Underground links are favored in numerous regions uncommonly in urban places., When it is anything but difficult to distinguish and revise the shortcomings in overhead line by negligible observation, it isn't conceivable to do as such in an underground cable. As they are covered somewhere down in the dirt it is difficult to identify the anomalies in them. Even when a fault is found to be available it is exceptionally hard to distinguish the correct area of the fault. This prompt digging of the whole region to recognize also, rectify the fault which causes wastage of cash what's more, labor. It is important to know the correct area of shortcomings in the underground links. [3]

1.2 STATEMENT OF THE PROBLEM

The target of this task is to decide the separation of underground link fault from base station in kilometers using an Arduino Uno R3 board. The underground link framework is a typical practice followed in numerous urban regions. While a fault happens for reasons unknown, around then the fixing procedure identified with that specific link is troublesome because of not knowing the correct area of the link fault.

The proposed project is to locate the correct area of the fault. The project uses the standard idea of Ohms law i.e., when a low DC voltage is connected at the feeder end through an arrangement resistor (Cable lines), at that point current would shift contingent on the area of fault in the link. In the event that there is a short out (Line to Ground), the voltage crosswise over arrangement resistors changes in like manner, which is then encouraged to inbuilt ADC of Arduino board to create exact computerized information for presentation in kilometers.

This project is achieved by testing different types of cables and how their resistance changes with length to get the precise value of resistance for every length of a cable. Further this project can be upgraded by using a capacitor in an air conditioner circuit to gauge the impedance which can even find the open circuited link, not at all like the short-circuited fault just utilizing resistors in DC circuit. [4]

1.3 MOTIVATION

My motivation about underground cable fault detector that underground cable links offer a moderate and legitimate arrangement for basic parts and now and again the whole length of overhead high voltage electrical cables. With proper innovation used in suitable spots, the natural effect of underground links can be limited.

There are different motivations about underground cable fault detector using Arduino are:

1. Underground cable fault detector using Arduino need less maintenance
2. Underground cable fault detector using Arduino can detect all short circuit faults
3. Underground cable fault detector using Arduino is cost effective.
4. Underground cable fault detector using Arduino have less complexity.
5. Arduino underground cable fault detector can be used for any type of cable.
6. Arduino underground cable fault detector can be used for any type of cable.

1.4 SIGNIFICANCE OF STUDY

This project provides a method of measuring an underground cable fault with a with Arduino R3 feedback network. The device is different from other previous devices because if provides a cheap way of measuring an underground cable fault without compromising its accuracy. This project can be used to detect underground cable faults in various industries and underground telecommunication lines.

1.5 PROJECT AIM AND OBJECTIVES

The aim of this project is to design and construct an underground cable fault detector that is capable of locating the exact fault location of cable using Arduino Uno R3. The objectives of this project are:

1. To design a low-cost method of detecting cable faults in underground cables without compromising its efficiency.
2. To determine the extent of which resistance varies in cable of various lengths and materials.
3. To use Arduino R3 feedback pins for testing the resistance and length variation of cable.

1.6 SCOPE OF THE PROJECT

The undertaking identifies just the area of the circuit fault in underground link line, yet it can likewise be reached out to recognize the area of an open circuit fault. We are able to recognize the correct area of short circuit fault in the underground link from feeder end in kilometers by using Arduino Uno R3 board. In future, this task can be executed to ascertain the impedance by using a capacitor in an AC circuit furthermore, in this manner measure the open circuit fault. We have assessed the area of short circuit flaws also, open circuit fault in the underground link from base station in km by utilizing Arduino. In future, we can to identify earth fault using an Arduino keyboard and a GPS module.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

A large number of researchers have made their contributions towards developing techniques for underground cable fault measurement. The different underground measuring methods they applied have made my task different from each one of them. In this chapter, I will review past works on underground cable fault detection.

2.1 RELATED WORKS

The authors in [5] worked on an underground cable measuring technique using the Murray loop test, this method uses a transmitter and receiver unit. In order to determine the location of fault in a cable, first, the cable is isolated from both the feeder end and consumer end using a megger to check the type of fault in the cable, after isolating the cable, the core and shielded from the underground cable and it is then connected to the output terminals of the transmitter unit. The transmitter unit consists of step up transformer with output controller and delay timer for injecting a series of high voltage pulse streams into the faulted cable shortly after the cable fault has been established. The receiver unit is traced along the length of the cable. The fault in the UG cable produces arcing which is accomplished by high frequency noise. The effect of noise caused by arcing voltage is received by a receiver.

In [6], the authors used a bridge circuit used for locating faults in underground or underwater cables. It uses the principle used in potentiometer experiment. One end of the faulted cable is connected through a pair of resistors to the voltage source. A null detector is also connected. The other end of the cable is shorted. The bridge is brought to balance by changing the value of the resistors.

In [7], the authors proposed a modified Murray loop test using a GSM module which is an improvement of authors [6] work. The system Proposed system is used to find out the exact location of the fault and sends an SMS with details to a remote mobile phone using GSM module.

Authors [8] worked on a project is to determine the underground cable fault. This project uses the simple concept of computer tomography theory, when any fault like short circuit occurs, voltage drop will vary depending on the length of fault in cable, since the current varies computer tomography 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

Authors [9] proposed an impedance-based fault location method for phase-to-phase and three phase faults. This method measures impedance by using a distance relay and the super imposed current factor to discriminate the fault location. The method they proposed is sensitive to the measured impedance accuracy and super imposed current factor.

In [10], the authors, they used shunt admittances between the core and sheath, and the sheath and earth. The method they proposed first determines all these impedances and admittances from the cable dimensions, cable material properties, and the earth parameter conduction and skin effects. Next, the admittance matrix of a single cable, relating the voltages and currents at its two ends, is then calculated from the given dimensions and material properties of the cable, and earth conductivity. The admittance matrix of the cable can then be compared with the experimental admittance matrix obtained from the voltage and current measurements at the ends of the cable.

Authors [11-13] worked on estimating the parameters of a multi-conductor transmission line and that of a single-phase transformer that can be found in [11-13]. The practical utility of the proposed approach used in [11-13] is that this approach is able to determine the component parameters analytically without using the well-known estimation theory using existing methods. The proposed work is sufficient to determine the cable parameters from a single set of simultaneous measurements at the two ends of the cable and know whether the ageing process has started in the cable.

Authors [14-16] proposed a multi-conductor transmission line and that of a single-phase transformer, the practical utility of the proposed approach used in [15-17] is that this approach is able to determine the component parameters analytically without using the well-known estimation theory used in existing methods. The proposed method is better than [11-13] because it is sufficient to determine the cable parameters from a single set of simultaneous measurements at the two ends of the cable and know whether the ageing process has started in the cable.

The authors in [17] presented behaviour of simultaneous fault signals in distribution underground cable using dead weight tester (DWT). The simulations were performed using ATP/EMTP, and the analysis behaviour of characteristics signals was Performed using a deadweight tester. Various case studies were carried out including the single faults and simultaneous faults.

Authors [18] presented underground cable fault detection and identification with Fourier analysis. They proposed a method using impedance calculation via sending end voltage and differential voltage can be used for differentiating between the different types of cable defects from phase information. It needs study to be conducted to find the best way of visualizing the results, especially the magnitude response.

Authors [19] presented an automatic fault location method using TDR. This method uses acquired data from an existing time domain reflectometer (TDR) instrument. It enables the engineer of TDR equipment to locate a short circuit cable faults without user interpretation.

Authors [20-21] developed a resilient incipient fault location algorithm in the time-domain, which utilizes data collected by PC monitors to estimate the fault location in terms of the line impedance by taking into account the arc voltage associated with the incipient cable faults. The algorithm they proposed predicts cable fault location between two adjacent manholes. The ANNs are a family of statistical learning algorithm inspired by biological neural networks and are used to appropriate functions that depends on the large number of inputs. The proposed algorithm pin-points the exact fault in the underground cable.

Authors [22] proposed an underground cable fault detector using a shock discharge method, high voltage surge tester is used to generate spark at fault position which produces noise and vibrations in fault site set and exact fault point is located by detecting the fault. The surge wave device is a high voltage pulse generator consisting of a dc power supply and a high voltage capacitor. The power supply is used to charge the capacitor into the cable under test. If the voltage is enough to break the fault, the energy stored into the capacitor is suddenly discharged into the cable producing sound and vibrations which is also called "thump" and this device is called as voltage thumper and is called as shock discharge method. The result found in author [22] proposed technique provides satisfactory result and will be very useful in the development of power systems protection schemes in the future.

Authors [23] proposed a system that uses robot technology, a detection robot consists of a signal generator part and robotic part. Short circuit cable is checked for its continuity by passing through a 3 KHz low frequency signal. A signal generator can be used to generate this signal. The AC signal passing through wire produces a magnetic field around it. This magnetic field is sensed by the robot using a inductor circuit. The AC signal sensed by robot is then amplified using a LM386 circuit. This amplified signal is then rectified and converted to DC. DC level is provided to the analog input of microcontroller. Microcontroller converts this analog input to digital signal. Based on the program programmed in the microcontroller the robot movement is controlled. When the robot reaches the point where the discontinuity lies, the magnetic field will be zero. In such case the input signal at the analog input port will be substantially low. When the input signal strength is less than 10 (binary reading), the PIC is programmed to display, short circuit Detected and is displayed in LCD.

Authors [24] improved on [23] design by adding a GSM and SMS technology, their proposed system is made up of robot designed who will find out correct location of fault then by using GSM technology SMS will send cable information to the main control room. The engineer can directly dig at that point and fix the issue.

Authors [25] used simple OHMs law is used to locate the short circuit fault. A DC voltage is applied at the feeder end through a series resistor, depending upon the length of fault of the cable current varies. The voltage drop across the series resistor changes accordingly, this voltage drop is used in determination of fault location.

Authors [26-27], proposed a system that will combine Arduino and OHMs law where a low DC voltage is applied at the feeder end through a series resistor. The current would vary depending upon the length of the cable fault in case there is a short circuit of LL or LG etc. The series resistor voltage drop changes accordingly which is then fed to an ADC to develop precise digital data which the programmed microcontroller would display the same in Kilo meters.

Authors [28-33], developed a system whose circuit consists of a power supply, [30-31] used 4-line display, Arduino and resistance measurement circuit. To induce faults manually in the kit, fault switches are used. Fault switches are used which are arranged in three rows with each row having 4 switches. The fault switches: have 2 positions, No fault position(NF) and fault position(F). The main component of the underground cable fault detection circuit is low value resistance measurement. It is constructed using a constant current source of around 100mAmps. It can measure very low value resistance as the cables have around 0.01 Ohm/meter resistance. The circuit is able to measure the exact fault location in a cable.

The authors in [34] worked on a high voltage radar technique that overcomes the 200 Ω limitation of low-voltage radar. In addition to the TDR, an arc reflection filter and surge generator is required. The surge generator is used to create an arc across the shunt fault which creates a momentary short circuit that the TDR can display as a downward-going reflection. The filter protects the TDR from the high voltage pulse generated by the surge generator and routes the low-voltage pulses down the cable. Arc reflection is the most accurate and easiest pre-location method. The fault is displayed in relation to other cable landmarks such as splices, taps and transformers and no interpretation is required. Arc reflection makes it possible for the TDR to display "before" and "after" traces or cable signatures. The "before" trace is the low-voltage radar signature that shows all cable landmarks but does not show the downward reflection of a high resistance shunt fault. The "after" trace is the high-voltage signature that includes the fault location even though its resistance may be higher than 200 Ω. This trace is digitized, stored and displayed on the screen and the cursors are positioned in order to read the distance to the high resistance fault.

The authors in [35-40] improved on the previous design in [34] by working on an IoT enabled underground cable fault detection system. 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. The system consists of Wi-Fi module,

Microcontroller, authors [37] used an ATmega328P Micro controller and Real-Time Clock. Authors [41-42] added an 8051 microcontroller to locate the exact type of fault and its location in the cable. [43-44] worked on using various embedded system to make the TDR method of underground cable fault measurement more accurate.

CHAPTER THREE

3.0 METHODOLOGY

Underground cable fault measurement device is an important instrument in the field of measurement and instrumentation in electronics Engineering for measuring and locating exact cable faults without digging the entire length of the cable. Underground cables are difficult to assess because they are buried, fault which occurs in an underground cable might involve digging through the entire length cable which increases manpower, waste time and affects the economy of a nation at large. Faults in underground cables are inevitable as at the time of writing this report, faults can occur in a cable due to excess current, underground heating or artificial disaster. Underground cable measuring device is also useful in detecting faults in underground telecommunication lines like fiber optics cable.

This project was constructed with Arduino Uno R3 board and other components, I am using 16x2 LCD for this project to display the result of an underground cable fault. The resistance measuring device gives the digital equivalent length of an underground cable fault by taking a feedback from pin 2 of an Arduino Uno R3 board. The power circuit ensures that 12V gets to the rectifier unit, the rectifier unit with the LM7808 voltage regulator ensures that exactly 8v gets into the LCD to get a bright and clear display.

3.1 REQUIREMENTS AND SPECIFICATIONS

The circuit is constructed using an Arduino Uno R3 board and an LM317T voltage divider regulator, I used a 16 X 2 Liquid Crystal Display (LCD) to display the underground cable fault, the LCD is connected to the feedback pins of the Arduino board from pin 1-7, Which is compared to the base resistor set in the circuit.

The simulation is done with Proetus software and assumes that the Arduino board is already powered but in the implementation of the circuit an 8V power supply was supplied to the Arduino board to ensure that the board is powered and the LCD get the required 5V from the Arduino board to ensure the brightness is up to standard.

Circuit diagram for the project is shown below:

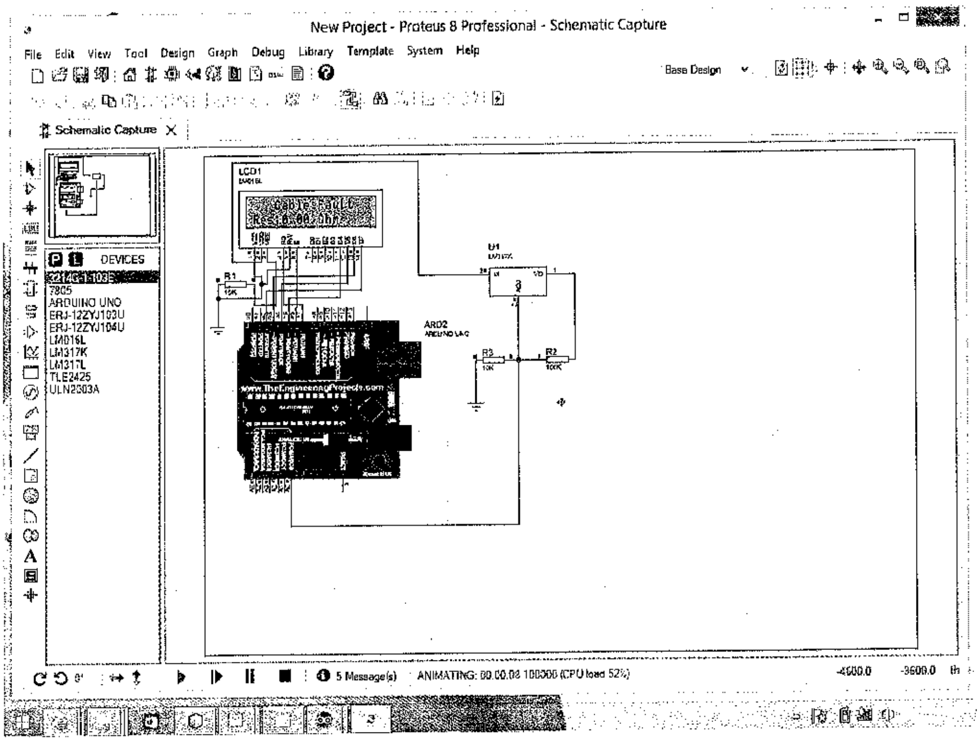


Fig 3.1 Circuit diagram (Proteus circuit simulation)

1. **Step down transformer**

A step down transformer is the first part of the regulated power supply. To lower the 230v AC, we need a step down transformer to get our desired. 12v output. The main features of a step down transformer are:

1. Power transformers are desired to operate on a low impedance source at a single frequency
2. It is necessary to build with a sufficient dielectric
3. The volt amplifier of each winding or secondary winding is added to the secondary VA total. To this are added losses.
4. Raising the temperature of a transformer is decided on two well-known factors, namely unit decided on two well-known factors namely losses provided by the transformer dissipation heating or cooling. [45]

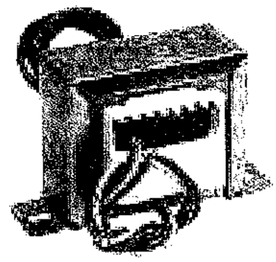


Fig 3.2 A transformer

2. **Diodes**

A rectifier is used to convert alternating current into direct current by pulses. Semiconductor diode is used as a grinding member because of its property to conduct current in one direction. Generally, there are two types of rectifiers.

1. Half wave rectifiers
2. Full wave rectifiers

In half wave rectification, only the half cycle of the positive side of the wave is corrected which is inefficient. For the sake of this project, full wave rectification was used. A hybrid diode network was used to achieve full wave rectification for this project.

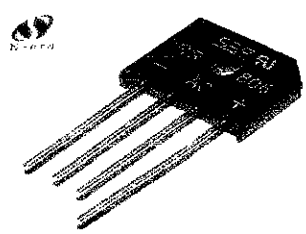


Fig 3.3 Hybrid diode

3. Voltage regulators

A voltage regulator is an electrical controller designed to automatically maintain the same voltage level. In this project, 8V voltage regulator connected to the end of a power supply is required. The choice of the voltage regulator is because the Arduino required input is 7-12V, 7808 regulator was used to achieve this result 78 represents a positive power supply while 08 represents the output voltage of the regulator.

Another voltage divider regulator (LM317T) was used during the project. LM317T is an adjustable voltage regulator They are designed to supply more than 1.5 A of load current with an output voltage adjustable over a 1.2 to 37 V range. The nominal output voltage is selected by means of a resistive divider, making the device exceptionally easy to use and eliminating the stocking of many fixed regulators. Key features of an adjustable voltage regulators are:

1. Output voltage range: 1.2 to 37 V
2. Output current in excess of 1.5 A
3. 0.1% line and load regulation
4. Floating operation for high voltages
5. Complete series of protections: current limiting, thermal shutdown and SOA control

In the case of this project, adjustable voltage control regulator was used to measure the resistance of the cable to locate short circuit fault distance in the cable [46]

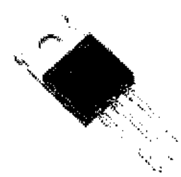


Fig 3.4 Voltage regulator

Type number	Output voltage
7805	+5.0 V
7806	+6.0 V
7808	+8.0 V
7809	+9.0 V
7812	+12.0 V
7815	+15.0 V
7818	+18.0 V
7824	+24.0 V

The 7800 series

Fig 3.5 78xx voltage regulators table

4. Liquid Crystal Display (LCD)

LCD known as Liquid Crystal display is the eye of the project. LCD display used in this project is 16 X 2 display. 14 pins are connected to the Arduino boards for feedback and output. LCD takes power directly from the Arduino board (5V) power supply. It displays the distance of the cable fault according to the C++ code.

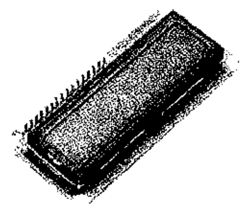


Fig 3.6 Liquid Crystal Display

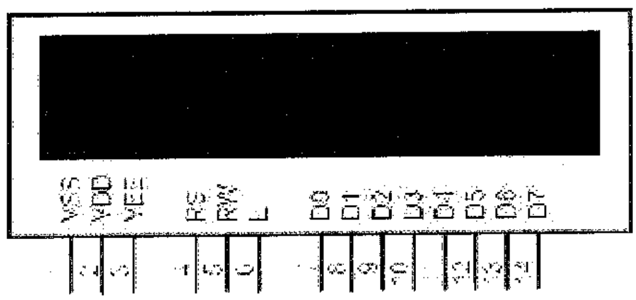


Fig 3.7 Liquid crystal display pins

Pin No	Symbol	Level	Description
1	Vss	0 V	Ground
2	Vdd	5.0V	Supply voltage for logic
3	Vo	variable	Operating voltage for LCD
4	RS	H/L	H: data, L: instruction code
5	R/W	H/L	H/Read (MPU→Module) L/write (MPU→Module)
6	E	H, H-L	Chip enable signal
7	DB0	H/L	Data bit 0
8	DB1	H/L	Data bit 1
9	DB2	H/L	Data bit 2
10	DB3	H/L	Data bit 3
11	DB4	H/L	Data bit 4
12	DB5	H/L	Data bit 5
13	DB6	H/L	Data bit 6
14	DB7	H/L	Data bit 7
15	A		Power supply for LED backlight (+)
16	K		Power supply for LED backlight (-)

Fig 3.8 Liquid Crystal Display pins description

5. Arduino Uno R3 board

The Arduino UNO is an open-source microcontroller board base the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 12 volts. Arduino Uno programming language is C++ which code was used to measure the distance of the cable in my project. [47]

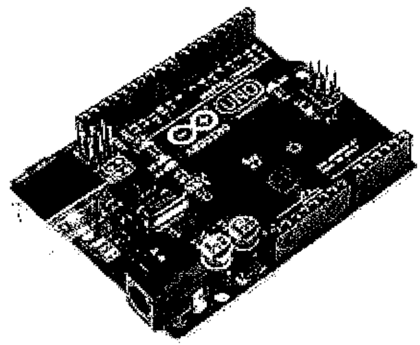
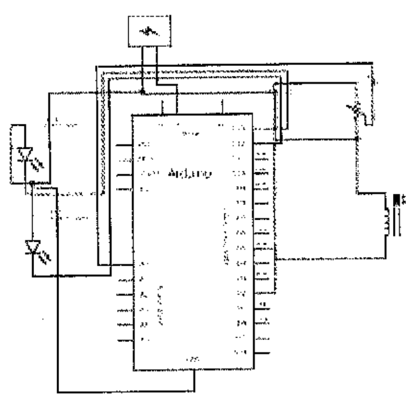


Fig 3.9 Arduino Uno R3 board



3.10 Arduino Uno architecture

6. 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 [48]. Resistors are very important components of both electrical and electronics engineering. In this project resistors are used to limit voltage and to measure an unknown resistance.

Fig 3.11 Resistors

Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

Fig 3.12 Resistor colour coding table

7. C++ programming language

C++ is a middle-level programming language developed by Bjarne Stroustrup starting in 1979 at Bell Labs. C++ runs on a variety of platforms, such as Windows, Mac OS, and the various versions of UNIX. This tutorial adopts a simple and practical approach to describe the concepts of C++. C++ programming language is simple, fast, object oriented and efficient. C++ is used in programming the Arduino board with full instruction on how code running and feedback measurement. [47]

Fig 3.13 C++ logo

3.2 Design

This system was constructed using Arduino Uno R3, LCD and voltage regulators voltage regulator is used to divide the resistance of the cable and the resistance of the known resistor with the help of the voltage divider theorem. The Arduino Uno R3 board is powered by an 8V power supply through the power supply unit of the circuit.

The design of the project was started with the drawing of the block diagram, the block diagram gave the whole concept of what the project would look like and how the components of the project would communicate to give a perfect design. The block diagram of the project is shown below:

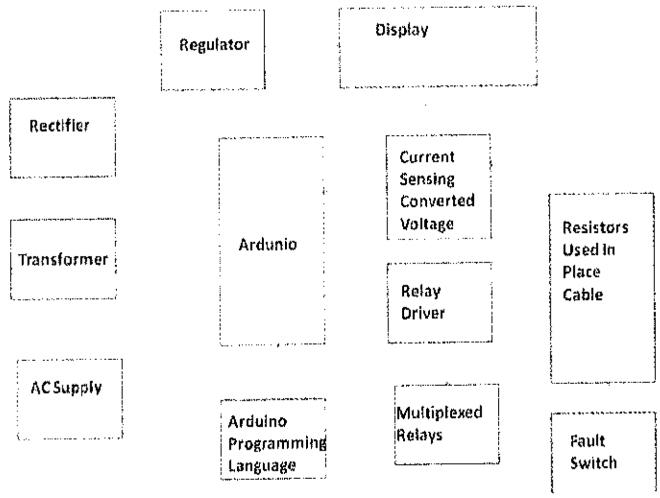


Fig 3.14 Block diagram

Power supply

A 12V input is received from the transformer is fed into the for diodes according to the arrangement shown above the output of the diode is a pulsating DC and it is fed into the input of the 8V regulator. The 8V regulator is directly connected to the power input of the Arduino Uno R3 board.

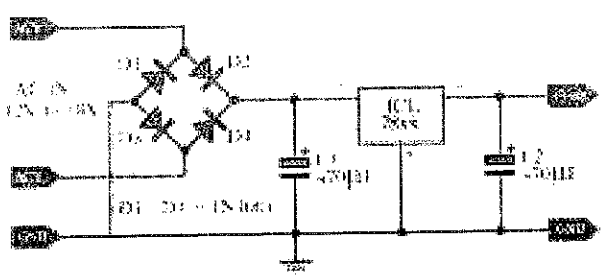


Figure 3.15 Rectifier circuit

Control Unit

The circuit is consisting of a 4-line liquid crystal display, Arduino and resistance measurement circuit. Main component of the underground cable fault detection circuit is low value resistance measurement. It is constructed using a constant current source of

100mAmps. It can measure very low value resistance as the cables have around 0.01 Ohm/meter resistance. The iterative values obtained overtime is used to calculate the distance to resistance ration of cable and it is used to calibrate the Arduino Uno R3 board. This circuit can measure resistance up to 50-ohm, maximum cable length the circuit is able to check is 2500 meters

Software Unit

For the software, I used Arduino Uno desktop application which is built on a C++ platform. The Arduino pins are connected directly to the LCD and a pin was used for the feedback from the transistor. The output of LM317T is connected to pin A0 of the Arduino Uno R3 board for feedback measurement.

Code used for the project

```
/* Arduino Based Underground Cable Fault Detection */
// include the library code:
#include <LiquidCrystal.h>
// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);
const double Rc = 0.01;   //Cable Resistance per meter its 0.01 Ohm/Mtr
void setup() {
// set up the LCD's number of columns and rows:
lcd.begin(16, 4);
// Print a message to the LCD.
lcd.print ("Cable Fault ");
}
void loop() {
double Vx=(5.0/1024.0) * analogRead(A0); //Voltage across Rx
double Rx = Vx / (1.25/12); //Cable Resistace  (1.25/R2)=I Constant Current Source
//Display Cable Resistance
lcd.setCursor(0, 1); // set the cursor to column 0, line 2
lcd.print("Res:");
lcd.print(Rx);
lcd.print(" Ohm");
```

```
//Display Fault Location
lcd.setCursor(0, 2); // set the cursor to column 0, line 3
lcd.print("Dist:");
lcd.print((Rx/Rc)/2); //Find Location of Fault
lcd.print(" Mtr");
}
```

CHAPTER FOUR

4.0 TESTING, ANALYSIS AND DISCUSSION

The processes, procedures and testing of this project are described in details in this chapter.

CONSTRUCTION PROCEDURE

In building this project, the following procedures were dully followed

i. Purchasing of materials needed for the project
ii. Testing of the components involved in the project
iii. Drawing a sketch for better understanding of the project
iv. Testing the completed system
v. Implementation of the design of the project

After purchasing the materials, I tested components by using a digital multimeter and latter tested the components by arranging them in a breadboard and after arranged the components into the Vero board, I soldered the components carefully into the Vero board after and I positioned the circuit neatly into the casing after.

INSTALLATION OF THE COMPLETED DESIGN

The project can be used effectively to measure underground cable fault. It is recommended that the system is plugged into a 200-220v power supply to avoid wrong readings.

This system can be placed anywhere there is power supply but should be kept away from water and dangerous gasses.

PACKAGING

The packaging of this project is started arranging the components circuit and the remaining component to the adapter box, the transformer is bolted to the body of the adapter box while the remaining components were glued to the adapter box. External components such as the Liquid Crystal Display and the light emitting diode are all included in the casing.

ASSEMBLING OF SECTIONS

Having achieved the casing and finishing the construction of the system, the assembling and component casing followed. The sections were laid out and assembled into the casing where the general coupling took place.

Finally, the main plug and the LED were brought out of the casing, they are the external part of the project. The cable is connected to a 13 Amp socket and the whole casing is permanently screwed together.

4.1 TESTING

At this stage, the system is due for testing and operation. The system operations were tested with the following steps:

i. Getting different types of cables.

ii. The system is connected to the power supply.

iii. The cable fault is manually measured.

iv. The project hardware is used to measure cable fault.

4.2 ANALYSIS

The table below shows the difference between manual measurement and device measurement.

Manual reading (cm)	Project reading (cm)
102	101
130	130
170	169
200	200
400	400

Table 4.1 Manual measurement and device measurement comparison

The table below shows the graph of device measurement against actual measurement.

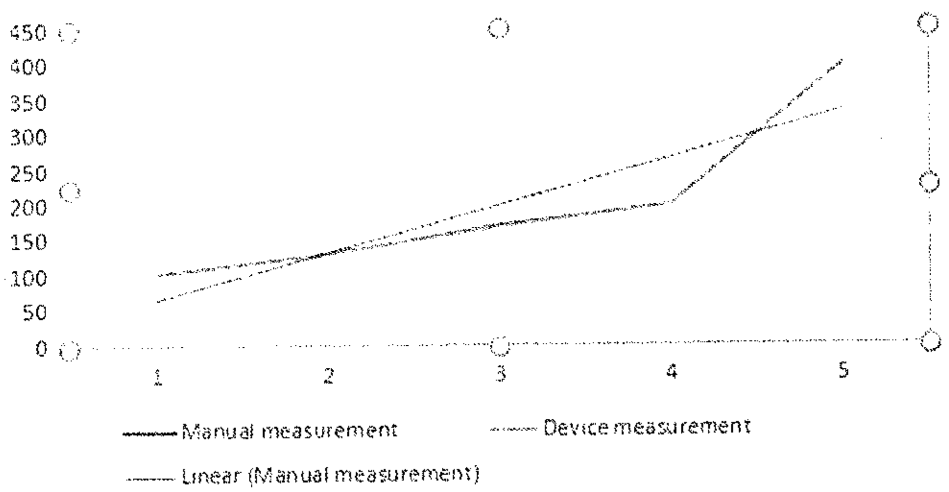


Figure 4.1 Device measurement against manual measurement

COST ANALYSIS

The cost of the project and the quantity of materials purchased are listed in the table below:

Materials/components	Description	Quantity	Unit price (naira)	Total price (Naira)
Transformer	12V/220V, 500mA	1	500	500
Rectifier		1	100	100
Plug		1	100	100
Resistors		5	10	50
LCD		1	1500	1500
Arduino Uno R3		1	3000	3000
Connecting wire		1	300	300
Led (solder)		1	200	200
Soldering iron		1	700	700
Voltage regulators		2	200	400
Multimeter		1	2000	2000
Vero board	line	1	100	100
Bread board		1	500	500
Adapter box	Casing	1	1500	1500
Shipping & transportation		1	3200	3200
Total				14150

Table 4.2 Cost estimate of the project

4.3 PROJECT MANAGEMENT

The following processes were entailed in the management of the project

4.3.1 PROJECT SCHEDULE

This section shows the task that were carried out in executing this project and the time taken to complete each task. The chart below represents the project schedule.

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 9	Week 10	Week 11	Week 12	Week 13
Literature review												
Task 1												
Task 2												
Task 3												
Task 4												
Task 5												
Task 6												
Task 7												
Task 8												
Task 9												
Task 10												

Table 4.3 Task schedule

Task description

Task 1: Information gathering stage

Task 2: Drawing the circuit diagram and block diagram

Task 3: Acquiring the materials involved in the project.

Task 4: Gathering the required codes

Task 5: Hardware prototyping

Task 6: Hardware implementation stage

Task 7: Soldering and testing of components

Task 8: Hardware testing

Task 9: Rewriting the program code

Task 10: Casing the project

4.3.2 RISK MANAGEMENT

This project involves a lot of electronic components, over voltage due to voltage leak and overvoltage due to malfunctioning equipment like the transformer. Electric shock was also a risk when testing the project.

4.3.3 SOCIAL, LEGAL, ETHICAL AND PROFESSIONAL CONSIDERATION

The system has been built with a high standard of ergonomics in place, the users of the product can easily understand the final output without further calculations. No government laws were encountered when buying the components involved.

No hazard to health the project has zero emissions.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

During the course of undergoing this project has disclosed important things about cable fault measurement to instrumentation engineering, the importance of iterative testing, cost management and project management techniques. The importance of automatic systems for cable fault measurement, a more efficient way of ensuring the product works without errors for a long time.

In this project I have used the combination of LCD, Arduino Uno R3 and voltage regulators to build a simple and accurate underground cable fault measuring technique.

This project is designed to be used in the industries, commercial areas with underground cables, and in buried telecommunication lines. This product should be operated by a certified professional and should be kept away from water and dangerous gasses to ensure continuous accuracy of the device.

5.1 CONTRIBUTION TO KNOWLEDGE

By successfully finishing this project, I now fully understand how Arduino feedback loop works, how to write programs into a microcontroller and conceptualizations of circuit layout and design into a real-life product. Cost management was also learnt in the course of building this project.

5.2 LIMITATIOINS

A perfect Engineering project is desirable but seems not to exist, which means research must be made continually to improve in technologies and the various ways engineering problems can be solved and projects can be improved. This project in discussion suffers some drawbacks which includes.

i. Lack of proper understanding of the components involved, the project involved a lot of components, Arduino Uno R3 was very difficult to integrate with the project because the value of the resistors must be subtracted from the final output of the Arduino Uno R3 to ensure that the final output is accurate as possible.

ii. Inserting the various materials into the casing was also a challenge involved in the project, the casing must be as small as possible to ensure that the device is as cheap as possible.

iii. The selection of microcontroller was also a challenge, microcontrollers needs to provide fast and efficient feedback loop to ensure accurate result at all times. Arduino Uno R3 was the most cost-effective selection for that.

iv. The heat generated by components if not properly managed can reduce the life span of the device.

5.3 FUTURE WORKS

The following are possible future advancement of this project:

i. Increase the range of the cables that can be measured with the device

ii. An I/O can be added system in which users can communicate with the device to increase the range of the system

iii. The system can be incorporated directly with underground cable network and sends signals to the control room whenever a cable fault is detected.

5.4 CRITICAL APPRAISAL

The importance of underground cable fault measurement in the field of instrumentation engineering cannot be underemphasized the project is very useful in making the project automated instead of random manual digging which wastes time and money and also eliminates trial and error method in checking for faults in cables.

The system is user friendly which allows the user to easily read a cable fault without needing to do another rigorous calculation, the system is very codes allow necessary calculations to be made before returning the cable fault to the user, it is easy to operate, mount and maintain.

REFERENCES

1. A. Pulwama and S. Irum, "Arduino Based Underground (Single Phase) Cable fault detector," *Department of Electronics and communication engineering, IUST Awantipora, J & K*, [online], pp. 1-4, 2011.

2.M. R. Thakur, "Arduino Based Underground Cable Fault Detection," [online], assessed 21st December 2018. http://circuit4you.com/2016/05/17/arduino-based-underground-cable-fault-detection/amp/

3. Several contributors, "Arduino based underground cable fault detection, from, *Engineering students project training embedded training six weeks*," [online], 19th December 2018.

4. D. Kehinde, "Cable fault finding guide," [online], assessed 22nd December, 2018. *https://www.slideshare.net/PowerpointEngineering/cable-fault-finding-guide*

5. A. Paulose, A. Ravi, A. Murali and N. John, "Fault Location in Underground Distribution Networks," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, ISSN: 2278 – 8875 Vol. 5, no. 3, pp. 175-176, March 2016.

6. P. Sawatpipat and T. Tayjasanant, "Fault classification for Thailand's transmission lines based on discrete wavelet transform", *International Conference on Electrical Engineering/Electronics Computer Telecommunications and Information Technology (ECTI-CON)*, pp. 636 – 640, 2010.

7. S. C. Kor and V. D. Bavdhane 'Modified Murray Loop Method for Underground Cable Fault Location Detection Using GSM" *International Journal of Science and Research (IJSR)*, ISSN: 2319-7064, pp. 1892-1894, 2016.

8. R. K. Mansingh, R. Rajesh, S. Ramasubramani, M. Tejasri, P. Prajakta and S. Nayan, "Underground Cable Fault Detection," *International Engineering Research Journal*, vol. 2, no 2, ISSN: 2395-1621 pp. 417-419, 2016.

9. H. Shateri and S. Jamali, "Impedance Based Fault Location Method for Phase to Phase and Three Phase Faults in Transmission Systems", *Institution of Engineering and Technology conference*, 0018-1231, pp. 1-5, 2010.

10. S. Indulkar, C. Ramalingam and K. Ramalingam, "Estimation of multi-conductor underground cable parameters from measurements,". *Joint International Conference on Power Electronics, Drives and Energy Systems*, ISSN: 1558-0598 pp. 337-342, 2010.

11. C. S. Indulkar and K. Ramalingam, “Estimation of transmission line parameters from measurements,” *International Journal of Electric Power and Energy Systems*, ISSN: 1451-1521, vol. 30, no. 5, pp. 337-342, 2008.

12. C. S. Indulkar and K. Ramalingam, “Transformer equivalent circuit from field measurements” *International Journal of Electrical Engineering Education*, vol.44, pp. 43-48, 2007.

13. C. S. Indulkar and K. Ramalingam,” Analytical determination of multi-conductor transmission line parameters from measurements”, *National Conference on Advances in Electrical Power and Energy systems*, 2010.

14. C. S. Indulkar and K. Ramalingam, “Estimation of transmission line parameters from measurements,” *International Journal of Electrical Power and Energy Systems*, vol. 30, no. 5, pp. 337-342, 2008.

15. C. S. Indulkar and K. Ramalingam, “Transformer equivalent circuit from field measurements” *International Journal of Electrical Engineering Education*, vol.44, pp. 43-48, January, 2007.

16. C. S. Indulkar and K. Ramalingam, “Analytical determination of multi-conductor transmission line parameters from measurements”, *National Conference on Advances in Electric. Power and Energy systems*, ISSN: 0142-0615, pp. 812-915, 2010.

17. A. Ngaopitakkul, C. Pothisarn, M. Leelajindakrairerk, “Study of Characteristics for simultaneous Faults in Distribution Underground Cable using DWT”, *International Journal of Electrical Engineering Education,* ISSN: 2159-3442, pp. 1116-1121, 2011.

18. A. Pandey, N. H. Younan, “Underground Cable Fault Detection and Identification via Fourier Analysis”, *International Conference on High Voltage Engineering and Application*, ISSN: 1558-4402, pp. 618-621, 2010.

19. S. Navaneethan, J. J. Soraghan, W. H. Siew, F. M. Pherson and P. F. Gale, “Automatic Fault Location for Underground Low Voltage Distribution Networks” *IEEE Transactions on Power Delivery,* ISSN: 0018-9219, vol. 16, no. 2, pp. 346-351, 2001.

20. P. S. Pooja and M. Lekshmi, ‘Fault Detection Technique to pinpoint Incipient Fault for Underground Cables,’ *International Journal of Engineering Research and General Science*, ISSN: 2091-2730, vol. 3, no. 3, 2015.

21. S. T. Sidhu and X. Zhihan, "Detection of Incipient Faults in Distribution Underground Cables", *IEEE Transactions on Power Delivery,* ISSN: 0018-9219, Vol. 25, NO. 3, JULY 2010.

22. S. A. Kale, A. S. Gharpande and G. S. Darvhankar, "3-ph Underground Cable Fault Locator Using Shock Discharge Method" In*ternational Journal of Electrical, Electronics and Data Communication,* ISSN: 2320-2084, pp. 40-42, 2015.

23. J. Althaf, M. Imthiaz and R. Raj "Underground Cable Fault Detection using Robot" *International Journal of Electrical and Computer Engineering (IJECE),* ISSN: 2088-8708, vol. 3, no. 2, pp. 145-151, April 2013.

24. N. R. Radhika., M. S. Swapnali, and T. Gururaj, "Underground Cable fault finding Robot Using GSM Technology and AT MEGA 16 interfacing," *International Journal to publish research paper in the area of civil Engineering, Mechanical Engineering and Energy Science,* ISSN: 2278-2540, vol. 2, no. 2, pp. 27-29, March 2016.

25. D. A. Dhivya, T. Sowmya, "Development of a Prototype Underground Cable Fault Detector," *International Journal of Electrical, Electronics and Computer Systems (IJEECS),* ISSN: 2347-2820, vol. 2, no.7, pp. 1-6, 2014.

26. S. P. Ghodake and P. P. Ingale, "Arduino Based Cable Fault Detector (Fault Detector And Distence Locator)," *International Journal on Recent and innovation trends in computing and communication,* ISSN: 2321-8169, vol. 6 no. 4, pp. 229-231 April, 2018.

27. A. Singh and M. A. Ansari, "Under Ground Cable Fault Detection using IOT" *Advanced Research in Electrical and Electronic Engineering,* ISSN: 2349-5812, vol. 4, pp. 6-8, no. 1, 2017.

28. F. M. Yakub and D. Rojatkar, "Arduino Cable fault Detector: A Survey", *Imperial Journal of Interdisciplinary Research (IJIR),* ISSN: 2349-5162 Vol.4, no. 1, pp.896-905, 2017.

29 K. Padmanaban, S. G. Sharon, N. Sudharini, K. Vishnuvarthini, "Detection of Underground cable fault using Arduino" *International Research Journal of Engineering and Technology (IRJET),* ISSN: 2395 -0056, Vol. 4, no. 3, pp. 2452-2455, 2017.

30. B. Bhuvneshwari, A. Jenifer, J. J. Jenifer, S. D. Devi, G. Shanthi, "Underground Cable Fault Distance Locator" *Asian Journal of Applied Science and Technology (AJAST),"* vol. 1, no. 3, pp. 95-98, 2017.

31. R. Shunmugam., B. Divya., T.G. Janani, N. Megaladevi., P. Mownisha., "ARDUINO BASED UNDERGROUND CABLE FAULT DETECTOR" *International Journal of Recent Trends in Engineering & Research (IJRTER),* vol. 2, no. 4; ISSN: 2455-1457, pp. 17-21, 2016.

32. T. Nandhini, J. Shalini, T. S. Sangeeetha and D. Gnanaprakasam, "Underground Cable Fault Detection using Arduino", *International Journal of Engineering Science and Computing,* vol. 7, o.4 pp. 6460-6463, April, 2017.

33. A. Jagtap, J. Patil, B. Patil, D. Patil, A. A. Husan, and A. Barhate, "Arduino based Underground Cable Fault Detection", *International Journal for Research in Engineering Application & Management (IJREAM),* ISSN: 2454-9150, vol. 3, no. 4, pp. 88-98, 2017.

34. M. F. Badillo, L. N. Navarrete, A. G. Parada and A. C. Miranda, "Simulation and analysis of underground power cables faults" *Elsevier Procedia Engineering,* 2012.

35.N. Sampathraja, L. A. Kumar, K.V. Murthy, V. Kirubalakshmi and C. Muthumaniyarasi, "IOT Based Underground Cable Fault Detector," *International Journal of Mechanical Engineering and Technology (IJMET),* ISSN: 0976-6359, vol. 8, no. 8, pp. 1299–1309, 2017.

36. R. Nithya, S. Manasa, and B. Srikanth, "Underground Cable Fault Distance Locator using GSM" Vol. 5, ISSN: 2348-4470, no. 4, pp. 251-255, 2018.

37. T. Kedia, A. Lal, and A. Verma, "IoT Technology Based Underground Cable Fault Distance Detection System Using ATmega328P Micro controller" *International Journal of Innovative Research in Science, Engineering and Technology,* ISSN: 2319-8753 vol. 7, no. 3, 2018.

38. T. Kedia, V. Sahare, K. K. Bauri, R. K. Sahu, Sanjeev Kumar and Abhijeet Lal, "Arduino Cable Fault Detector," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering,* ISSN: 2278 – 8875, vol. 6, no. 10, pp. 8018-8026, October 2017.

39. B. Y. Swamy, D. R. krishna, C. H. Chandu, K. Venkatesh, and S. Reddy, "Underground Cable Fault Detection," *International Journal for Research in Applied Science &*

Engineering Technology (IJRASET) ISSN: 2321-9653 vol. 6 no. 3, pp. 3060-3064, March 2018.

40. S. Shahir, S. Tariq, A. Bangi and K. Khot, "Underground Cable Fault Detection Using Arduino Microcontroller" *Asian Journal of Applied Science and Technology (AJAST)*, vol. 1, no. 3, ISSN: 2277-9477, pp. 95-98, 2017.

41. G. J. Rao, S. Sharmilla, M. M. Avinash, N. D. Kumar, S. M. Swamy and B. R. Kumar, "Underground Cable Fault Detection Using Arduino Microcontroller" *International Research Journal of Engineering and Technology (IRJET)*, ISSN: 2395 -0056, vol. 4, no. 2, pp.114-118, Feb, 2017.

42. P. S. Warade and K. Lakshman, "Underground cable fault detection using Arduino" *International Journal of Recent Trends in Engineering & Research (IJRTER)*, ISSN: 2455-1457, vol. 2, no. 4; pp. 114-118, 2016.

43. M. Basha, T. Govind and P. G. Reddy, "Arduino Based Underground Transmission Cable Fault Location System" *International Journal of Scientific Research in Science, Engineering and Technology*, ISSN: 2395-1990, vol. 3, no. 2, pp. 896-905, 2017.

44. P. H. Pande, H. M. Polade and D. P. Pawar, "Underground Cable Fault Detection Using Arduino Microcontroller," *International Journal of Electronics, Communication & Soft Computing Science and Engineering*, ISSN: 2277-9477, pp. 114-118, 2017.

45. Wikipedia contributors, "Transformer," [online], assessed 23rd December, 2018. https://en.wikipedia.org/wiki/Transformer

46. Wikipedia contributors, "Voltage regulator" "Step down transformers," [online], assessed 24th December, 2018. https://en.wikipedia.org/wiki/Voltage_regulator

47. Wikipedia contributors, "Arduino," [online], assessed 24th December, 2018. https://en.wikipedia.org/wiki/Arduino

48. Wikipedia contributors, "Resistor," [online], assessed 22nd December, 2018. https://en.wikipedia.org/wiki/Resistor