WALCHAND COLLEGE OF ENGINEERING, SANGLI

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A PROJECT REPORT ON

UNDERGROUND CABLE FAULT DETECTION

Submitted in partial fulfilment of the requirements for the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRICAL ENGINEERING

Submitted by

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CERTIFICATE

This is to certify that the Project Report entitled, "**Underground Cable Fault Detection**" submitted by

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to Walchand College of Engineering, Sangli, India, is a record of bonafide project work carried out by them under my supervision and guidance and is worthy of consideration for the award of the degree of 'Bachelor of Technology' in Electrical Engineering of the Institute.

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ACKNOWLEDGEMENT

We feel immense pleasure in submitting this Project report entitled **“Underground Cable Fault Detection”.**

We would like to convey our deep appreciation to our project Guide Prof.S.L.Shaikh of electrical engineering department for his valuable suggestions and encouragement throughout the duration of the project work.

We would also like to express our gratitude to our head of Department Dr.R.P.Hasabe for providing all the required facilities to accomplish our project.

Our thanks and appreciations also go to our group members, without their support and coordination we would not have been able to complete this project.

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DECLARATION

We hereby undersigned solemnly declare that the report of the project work entitled "**Underground Cable Fault Detection**", is based our own work carried out during the course of our study under the supervision of our Guide **Prof. S.L. Shaikh**

We assert that the statements made and conclusions drawn are an outcome of the project work. We further declare that to the best of our knowledge and belief that the project report does not contain any part of any work which has been submitted for the award of any other degree/diploma/certificate in this University or any other University.

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ABSTRACT

Project aims to model an Arduino board-based cable fault locator of the underground cables from base station. Underground cables are usually used in such locations as urban areas where overhead lines can be affected by adverse weather conditions, in areas where local or state regulations override economic considerations, near airport and other locations where an overhead line may endanger lives, and in scenic areas where appearance is an important consideration.

Even when fault is found to be present in under-ground cable, it is difficult to find the exact location of the fault. Further it requires digging of entire area for detecting and correcting the fault which in turn causes the wastage of money time and man-power. So, it is necessary to find the exact location of the fault Looking into the current technologies and advantages along with accurate and fast fault location, it is proposed to go for a digital/advanced technologies like Arduino, microprocessor, etc. It is expected that these technologies may provide not only fast but also a better accuracy in the results. The cable fault detecting equipment presently being used is comparatively heavy. Further in some cases, only one method is not sufficient and assume fault determination may require more than one method together. In view of the above, this project is a method of underground cable fault detection using Arduino, where it intended to calculate correct and the exact location of a cable fault.

CHAPTER 1
INTRODUCTION

1.1 ELECTRICAL DISTRIBUTION SYSTEM: -

The importance of electrical energy may be felt in practically every aspect of a person's daily life. The electrical power system is divided into four sections: generation, transmission, distribution, and use. The distribution network is one of the most important components of an electrical power system, and it is usually connected directly to the load centre. A utility's electrical distribution network distributes the generated and then transferred electrical energy to customers. Electrical distribution substations step-down transmission line voltage levels between 66 kV and 765 kV to distribution voltage levels, usually 33 kV or less, in the distribution system network. Stepped down voltage is normally 33 kV/11 kV according to Indian norms. Stepped down voltage is normally 33 kV/11 kV according to Indian norms. Overhead electrical lines and underground cable systems can both be used in distribution networks. Utility transformers or customer-owned and operated transformers may be required to reduce or step down voltages at utility customer delivery points to a level of 400 V (three phase) or 230 V. (single phase).

Overhead transmission systems or underground wires can be used to deliver electricity. As a result, proper cable selection in the distribution network is critical in order to ensure the required level of operational reliability while keeping costs in mind.

1.2 UNDERGROUND CABLES: -

Generally Overhead transmission lines are used in most of the distribution systems. It is easy to detect the fault and correct it by near observations in case of overhead system. Due to the present concerns of the urbanization, difficulties have been faced in having Overhead distribution systems. Hence for such crowded and critical areas the underground distribution system is preferred. The underground cables provide the uninterruptable power supply which is not possible with the overhead lines due to the limitations mentioned earlier. However, there are other technical factors which also have made the underground cable to have an edge over the overhead cables which include reduced risks of fault due to external factors like rain, wind and adverse climatic conditions. The underground cables are also free from radio interference. The transmission towers are not required except for the local transformers in the system without considerable height of the tower. However, the underground cables are not free from limitations. Damage to underground cable is difficult to locate, and restoration of the system once the faults are located might take considerably long time.

1.3 CABLES AND THEIR SELECTION: -

Cables are distinguished from naked overhead conductors by the insulation they are provided with. As a result, the aspect of relative safety can be assured. The cables are designed in general based on the requirements. Power cables are an assemblage of one or more individually insulated electrical conductors, usually held together with an overall sheath, that are used for the transmission and distribution of power.

1.4 MECHANISM OF BREAKDOWN OF CABLE: -

Breakdown of cables usually occurs in one of two ways. One method is to use progressive coring and tracking, which begins with the core or sheath and ends with the electrodes being bridged. Another method is thermal instability, which is caused by a rapid increase in power factor as the temperature rises. One significant distinction between the ways of cable breakdown is that coring will continue until the cable breaks down, whereas other procedures may take a long time to finish. Thermal instability, on the other hand, does not cause damage until right before collapse, therefore if the load is lowered before breakdown, the cables will not have been permanently altered. A very common occurrence is for coring to start and then introduce thermal instability at the center of coring.

- **Causes of failure of underground cables: -**

a. The cable sealing box is the most common point of failure, owing to poor cable jointer craftsmanship when the end was sealed.
b. Mechanical puncturing of a cable's lead sheathing, such as with a crowbar, is another typical cause, particularly in industrial settings where excavation and building operations are carried out in areas with multiple subterranean cables.
c. Vibration fatigue or overheating can also cause cable damage.

1.5 DIFFERENCE BETWEEN OVERHEAD LINE AND UNDERGROUND CABLE: -

Parameter	**Overhead Distribution System**	**Underground Distribution System**
Public Safety	Less Safe	Safer
Initial Cost	Less Expensive	More Expensive
Faults	Faults occur frequently	Very rare chances
Location of fault	Easily located	Cannot be easily located
Repair	Easily Repaired	Cannot be easily repaired
Working Voltage	Upto 400 KV	Upto 66 KV
Frequency of accidents	More chances	Little chances
Interference with communication system	Interferes	No interference
Insulation Cost	Less	More

Table 1. difference between overhead line and underground cable

1.6 UNDERGROUND CABLE CONSTRUCTION: -

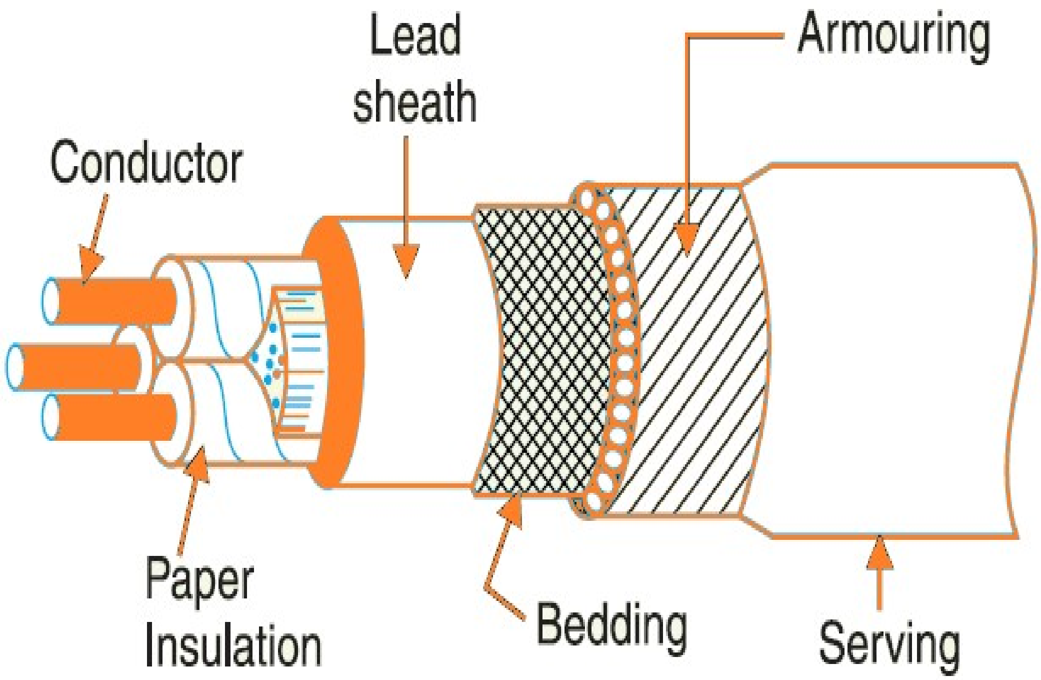


Figure 1-1 Underground cable construction

1) **Cores or Conductors-** Depending on the type of service it is intended for, a cable may have one or multiple cores (conductors). For example, for 3-phase service, the 3-conductor cable depicted in Fig. is used. The conductors are commonly stranded and constructed of tinned copper or aluminium to provide flexibility to the cable.
2) **Insulation-** Each core or conductor is insulated to a sufficient thickness, the thickness of which is determined by the voltage that the cable must withstand. Impregnated paper, varnished cambric, and rubber mineral compound are common insulation materials.
3) **Metallic sheath-** A metallic coating of lead or aluminium is put over the insulation to protect the cable from moisture, gases, or other destructive liquids (acids or alkalies) in the soil and atmosphere, as shown in Fig.

4) **Bedding-** A layer of bedding, consisting of a fibrous substance such as jute or hessian tape, is put over the metallic sheath. Bedding is used to protect the metallic sheath from corrosion and mechanical damage caused by armouring.

5) **Armouring-** Armouring, consisting of one or two layers of galvanized steel wire or steel tape, is placed over the bedding. Its aim is to shield the cable from mechanical damage while it is being laid out and handled. In the case of some cables, armouring may not be possible.

6) **Serving.** A layer of fibrous material (like jute) akin to bedding is applied over the armouring to protect it from atmospheric conditions. This is referred to as serving.

It's probably not a bad idea to point out that bedding, armouring, and serving are only used on cables to protect the conductor insulation and the metallic sheath from mechanical damage.

1.7 CLASSIFICATION OF UNDERGROUND CABLE: -

Cables for underground service may be classified in two ways according to

(i) The type of insulating material used in their manufacture

(ii) The voltage for which they are manufactured.

However, the latter method of classification is generally preferred, according to which cables can be divided into the following groups:

(i) Low-tension (L.T.) cables — upto 1000 V

(ii) High-tension (H.T.) cables — upto 11,000 V

(iii) Super-tension (S.T.) cables — from 22 kV to 33 kV

(iv) Extra high-tension (E.H.T.) cables — from 33 kV to 66 kV

(v) Extra super voltage cables — beyond 132 kV

A cable may have one or more than one core depending upon the type of service for which it is intended. It may be

(i) Single-core

(ii) Two-core

(iii) Three-core

(iv) Four-core etc.

For a 3-phase service, either 3-single-core cables or three-core cable can be used depending upon the operating voltage and load demand.

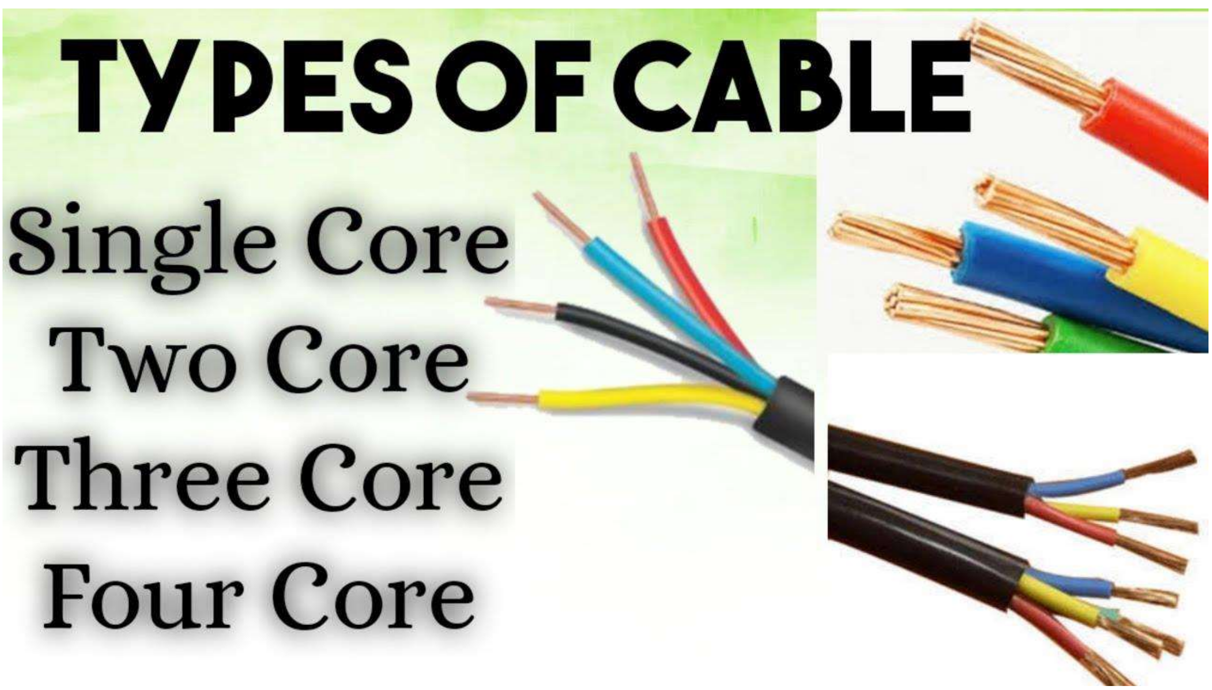


Figure 1-2 Types of cable

1.8 FAULTS IN UNDERGROUND SYSTEM: -

Fault detection is one of the biggest drawbacks of underground wires. Visual inspection procedures are ineffective since the cables are placed beneath the surface (directly or inside pressurised ducts). In overhead lines, however, this is not the case. We need to build unique ways to identify the cable defects, which will be presented in this study.

Before we go into fault detection methods, let's look at the different sorts of faults that can develop in underground cables and what causes them. The following are examples of cable faults:

- Open circuit fault
- Short circuit fault
- Earth faults

1.8.1 Causes of Faults in Underground Cables: -

When moisture enters the insulation, the majority of the defects arise. Inside the cable, the paper insulation is hygroscopic in nature. Mechanical injury during transit, the laying process, or various stresses faced by the cable during its operational life are some of the other causes. The lead sheath is regularly destroyed, mainly as a result of the acts of air agents, soil, and water, or mechanical damage and crystallisation of lead caused by vibration.

1.8.2 Open Circuit Fault: -

As the name suggests, this fault involves an open circuit in the conductors. When one or more cable conductors (cores) break, it leads to discontinuity. This discontinuity also occurs when the cable comes out of its joint due to mechanical stress. This is known as Open circuit fault.

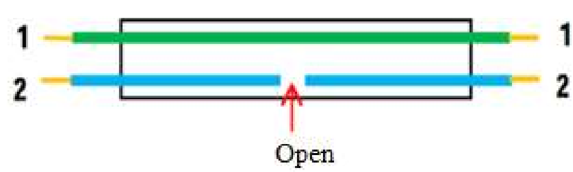


Figure 1-3 Open Circuit fault

1.8.3 Short Circuit Fault: -

It can only be found in multi-cored cables. A short circuit occurs when two or more conductors of the same cable come into touch with each other. Visual detection is impossible without dismantling the cable. When the individual insulation of the cables is destroyed, a short-circuit issue arises. A megger can also be used to detect it.

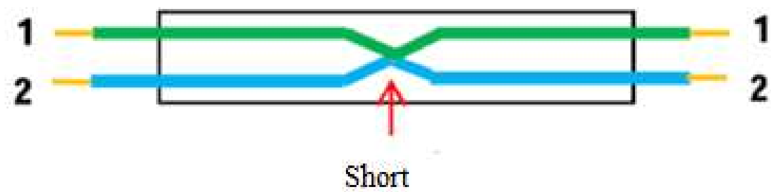


Figure 1-4 Short circuit fault

1.8.4 Earth Fault: -

An earth fault occurs when one of the cable's conductors comes into touch with the ground. This usually happens when the outer sheath is destroyed by soil chemical reactions, vibrations, or mechanical crystallisation. It's comparable to a short circuit defect in that the current goes through the ground because it's the least resistance path. A megger can also be used to detect this..

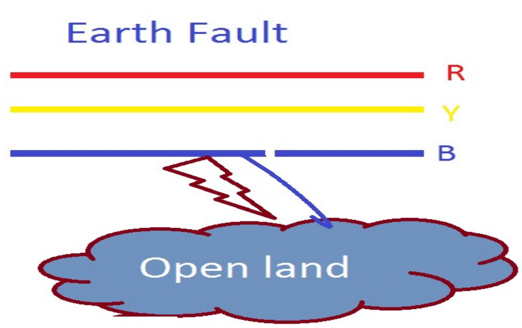


Figure 1-5 Earth fault

CHAPTER 2
LITERATURE SURVEY

2.1 SECTIONALIZING: -

It entails physically cutting and splicing the cable, which can compromise its integrity. To minimise the cable's reliability, it must be separated into small portions that allow us to locate the defect.

E.g. — on a 500-ft length cable, the cable is cut into 250-ft length sections each, and reading is measured in both ways with the help of Ohmmeter or high-voltage insulation resistance (IR) tester. If the reading on the IR tester shows low then it is defective. One has to repeat this procedure until reaching a short section which in turn will allow repairing the fault.

2.2 THUMPING: -

A cable thumper is a high-voltage surge generator that may be carried about. It's used to send a high-voltage DC surge (about 25 kV) into the broken cable. The open-circuit fault will break down if you apply a sufficiently high voltage to the faulty cable, resulting in a high-current arc. At the exact position of the fault, this high current arc generates a distinctive thumping sound.

To use the thumping method to locate a cable defect, set a thumper to thump frequently and then walk along the cable route to hear the pounding sound. The louder the ensuing thump, the higher the dc voltage applied. This strategy is best for wires that aren't too long. For longer cables, the thumping method becomes impracticable (imagine walking along a cable that runs several kilometers to hear the thump).

Cable thumping has the advantage of being able to pinpoint open circuit issues extremely precisely. This strategy is also simple to implement and understand.

Though the pounding approach is fairly accurate in terms of fault detection, it does have certain disadvantages.

It takes a long time to apply this procedure to longer wires. Walking along the wire to find the defect could take hours or even days. Furthermore, the cable is subjected to significant power spikes throughout this time. As a result, while the existing defect is being investigated, large voltage surges may degrade the cable's insulation. If you know how to cable thump, you may reduce the power transmitted through the cable to the bare minimum required to do the test, limiting the damage to the cable insulation. While modest pounding may not result in apparent damage, continuous thumping may cause the cable insulation to deteriorate to an undesirable level. Furthermore, this approach is incapable of detecting defects that do not arc-over (i.e., short circuit faults).

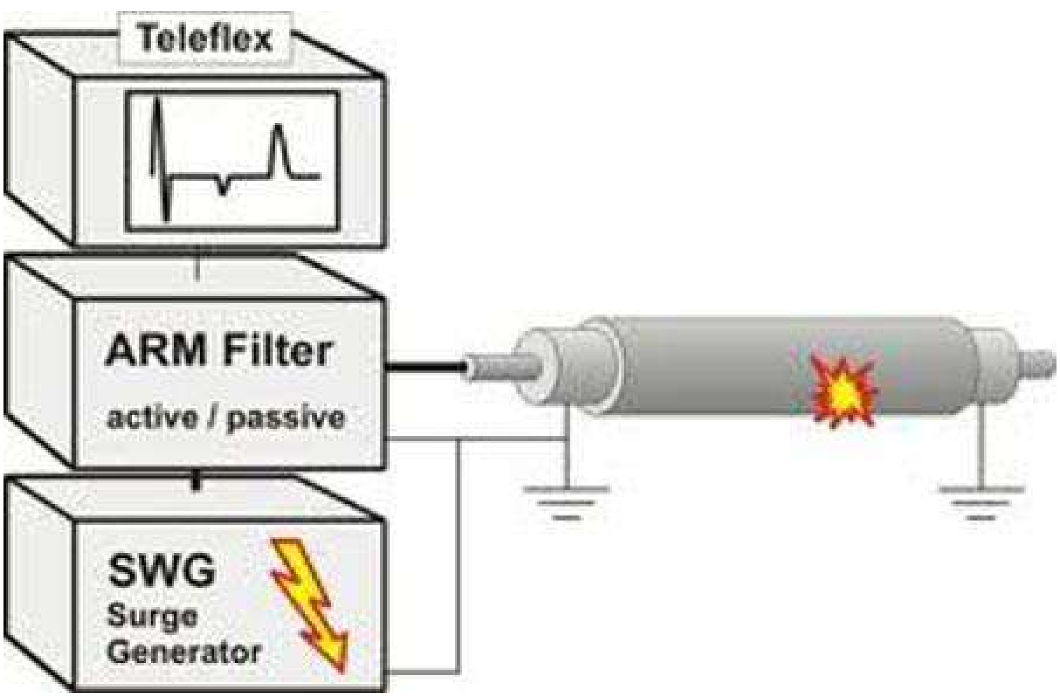


Figure 2-1 Cable thumper

2.3 TIME DOMAIN REFLECTOMETRY (TDR): -

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.

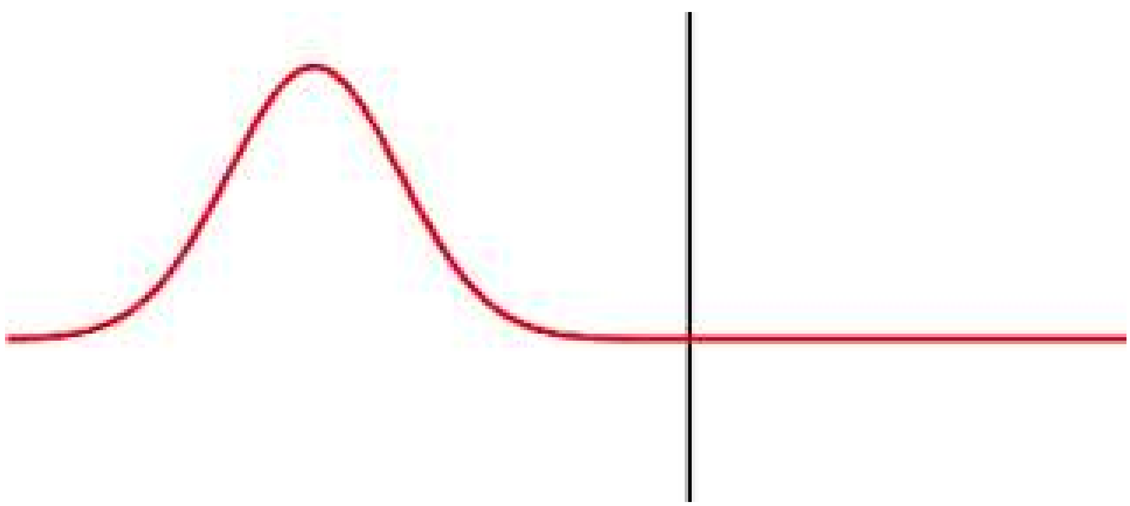


Figure 2-2 Signal transmitted through and reflected back from a fault

2.3.1 Advantages of TDR Method: -

Because a TDR emits a low-energy signal into the cable, the cable insulation is not harmed. This is a significant benefit of employing TDR to locate a fault in an underground wire. A TDR is useful for both open-circuit faults and conductor-to-conductor shorts.

2.3.2 Disadvantage of TDR Method: -

TDR has the drawback of not being able to pinpoint the specific site of defects. It provides an estimate of the distance between the fault and the site of the fault. This information is sometimes sufficient on its own, and other times it is just used to allow for more exact thumping. When the TDR sends a test pulse, the user may be blinded by reflections that occur during the outgoing test pulse. This is known as blind spots, and it occurs when flaws occur near the conclusion. Furthermore, a TDR cannot detect a ground fault with a large resistance (usually greater than 200 Ohms). If there is electrical noise in the area, it may interfere with the TDR signal.

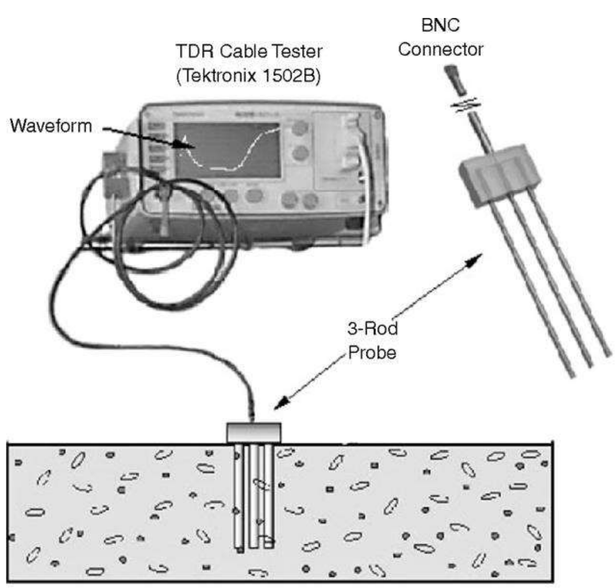


Figure 2-3 TDR

2.4 HIGH VOLTAGE RADAR METHOD: -

There are 3 basic high-voltage radar methods

2.4.1 Arc Reflection: -

A TDR (cable radar) and a surge generator are used in the arc reflection method of fault prelocation (thumper). A low voltage TDR and a high voltage surge generator can both be connected to the same cable using an arc reflection filter, and the TDR can be staring along the wire while thumping. The filter protects the TDR from high-voltage surge generator pulses while routing low-voltage pulses down the cable. This method takes advantage of the fact that when an arc forms at the fault, the resistance is decreased to less than 200 ohms, which reflects radar pulses. On the TDR cable trace, the arc location will appear as a downward moving reflection.

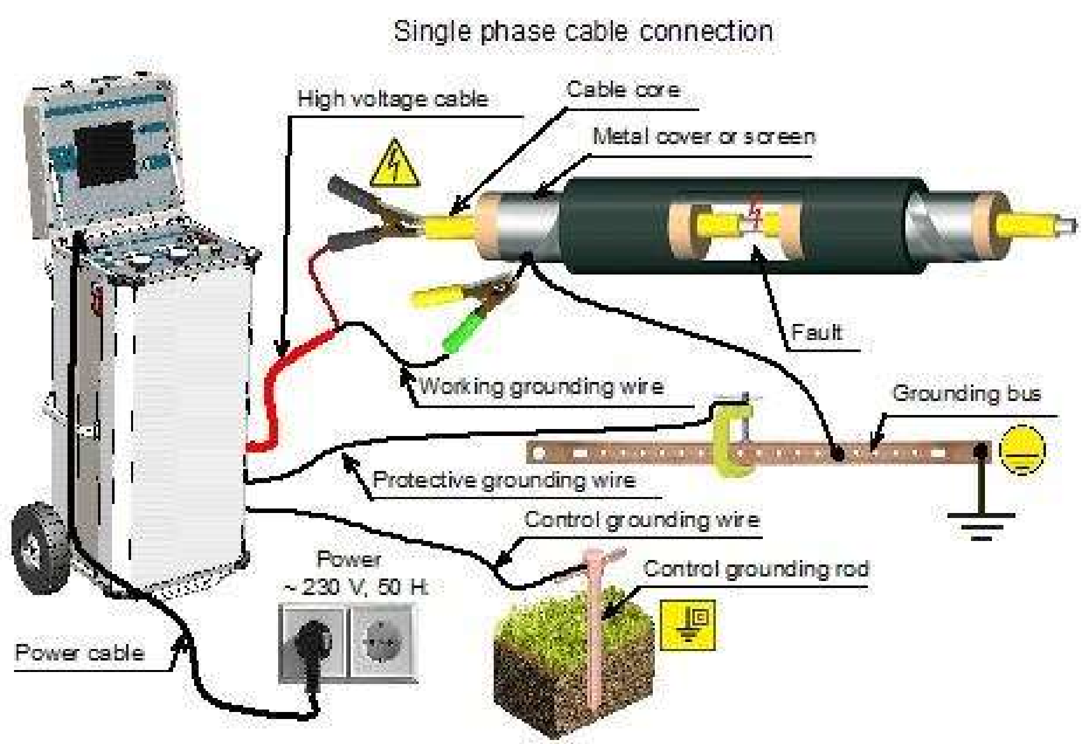


Figure 2-4 Arc Reflection

Advantages of Arc Reflection Method: - The ARC's strength is that it aids in the localization of any faults that will sustain an arc during the thumper pulse. Despite the usage of a surge wave generator, this method greatly decreases the amount of stress involved with the thumping technique because only one or two surges into the cable are required for the pulse echo to locate the fault, display the image, and calculate the distance. So, by minimising the number of surges required to identify this overall defect, the amount of stress on the cable is significantly reduced, and the output voltage is managed by the reflection filter or power separation unit.

Disadvantages of Arc Reflection Method: - One problem of this technology is that the pulse echo technique's reflected pulses can be quickly absorbed by long cables with greatly attenuated dielectrics or a lot of corrosion on the neutrals. Because the signals attenuate before reaching the receiver, it may not be possible to observe the end of the cable or the actual fault event if the TDR does not have enough sent pulse energy to overcome these very long cables or if high corrosion is bleeding down the signal.In addition, if the circuit is complicated with numerous branches and hence many reflections, the waveform can be difficult to interpret. A differential technique known as differential arc reflection can be used in this circumstance.

2.4.2 Surge Pulse reflection method: -

The current coupler and a storage oscilloscope with a thumper are required for this procedure. The capacity to find difficult and distant defects is the method's key advantage. Its drawback is that its strong output surge can damage cables, and reading the trace takes more skill than other methods.

2.4.3The voltage pulse reflection method: -

This method uses a voltage coupler and a proof tester. This method finds faults which occur above the maximum thumper voltage of 25kV

2.5 MEGGER: -

Figure 2-5 Megger

1. Open circuit fault: -

A Megger is used to test the resistance between each conductor and the earth. In the circuit of the conductor that is not broken, the megger will show 0 resistance. If a conductor is broken, however, the megger will show an endless resistance.

2. Short circuit fault: -

A megger's two terminals are linked to any two conductors. A zero reading on the megger indicates a short-circuit issue between these wires.

3. Earth Fault: -

One terminal of the megger is attached to the conductor and the other terminal is linked to the earth to identify this issue. The reading on the megger is zero. It denotes that the conductor is grounded.

- **Limitations: -**

1) At least 2 persons required to operate i.e., one for rotation of crank other to connect megger with electrical system to be tested.
2) Accuracy is not up to the level.
3) Require very high care and safety during use of the same.
4) Avoid using Megger if any part of it is damaged, as it is unsafe to use.

CHAPTER 3

PROBLEM STATEMENT

3.1 PROBLEM STATEMENT: -

In most urban locations, electrical wire is run underground rather than overhead. It is extremely difficult to pinpoint the exact site of a defect in an underground cable when it occurs. Because subterranean cable is not impacted by poor weather conditions such as snowfall, heavy rainfall, or storms, it is a significant technology for distribution, particularly in metropolitan cities, airports, and defence services. When a failure arises in the cable, however, it is difficult to locate the problem. The cable fault detection technology that is currently in use is somewhat heavy. Furthermore, in some circumstances, one approach is insufficient, and fault assessment may necessitate the use of multiple methods.

In view of the above, this project is a method of underground cable fault detection using Arduino, where it intended to calculate correct and the exact location of a cable fault.

3.2 AIM: -

In light of the foregoing discussion and the system's requirement, this project intends to design an Arduino-based cable fault locator for subterranean cables from the base station. Overhead transmission wires are commonly used. It's simple to spot the flaw and fix it just by looking at it. Weather conditions such as storms, snow, heavy rains, and pollutants have no effect on subterranean cable, however it is difficult to discover a fault in underground cable when it happens. Underground cables are commonly used in urban areas where overhead lines can be affected by bad weather, in areas where local or state regulations take precedence over economic considerations, near airports and other locations where an overhead line could endanger lives, and in scenic areas where aesthetics are important.

Even when a defect is discovered in an underground cable, pinpointing the exact site of the problem is challenging. Furthermore, it necessitates the excavation of the entire region in order to find and rectify the defect, resulting in a waste of money, time, and manpower. As a result, pinpointing the exact position of the defect is essential.

3.3 WHY CHOOSE ARDUINO BASED FAULT DETECTION: -

From the description above, many fault detection technologies such as TDR, megger, and others are used. Although these approaches are effective and beneficial for fault identification, they do have some drawbacks, as described below. In light of current technologies and benefits, as well as accurate and quick problem location, it is suggested that digital/advanced technologies such as Arduino, microprocessor, and others be used. These technologies are supposed to give findings that are not only quick but also accurate.

- The Arduino is an open-source electronics platform for creating electronic projects that is built on simple hardware and software.
- One thing that all Arduino boards have in common is a microcontroller. A microcontroller is essentially a little computer.
- You may use the Arduino to create and build devices that interact with their surroundings. The Arduino boards are essentially a controller for electronics. They can use their onboard microcontroller to read inputs (such as light on a sensor or an object near a sensor) and convert them to outputs (Drive a motor, ring an alarm, turning on an LED, display information on an LCD). They are also having;

- Low maintenance
- Improved public safety
- Less consumption of power
- Easy to handle

CHAPTER4

SOLUTION METHOD

4.1 METHODOLOGY: -

As discussed in literature survey various techniques and their limitations, it is preferred to go for Arduino technology for detecting underground cable faults. The method adopted in this project by using the Arduino technology has been discussed as follows:

1. This project uses the standard concept of Ohms law i.e., when a low DC voltage is applied at the feeder end through a series resistor to the Cable lines, then current would vary depending upon the location of fault in the short-circuited cable.
2. This system uses an Arduino board and a rectified power supply. Here the current sensing circuit made with combination of resistors are interfaced to Arduino board with help of the internal ADC device for providing digital data to the Arduino representing the cable length in KM's.
3. The fault creation is made by the set of switches.
4. The relays are controlled by the relay driver IC which is used for switching the power sequentially to all the lines.
5. A 16x2 LCD display connected to the Arduino to display the information.
6. In case of short circuit (Line to Ground), the voltage across series resistors changes accordingly, which is then fed to an ADC to develop precise digital data to a programmed Arduino board that further displays fault location in kilometres/meters.

4.2 BLOCK DIAGRAM: -

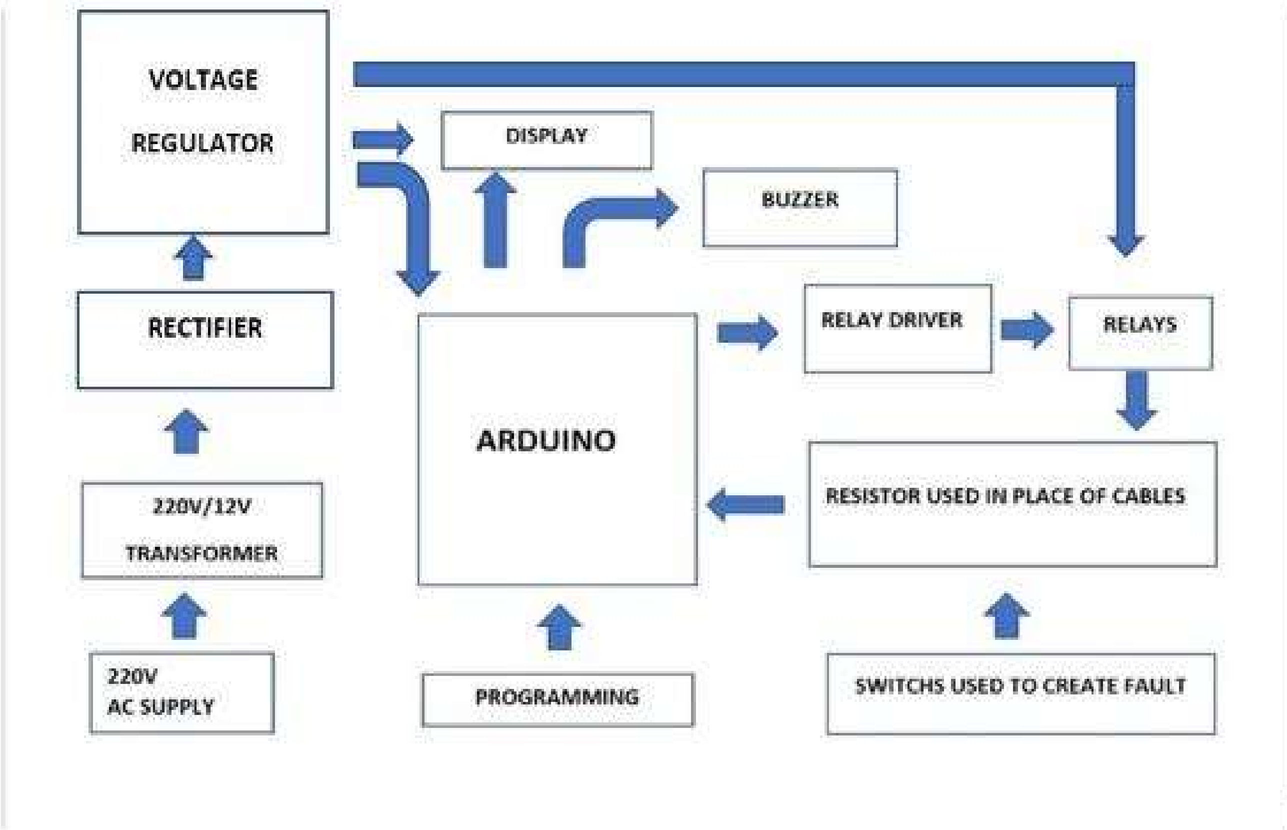


Figure 4.1 Block diagram

CHAPTER5

CODE AND SIMULATION RESULT

5.1CODE: -

```
#include <LiquidCrystal.h>

LiquidCrystal lcd (2,3,4,5,6,7);

#define sensor A0

#define relay1 8

#define relay2 9

#define relay3 10

#define buzzer 13

int read_ADC;

int distance;

byte symbol[8] = {

  B00000,

  B00100,

  B00100,

  B00100,

  B11111,

  B01110,

  B00100,

  B00000};
```

```
void setup() {
pinMode(sensor,INPUT);
pinMode(relay1, OUTPUT);
pinMode(relay2, OUTPUT);
pinMode(relay3, OUTPUT);
pinMode(buzzer, OUTPUT);
lcd.createChar(1, symbol);
lcd.begin(16, 2);
lcd.clear();
lcd.setCursor(0, 0); // set the cursor to column 0, line 1
lcd.print("Welcome to Cable");
lcd.setCursor(0, 1); // set the cursor to column 0, line 2
lcd.print("Fault Detection");
delay(2000);
lcd.clear();
}
void loop(){
lcd.setCursor(1,0);
lcd.print("R");
lcd.write(1);
lcd.setCursor(7,0);
```

```
lcd.print("Y");
lcd.write(1);
lcd.setCursor(13,0);
lcd.print("B");
lcd.write(1);
digitalWrite(relay1,HIGH);
digitalWrite(relay2,LOW);
digitalWrite(relay3,LOW);
delay(500);
data();
lcd.setCursor(0,1);
if(distance>0){lcd.print(distance); lcd.print("KM ");}
else{lcd.print(" NF ");}
digitalWrite(relay1,LOW);
digitalWrite(relay2,HIGH);
digitalWrite(relay3,LOW);
delay(500);
data();
lcd.setCursor(6,1);
if(distance>0){lcd.print(distance); lcd.print("KM “);}
else{lcd.print(" NF ");}
```

```
digitalWrite(relay1,LOW);
digitalWrite(relay2,LOW);
digitalWrite(relay3,HIGH);
delay(500);
data();
lcd.setCursor(12,1);
if(distance>0){lcd.print(distance); lcd.print("KM ");}
else{lcd.print(" NF ");}
}
void data(){
read_ADC = analogRead(sensor);
distance = read_ADC/100;
if(distance>9)distance = 0;
if(distance>0){
digitalWrite(buzzer,HIGH);
delay(2000);
digitalWrite(buzzer,LOW);
delay(200);
}
}
```

5.2 SIMULATION: -

5.2.1 NO FAULT:-

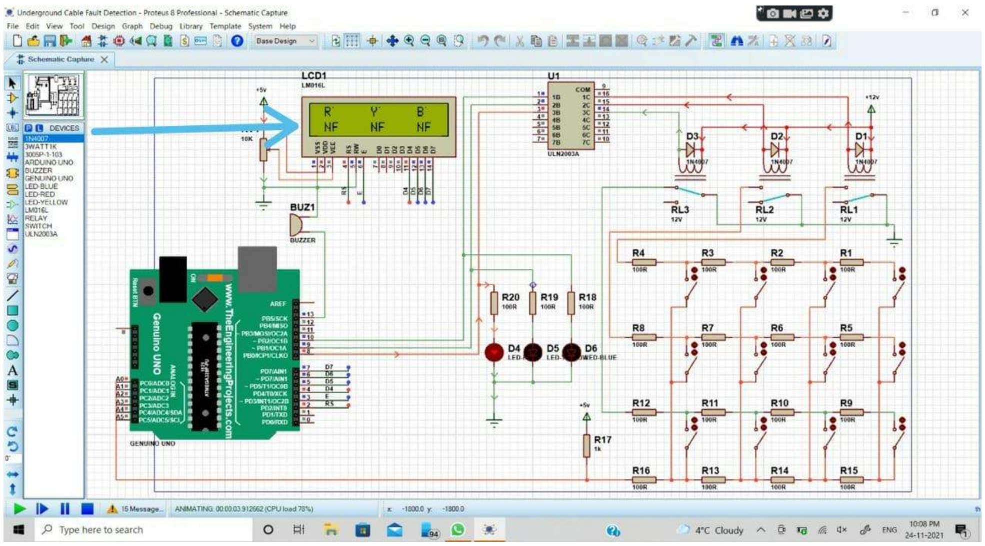


Figure 5.1 No fault(simulation)

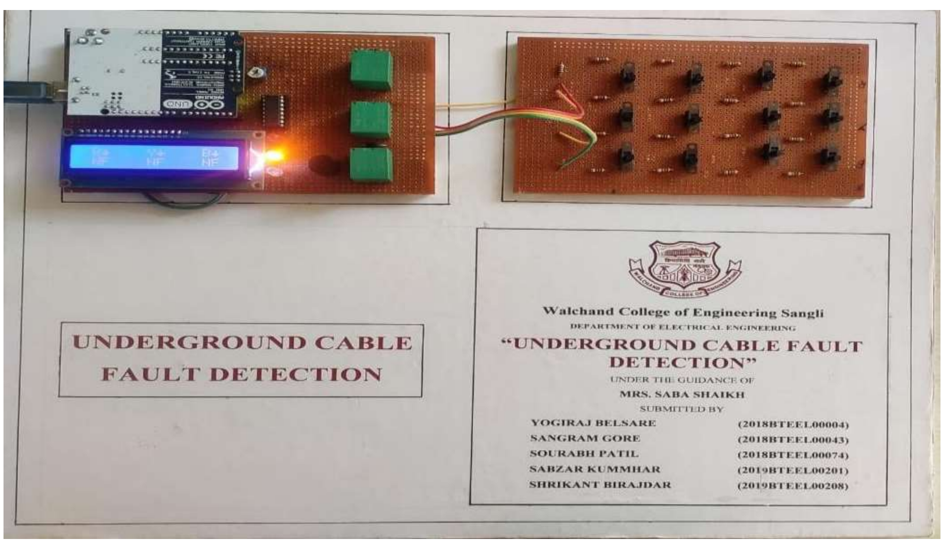


Figure 5.2 No fault (hardware)

5.2.2 TWO FAULTS AT SAME PHASE: -

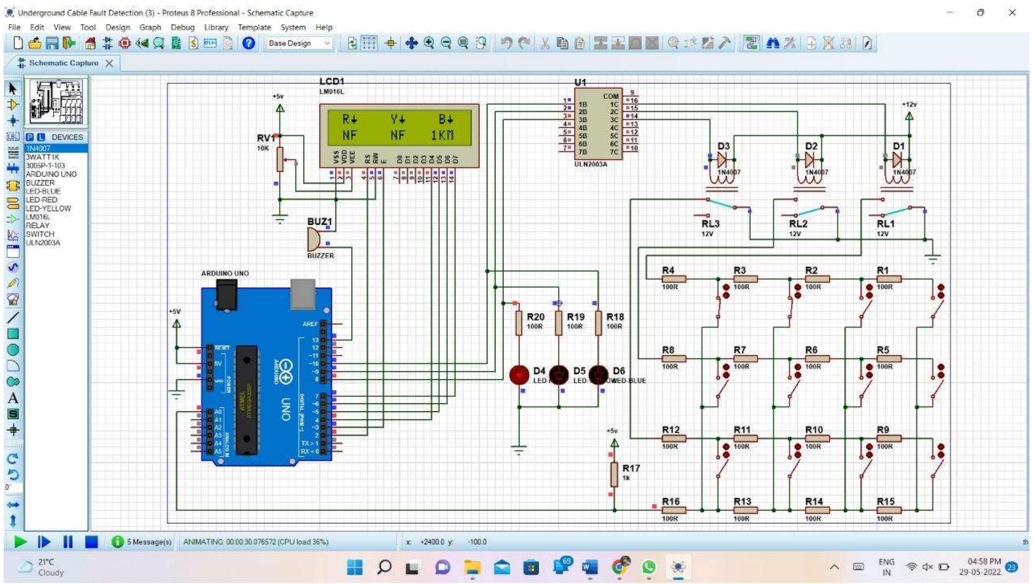


Figure 5.3 Fault near to substation is detected first (Simulation)

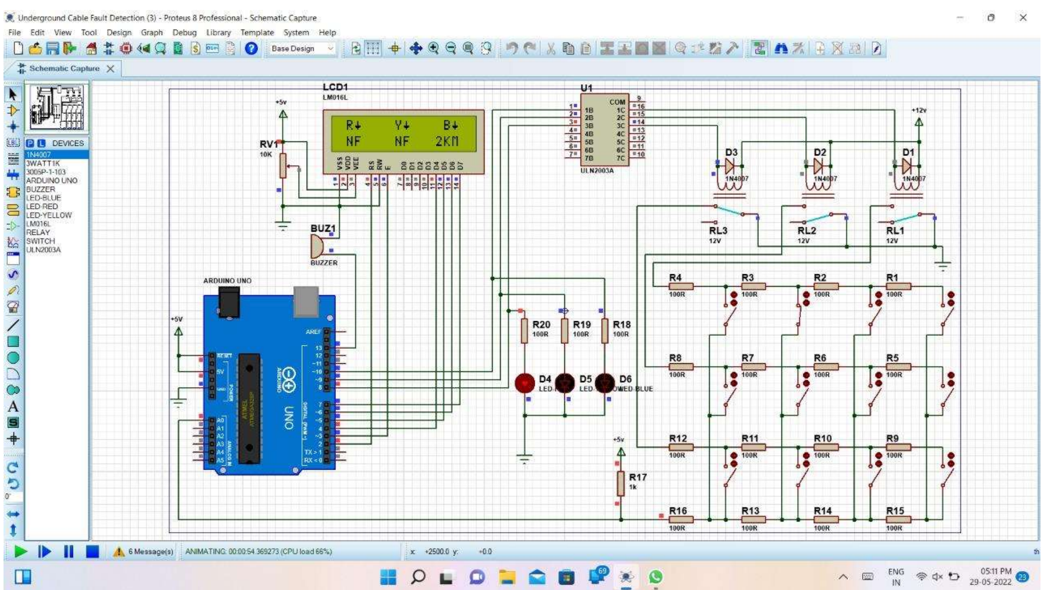


Figure 5.4 Fault near substation is cleared and far fault is detected (Simulation)

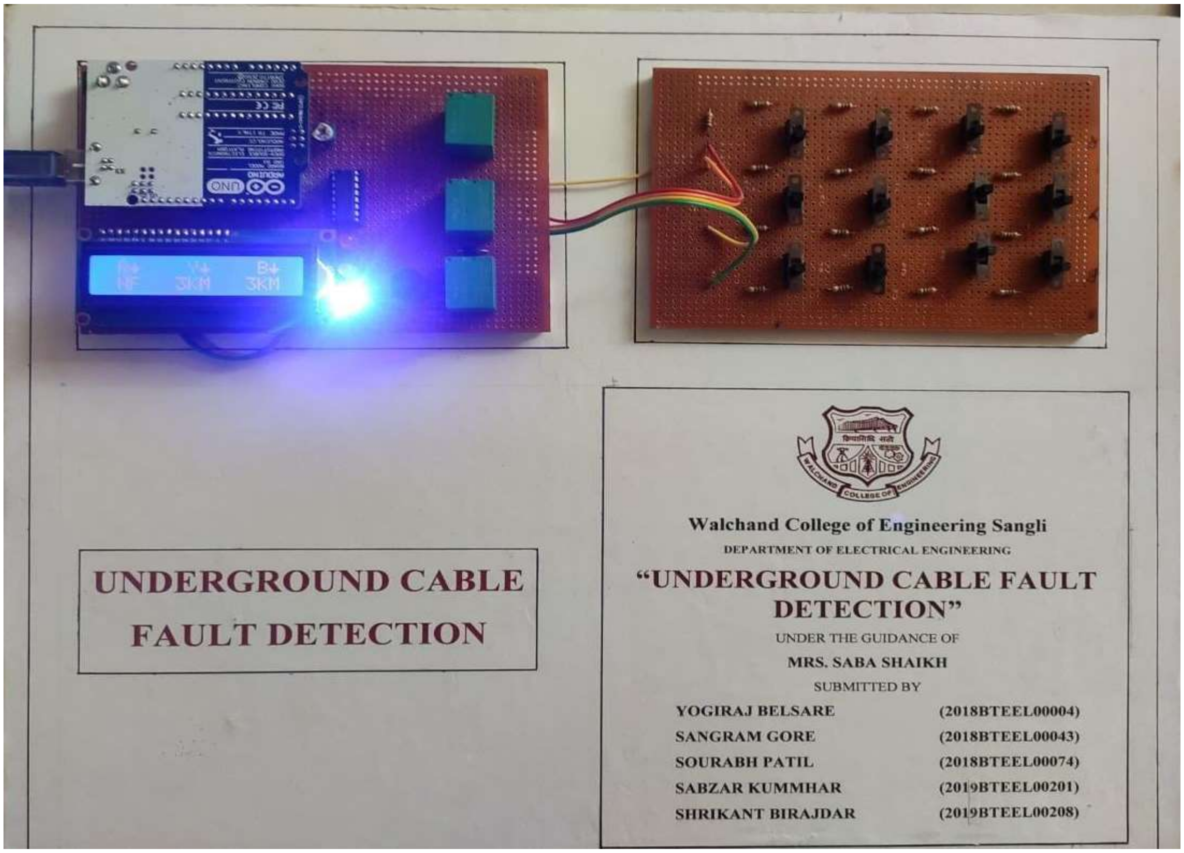


Figure 5.5 Two Fault at same phase(Hardware)

5.2.3 FAULT AT ONE PHASE : -

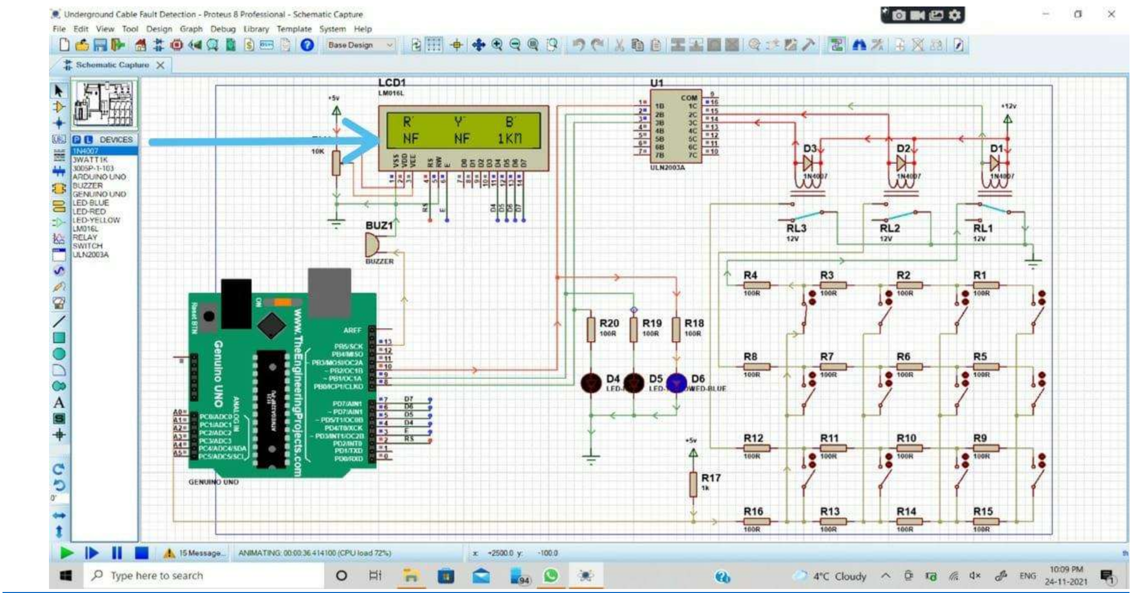


Figure 5.6 Fault at one phase (Simulation)

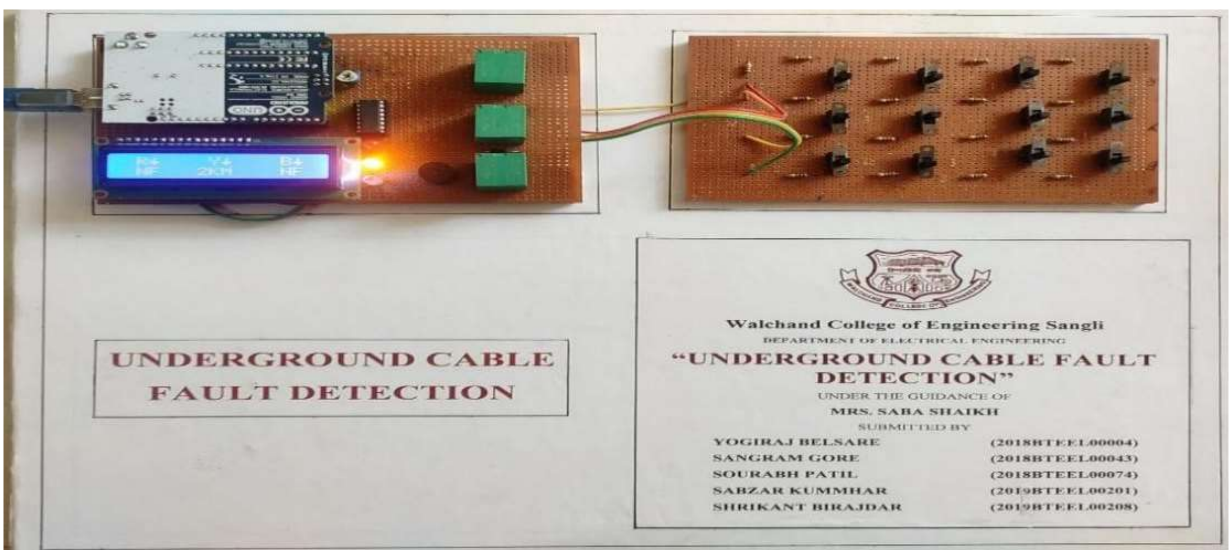


Figure 5.7 Fault at one phase (Hardware)

5.2.4 THREE PHASE FAULT:-

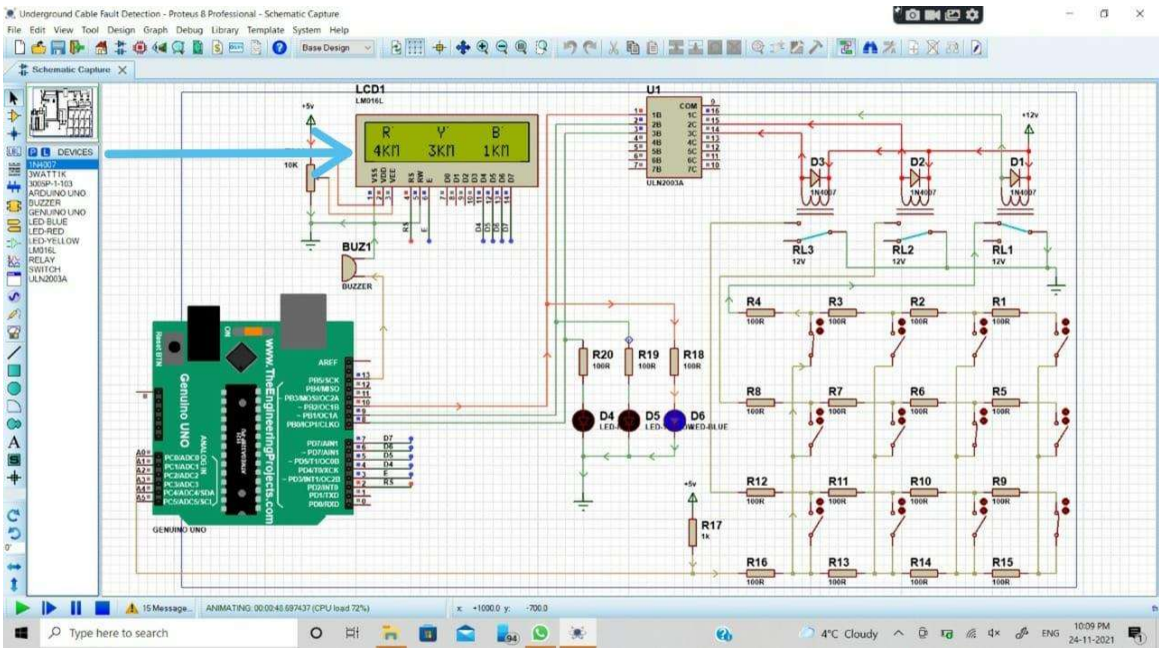


Figure 5-8 Three phase fault (Simulation)

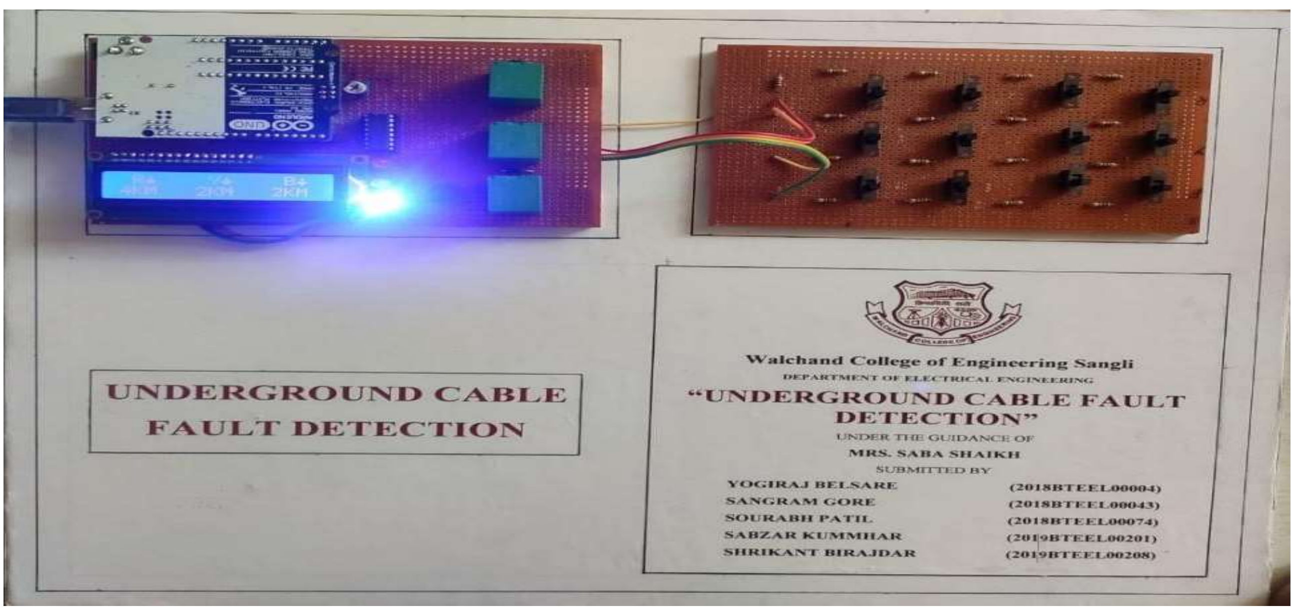


Figure 5-9 Three phase fault (Hardware)

CHAPTER 6

COMPONENTS AND COSTS

6.1 ARDUINO: -

Working in the electronics industry a decade ago required physics and math skills, expensive lab equipment, a laboratory-like setting, and, most importantly, a passion for electronics. But, with the exception of the last section, the situation has evolved over the last decade or two, with the above-mentioned elements becoming irrelevant to work around electronics.

"Arduino" is one such product that took advantage of the aforementioned and other factors to make electronics accessible to anyone, regardless of their background.

The phrase "Arduino" has grown quite famous in the realm of electronics since its introduction in 2005.

Introduction

Arduino is open-source electronics prototyping platform with simple hardware and software. In a nutshell, Arduino is a microcontroller-based prototyping board that can be used to create digital devices that can read inputs such as a finger on a button, touch on a screen, light on a sensor, and convert it to outputs such as turning on an LED, rotating a motor, playing music through a speaker, and so on.

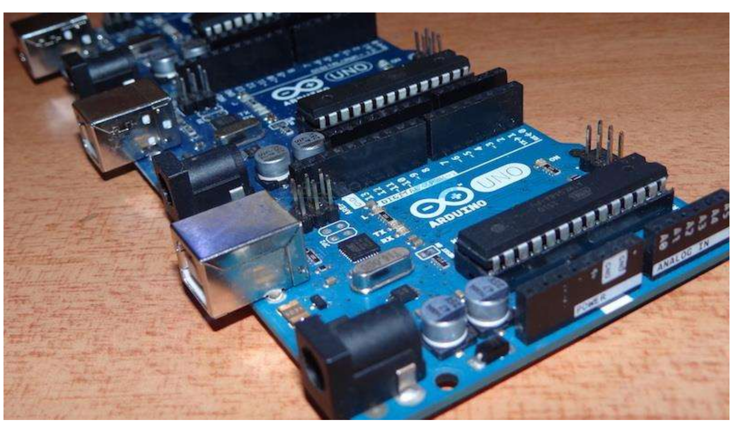


Figure 6.1 Arduino

Voltage regulators for 5V and 3V are built into the UNO board. The Arduino board can be programmed to do anything by simply programming the microcontroller on board with a set of instructions. The Arduino board includes a USB connector for communicating with your computer as well as a number of connection sockets for connecting to external devices such as motors and LEDs.

Arduino's goal is to teach the world of electronics to people who have little or no expertise with it, such as hobbyists, designers, and artists.

Arduino is an open-source electronics project, which means that all design specifications, schematics, and software are freely available to anybody. As a result, Arduino boards can be purchased from vendors as they are commercially available, or you can make your own board if you prefer, i.e., you can download the schematic from Arduino's official website, purchase all of the components according to the design specifications, assemble all of the components, and make your own board.

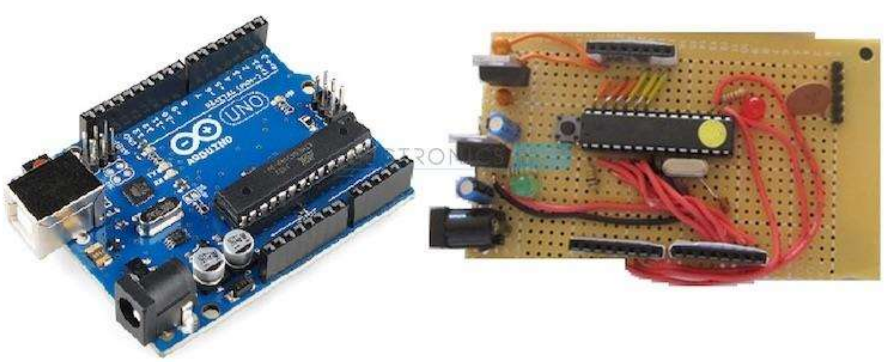


Figure 6.2 Arduino Assembly

Types of Arduino Boards: -

Although there are many different types of Arduino boards on the market, they all have one thing in common: they can all be programmed using the Arduino IDE. Diverse power supply requirements, connectivity possibilities, board applications, and so on are the reasons for different types of boards. Different sizes, form factors, and numbers of I/O pins are available for Arduino boards. Arduino UNO, Arduino Mega, Arduino Nano, Arduino Micro, and Arduino Lily Pad are some of the most well-known and widely used Arduino boards.

Figure 6.3 Different types of Arduinos

Arduino Shields are add-on modules that can be used to extend the functionality of the Arduino boards. Arduino Proto Shield, Arduino Wi-Fi Shield, and Arduino Yun Shield are some of the most popular shields.

6.1.2 ARDUINO UNO: -

The Arduino UNO is a simple and low-cost Arduino board that is the most popular of all Arduino boards, with a market share of more than 50%. The Arduino UNO is often regarded as the best prototyping board for people new to electronics and programming.

Figure 6-4 Arduino uno

The ATmega328P microprocessor is used in the UNO. The Arduino UNO is available in two versions: one with a through-hole microcontroller connection and the other with a surface mount type. The through-hole model will be advantageous since we will be able to remove the chip in the event of a problem and replace it with a fresh one.The Arduino UNO has a variety of functions and capabilities. As previously stated, the ATmega328P microcontroller utilised in UNO is an 8-bit microcontroller based on the AVR architecture. UNO has 14 digital input – output (I/O) pins which can be used as either input or output by connecting them with different external devices and components. Out of these 14 pins, 6 pins are capable of producing PWM signal. All the digital pins operate at 5V and can output a current of 20mA.

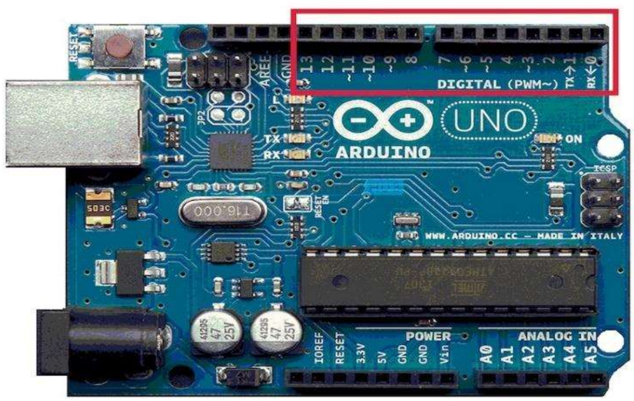


Figure 6-5 Arduino digital pin information

Special functionality is described below for some of the digital I/O pins.Serial communication takes place on pins 0 and 1. They receive and transmit serial data, which can be used in a variety of ways, including programming the Arduino board and interfacing with the user through serial monitor.External interrupts are handled on pins 2 and 3. These pins can be used to trigger an external event by sensing a low value, a change in value, or a falling or rising edge on a signal. As mentioned earlier, 6 of the 14 digital I/O Pins i.e. 3, 5, 6, 9, 10, and 11 can provide 8-bit PWM output.SPI communication takes place on pins 10, 11, 12, and 13 (SS, MOSI, MISO, and SCK, respectively).A built-in LED is attached to Pin 13. The LED is turned on when the pin is HIGH, and it is turned off when the pin is LOW.The Arduino Uno includes six analogue input pins with a resolution of 10 bits, or 1024 different values. The Arduino UNO's analogue pins are labelled A0 to A5.

Figure 6-6 Arduino analog pin information

All analogue pins can measure from ground to 5V by default. The Arduino UNO contains a feature that allows you to adjust the upper limit of the range by setting the AREF pin to a value less than 5V. Additionally, some analogue pins offer unique capabilities. I2C communication takes place on pins A4 and A5.The Arduino UNO board can be powered in a number of different ways. The microcontroller can be powered using the USB cord that was used to programme it.

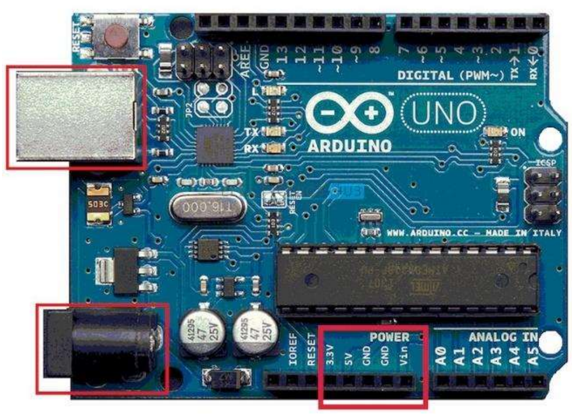


Figure 6-7 Arduino supply and power pin information

There is a power jack that can be used to supply an external regulated power supply in the range of 7V–12V. Additionally, the VIN pin can be used to supply power from a battery.

3 volts, which can be used to power small external devices such as LEDs.

6.2 16*2 LCD: -

Nowadays, we almost always use LCD-based products such as CD players, DVD players, digital watches, computers, and so forth. These are frequently utilised in the screen industry to replace the use of CRTs. When compared to LCDs, Cathode Ray Tubes use a lot more power, and they're also a lot heavier and bulkier. These devices are both slimmer and consume significantly less power. The LCD 162's working principle is that it blocks rather than dissipates light.

Liquid crystal display is the abbreviation for liquid crystal display. It is a type of electronic display module that is utilised in a wide range of circuits and devices such as mobile phones, calculators, computers, television sets, and so on. Multi-segment light-emitting diodes and seven segments are the most common applications for these displays. The main advantages of utilising this module are its low cost, ease of programming, animations, and the fact that there are no restrictions on displaying unique characters, special and even animations, and so on.

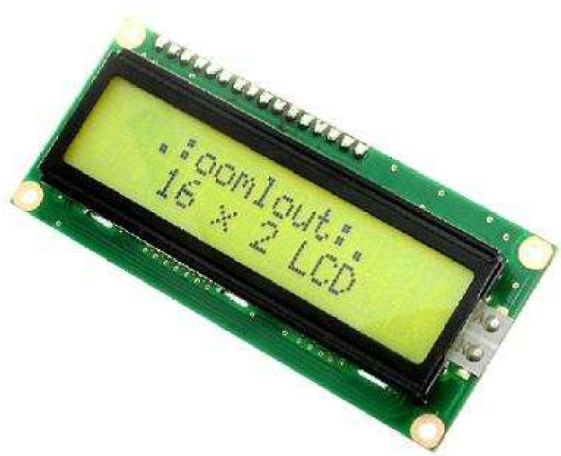


figure 6.8

6.2.1 LCD 16×2 PIN DIAGRAM: -

The 16×2 LCD pinout 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

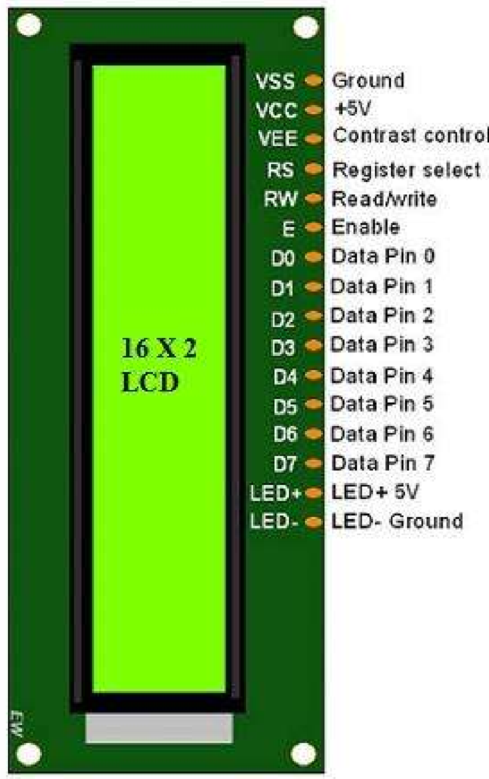


Figure 6.9 16*2 LCD Display pin information

6.2.2 REGISTER OF LCD: -

The data register and the command register are two registers on a 162 LCD. The RS (register select) is mostly used to switch between registers. It is known as a command register when the register set is '0'. When the register set is '1', it is referred to as a data register.

6.2.2.1 Command Register: -

The command register's primary role is to store the command instructions sent to the display. So that predetermined actions like cleaning the display, initialising, setting the cursor position, and controlling the display can be completed. Within the register, commands can be processed.

6.2.2.2 Data Register: -

The data register's primary role is to store the information that will be displayed on the LCD panel. The ASCII value of the character is the information that will be displayed on the LCD screen. Whenever we provide data to the LCD, it is transmitted to the data register, and the process begins there. The data register will be picked when register set =1.

6.2.3 FEATURES OF LCD16x2: -

The following are the primary features of this LCD.

- This LCD's working voltage ranges from 4.7 to 5.3 volts.
- It has two rows, each of which can produce 16 characters.
- With no illumination, the current utilisation is 1mA.
- A 58-pixel box can be used to create any character.
- Alphabets and integers are displayed on alphanumeric LCDs.
- Is the display capable of working in two modes: 4-bit and 8-bit?
- Backlight options include Blue and Green.
- It shows a few characters that were generated by the user.

6.3DIODE: -

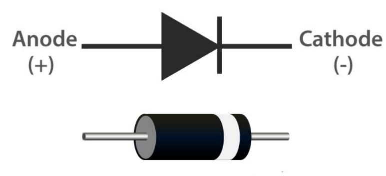


Figure 6.10 Diode

A diode is a semiconductor device that functions as a current one-way switch. It permits current to flow freely in one direction while drastically restricting current flow in the other. Because they convert alternating current (ac) to pulsing direct current (dc), diodes are also known as rectifiers (dc). The type, voltage, and current capability of diodes are all rated. Anode (positive lead) and cathode (negative lead) establish the polarity of a diode (negative lead). When positive voltage is given to the anode, most diodes enable current to flow.

Diodes come in a variety of shapes and sizes. Metal case, stud mount, plastic case with band, plastic case with chamfer, and glass case are shown from left to right.

A forward-biased diode permits electricity to pass through it. When a diode is reverse-biased, it functions as an insulator, preventing current from flowing through it.

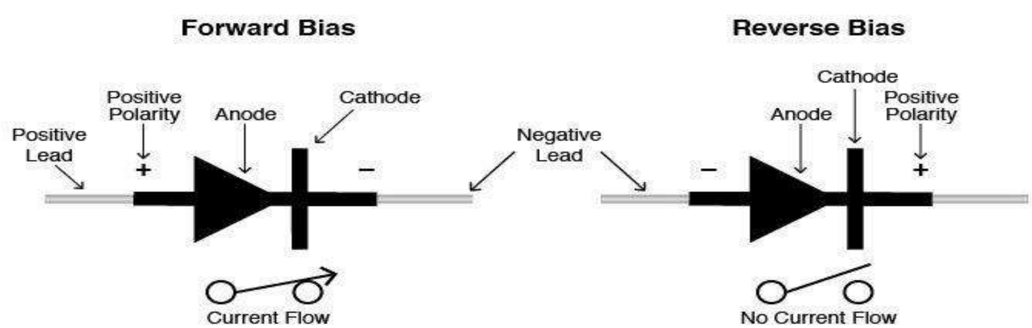


Figure 6-11 Forward and reverse biased diode

6.4 RELAY: -

Relays are electromechanical or electronic switching devices that open and close circuits. When the relay's circuit detects a fault current, it energizes the electromagnetic field, creating a temporary magnetic field. The relay armature is moved by this magnetic field to open or close the connections.

A relay is a switch that is controlled by electricity. A magnetic field is created by current flowing through the coil of the relay, which attracts a lever and switches the switch contacts. Relays have two switch positions and typically feature double throw (changeover) switch contacts, as indicated in the diagram, because the coil current can be on or off.

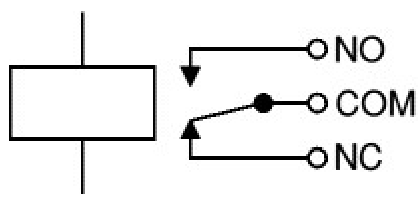


Figure 6.12 Relay Switch

The switch connections on the relay are commonly labelled COM, NC, and NO:

• COM means Common; always connect to this, as it is the switch's moving portion.

• NC means Normally Closed; when the relay coil is off, COM is connected to this.

• NO means Normally Open; while the relay coil is on, COM is connected to this.

If you want the switched circuit to be on when the relay coil is on, connect to COM and NO.

If you want the switched circuit to be on when the relay coil is off, connect COM and NC.

6.4.1 RELAY DRIVER: -

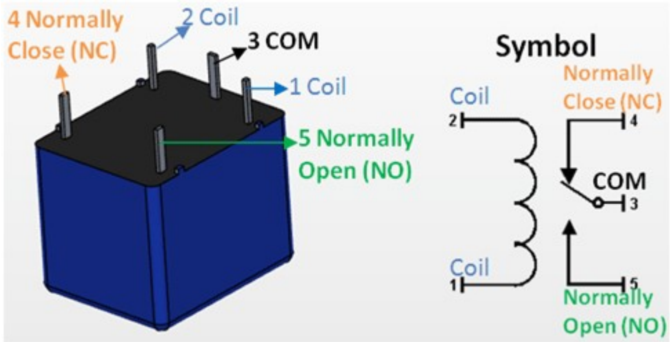


Figure 6-13 Relay driver

6.4.2 Relay Driver Circuit: -

A relay driver circuit is a circuit that is used to drive a relay and can be built using a variety of integrated circuits. These relays must be driven in order to activate or turn on. To switch on or off, relays require driving circuitry (based on the requirement). ULN2003, CS1107, MAX4896, FAN3240, A2550, and other integrated circuits can be used to implement the relay driver circuit.

Relay driver circuit using ULN2003 Because using a large number of relays using transistors is challenging, the relay driver ic ULN2003A can be utilized to provide more relays.

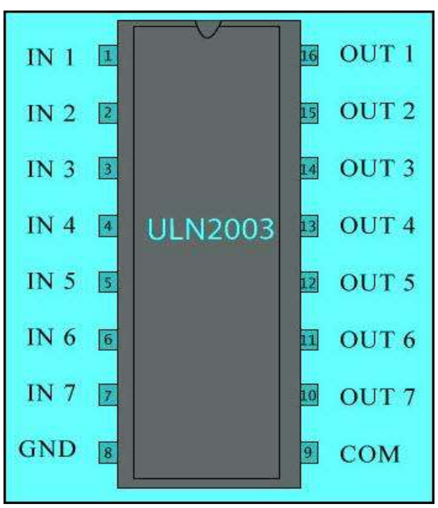


Figure 6-14 Relay driver ic ULN2003

The ULN2003A is a 16 pin IC. It is an array of 7 NPN-Darlington transistors capable of 500mA, 50v output. For these 7 Darlington pairs specification we have 7 I/O pins.

Specifications

- Contains 7 high-voltage and high-current Darlington pairs
- Each pair is rated for 50v and 500mA.
- Input pins can be triggered by +5v.

6.4.3 PIN CONFIGURATION: -

- **Pin 1-7 (Input 1 to input 7):**

Each pin is connected to the base of transistor and triggered by using +5v.

- **Pin 8 (Ground):**

Reference 0v.

- **Pin 9 (COM):**

Used as test pin or voltage suppresser pin

- **Pin 10-16 (Output 1 to 7):**

Respective output of 7 input pins. Each output pin will be connected to ground only when its respective input pin is high.

6.5 RESISTOR: -

Figure 6.15 resistor

A two-terminal passive electrical component that is used to limit or regulate the flow of electric current in electrical circuits.

The primary function of a resistor is to reduce current flow and lower voltage in a specific area of the circuit. It's comprised of copper wires that are wrapped around a ceramic rod and have an insulating paint coating on the outside.

There are two basic types of resistors as follows:

- Linear resistor
- Non-linear resistor

6.5.1LINEAR AND NON-LINEAR RESISTOR: -

1) **Linear resistor: -**

Linear resistors are resistors whose values fluctuate as the applied temperature and voltage change. Linear resistors are divided into two categories:

- **Fixed resistors: -**

Linear resistors are resistors whose values fluctuate as the applied temperature and voltage change. Linear resistors are divided into categories:

- Carbon composition resistors
- Wire wound resistors
- Thin film resistors
- Thick film resistors

- **Variable resistors**:-

These resistors do not have a fixed value and may be adjusted with the use of a dial, knob, or screw. These resistors are used to adjust the volume and tone of radio receivers. The many types of variable resistors are as follows:

- Potentiometers
- Rheostats
- Trimmers

2) **Non-linear resistors**

The resistor values change according to the temperature and voltage applied and is not dependent on Ohm’s law. Following are the different types of non-linear resistors:

- Thermistor
- Varistor
- Photo resistors

6.6BUZZER: -

A beeper or buzzer is an auditory signaling device that can be electromechanical, piezoelectric, or mechanical. The main purpose of this is to transform an audio signal to a sound signal. It is commonly used in timers, alarm devices, printers, alarms, computers, and other equipment that are powered by DC voltage. It may produce various sounds such as alert, music, bell, and according on the varied designs.

Figure 6.16 Buzzer

The buzzer's pin arrangement is seen above. It has two pins, one positive and one negative. The '+' symbol or a longer terminal is used to represent the positive terminal of this. The positive terminal is represented by the '-'symbol or short terminal and is connected to the GND terminal, whereas the negative terminal is represented by the '-'symbol or long terminal and is powered by 6Volts.

6.6.1 TYPES OF BUZZERS: -

A buzzer is available in different types which include the following.

(i) Piezoelectric

(ii) Electromagnetic

(iii) Mechanical

(iv) Electromechanical

(v) Magnetic

6.7 SOLDERING IRON: -

Figure 6.17 Soldering iron

Soldering is done with a soldering iron, which is a hand tool. It provides heat to melt solder and allow it to flow into the joint between two pieces of work.An insulated handle and a hot metal tip make up a soldering iron. Heating is frequently accomplished electrically, by transferring an electric current via a resistive heating element (provided via an electrical cord or battery connections). A catalytic heater, rather than a flame, can be used to heat cordless irons by combusting gas stored in a tiny tank. Simple irons, which are less popular today than they were in the past, consisted of a huge copper bit on a handle that was heated in a flame. Solder melts at 185 degrees Celsius (365 degrees Fahrenheit). Soldering irons have a temperature range of 200 to 480 degrees Celsius (392 to 896 degrees Fahrenheit). Soldering irons are most commonly used in electronics assembly for installation, repairs, and limited production operations. Other soldering procedures are used on high-volume production lines. Soldering joints in sheet metal items can be done with large irons. Pyography (burning designs into wood) and plastic welding are two less common applications (as an alternative to ultrasonic welding).

6.8 SOLDERING WIRE: -

Figure 6.18 Soldering wire

Solder Wire is one of the most often purchased types of solder. It's used in a variety of industries where solder is employed. Varied wires are suited to different purposes and temperatures, so not all solder wires are created equal. The solder wire can also differ significantly depending on the sort of solder you want to buy. Solder wires are low-melting-point wires that can melt in tandem with the soldering iron. Soldering wires come in a variety of shapes and sizes, depending on the application and soldering temperature.

Solder wires are generally two different types –

Lead-free solder and lead-alloy solder wire There is also rosin-core solder wire, which features a tube in the middle that holds the flux. Lead solder wire is typically manufactured from a tin-lead alloy. Because of its lower melting temperature, tin is widely utilised with lead. It features a 63/37 or 60/40 alloy ratio. When working with electrical components, the ideal ratio is 63/37. When the temperature changes, this solder wire undergoes a quick transition between solid and liquid states. This characteristic is particularly effective for decreasing cold joints, which occur when components shift during cooling.

6.9 VEROBOARD: -

Figure 6.19 Veroboard

Veroboard is a brand of stripboard, a pre-formed circuit board material made of copper strips on an insulating bonded paper board that was invented and developed by Vero Precision Engineering Ltd's Electronics Department in the early 1960s (VPE). It was introduced as a general-purpose material for use in the construction of electronic circuits, differentiating from purpose-designed printed circuit boards (PCBs) in that a standard wire board can be used to build a variety of electronic circuits. Veroboard is a printed circuit board having rows of copper rails and holes drilled in them for soldering electrical components to build electronic circuits. All of the holes and tracks are a tenth of an inch apart. If that measurement seems familiar, it's because it's the same spacing as ICs, which means these will fit nicely. The idea is that the copper strip connects all the holes in a row electrically, so you can organize your layout accordingly.

COST TABLE

SR NO	Components	Quantity	Price	Total Price	Amps	Volts	Ohm
1	Arduino UNO	1	700	700	150 mA	6-20 V	
2	LCD Display 16 x 2	1	60	60	1 mA	4-5 V	
3	Relay Driver	3	15	45	90 mA	5 V	
4	Buzzer	1	10	10	32 mA	5 V	
5	Diode IN4007	3	4	12	1 A	Upto 700 V	
6	LED	3	5	15	10-30 mA	1.2-3.6 V	
7	Slide Switch	12	3	36	Upto 5 A	5 V	
8	Resistor	20	1	20		5 V	100 ohms
9	Soldering Wire	1	30	30			
10	Soldering Paste	1	20	20			
11	ULN2003A	1	40	40		5 V	
12	Adapter	1	145	145			
13	Veroboard	2	60	120			
14	Variable Resistor	1	1	1			
15	Male Female Header	24	2	48			
16	Connecting Wire	1	30	30			
17	POT	1	130	130		5 V	10K ohm
				1462			

Table 2 Cost table

CHAPTER7

RESULTS AND CONCLUSION

7.1 RESULTS: -

1) In this project we calculate the resistance of the cable with the help voltage applied and the current from station to the faulty point and then convert it into distance in km.
2) Our system is checking fault in every phase one by one. If there are faults at two points in the same phase then first fault near to the station is cleared and we look for the fault far from the station.
3) After having the fault in cable, it generates output at LCD with activating the buzzer as well as LED which helps to sort out the fault.
4) Some photos of our demo are above in the simulation and result section.

7.2 CONCLUSION: -

In this work, a simplified method is proposed for detecting the location of cable faults in the underground area. We discover the position or location of faults and also find the accurate distance from the breaker point. The line to line, single line, line to ground fault in the underground cable is located using simple concepts of Ohms law to rectify the fault efficiently. The work automatically displays the phase and the exact location of fault with the help of Arduino uno, LCD Display, Relay circuit etc. The benefits of accurate location of fault are, fast repair so as to revive back the power system, improvement in the system performance, reduction in the operating expense and reduced time needed to locate the fault in the field.

APENDIX

8.1 ALGORITHM: -

1) Import the header file of Liquid Crystal display which contains pre-defined functions related to LCD.
2) Assignment of variables to the pins.
    a) A0 => sensor
    b) 8 => relay1
    c) 9 => relay2
    d) 10 => relay3
    e) 13 => buzzer
3) Variable declaration.
    a) read_ADC => Integer variable
    b) Distance => Integer variable
4) Setting up pins as input/output.
    a) sensor => input
    b) relay1 => output
    c) relay2 => output
    d) relay3 => output
    e) buzzer => output
5) Setting up LCD.
    a) Declaration of 16 column, 2 rows display.
    b) Clear screen.
    c) Display message at the beginning by setting cursor to appropriate position.
    d) Clear display after some time by giving delay.
    e) Clear screen.
6) Define the function to calculate the distance (data ()).
    a) Taking analog input form sensor.

b) Arduino's inbuilt ADC will scale the input between 0 to 1023 according to the strength of the input.

c) Divide the input of the sensor with a constant which is taken according to distance in which the input is scaled.

d) If there is fault it will give distance.

e) If distance is greater than 0, that means fault occurred, then give buzzer pin will be high for 2 seconds.

f) After 2 seconds it will turn low.

7) Main loop.

a) Setting cursor and printing appropriate letters on display.

i) Setting cursor to column 1, row 1 and write letter 'R' to represent R phase.

ii) Similarly print letter 'Y' at column and "B" at column 13 to represent Y and B phases respectively.

b) Taking input from "R" phase by giving high value to that relay pin and giving low value to remaining two phase relay pins.

c) Delay of 500 micro-seconds for smooth functioning.

d) Call the function defined earlier to calculate distance. If there is any fault, It will give the value of distance in Kilometers and gives input to buzzer for 2 seconds. If there is no fault it will give value of distance 0.

e) Set the cursor to column 0, row 2.

f) If distance is greater than zero, print distance along with suffix "KM". Else, print "NF" to represent no fault.

g) Similarly, for Y phase, give high signal to relay2 and low signal to remaining two relays.

h) Calling the "data ()" function to calculate distance and get that value.

i) Set the cursor to column 6, row 2.

j) If distance is greater than zero, print distance along with suffix "KM". Else, print "NF" to represent no fault.

k) Similarly, for B phase, give high signal to relay2 and low signal to remaining two relays.

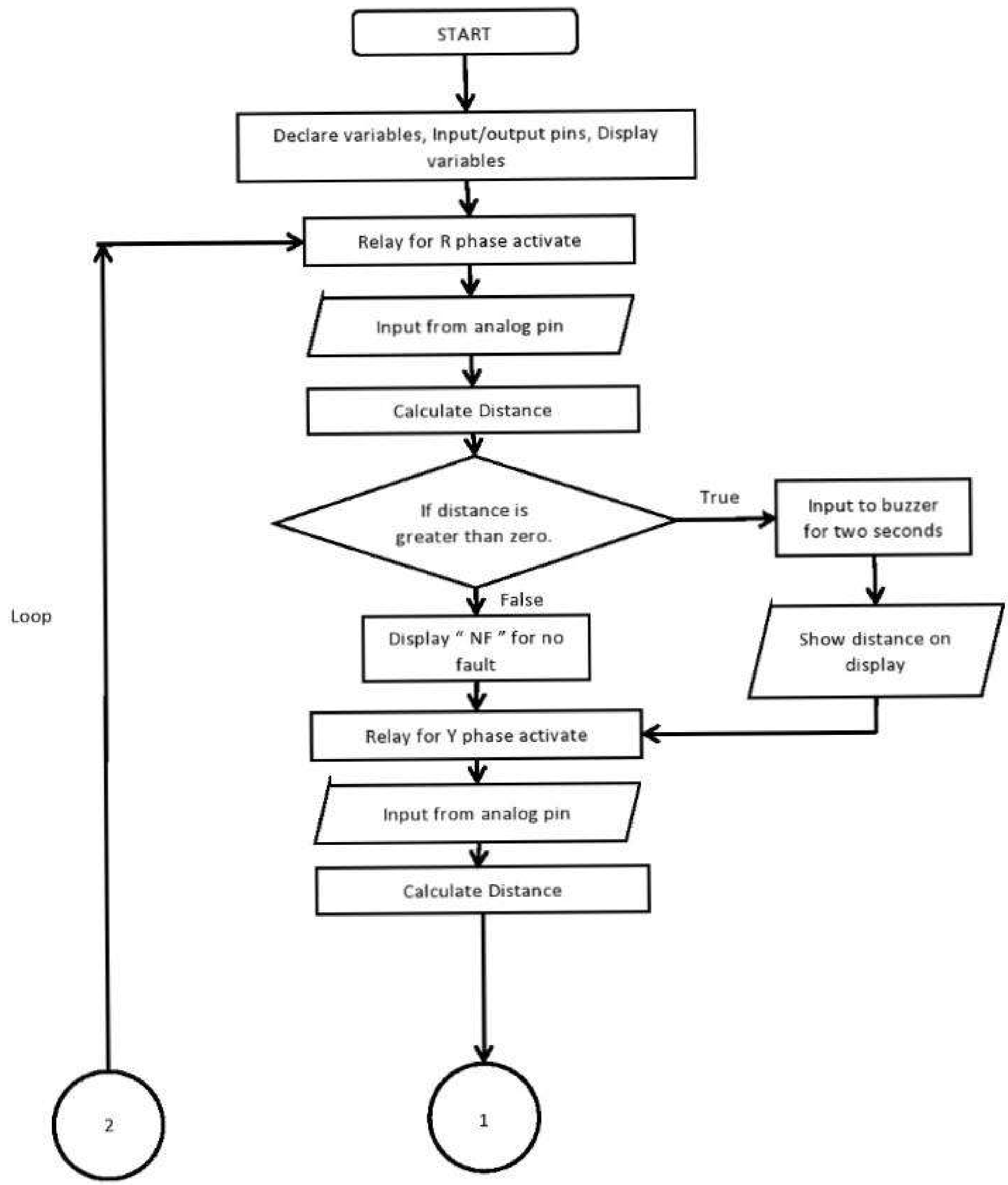
l) Calling the “data ()” function to calculate distance and get that value.

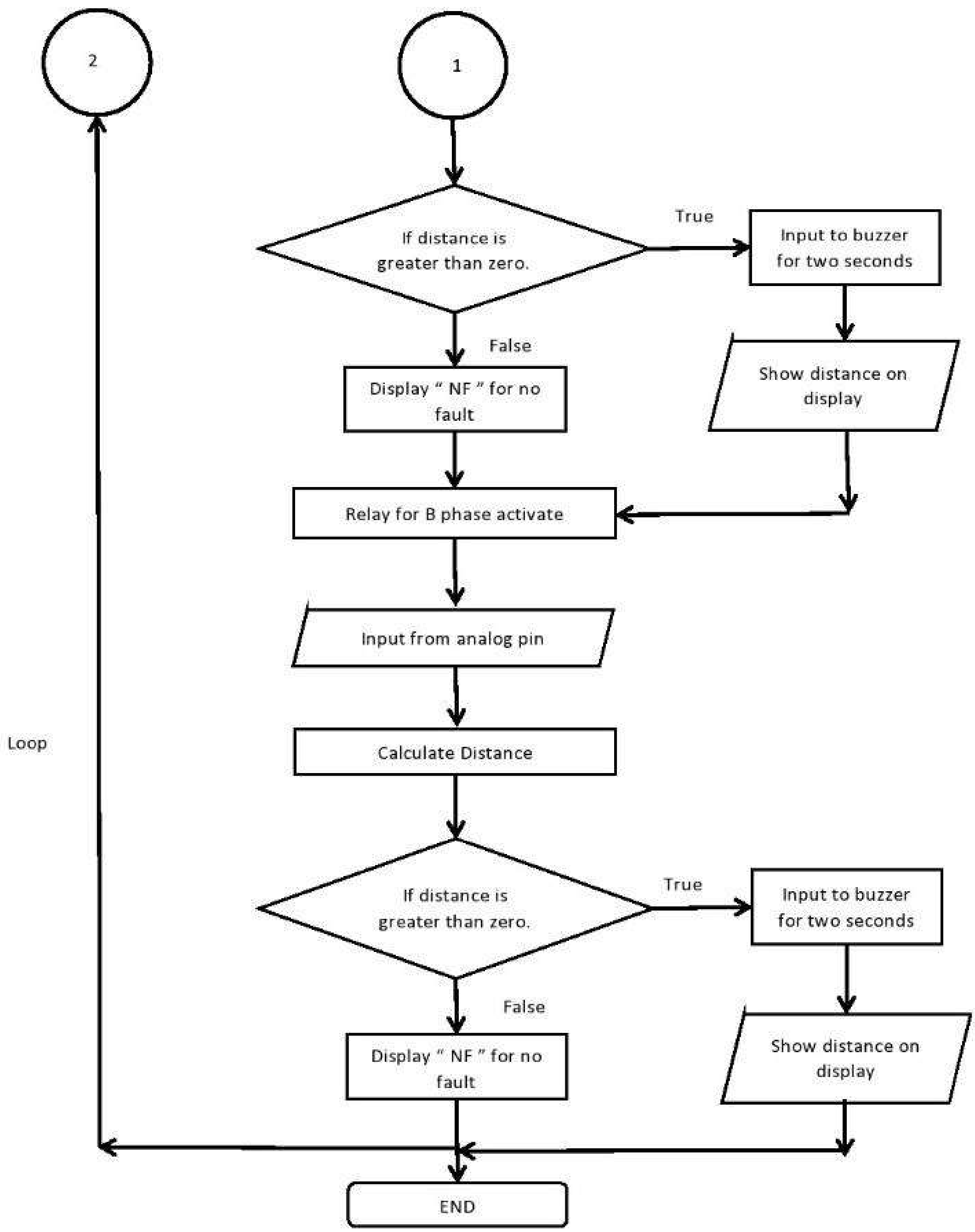
m) Set the cursor to column 12, row 2.

n) If distance is greater than zero, print distance along with suffix “KM”. Else, print “NF” to represent no fault.

8) Void loop () function continuously iterate over the code written in the function and it will alternately check for the fault and if there is fault it will give value of distance in kilometres.

8.2FLOWCHART: -




2
1
If distance is greater than zero.
True
Input to buzzer for two seconds
False
Display " NF " for no fault
Show distance on display
Relay for B phase activate
Input from analog pin
Loop
Calculate Distance
If distance is greater than zero.
True
Input to buzzer for two seconds
False
Display " NF " for no fault
Show distance on display
END

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