Visvesvaraya Technological University

Belgaum, Karnataka-590 018

A Project Report on

"IoT Based Underground Cable Fault Distance Detection System"

Project Report submitted in partial fulfillment of the requirement for the award of the degree of

Bachelor of Engineering
In
Electrical & Electronics Engineering

Submitted by

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2020-2021

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Certificate

Certified that the project work entitled **"IoT Based Underground Cable Fault Distance Detection System"** carried out by Mr. Likith C Reddy, USN 1CR17EE032; Mr. S. Tejas, USN 1CR17EE059; Mr. Sagar .S, USN 1CR17EE060; Mr. Sumanth Rithu K.N, USN 1CR17EE071 are bonafied students of CMR Institute of Technology, Bengaluru, in partial fulfillment for the award of Bachelor of Engineering in Electrical & Electronics Engineering of the Visvesvaraya Technological University, Belgaum, during the year 2020-2021. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library.

The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said Degree.

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DECLARATION

We, [Mr. Likith C Reddy (1CR17EE032)**,** Mr. S. Tejas (1CR17EE059)**,** Mr. Sagar .S (1CR17EE060)**,** Mr. Sumanth Rithu K.N (1CR17EE071)]**,** hereby declare that the report entitled **"IoT Based Underground Cable Fault Distance Detection System"** has been carried out by us under the guidance of **Dr. K. Chitra,** Professor & HOD, Department of Electrical & Electronics Engineering, CMR Institute of Technology, Bengaluru, in partial fulfillment of the requirement for the degree of **BACHELOR OF ENGINEERING in ELECTRICAL & ELECTRONICS ENGINEERING**, of Visveswaraya Technological University, Belagaum during the academic year 2020-21. The work done in this report is original and it has not been submitted for any other degree in any university.

Place: Bengaluru

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Abstract

Underground cables are used for power applications where it is impractical, difficult, or dangerous to use the overhead lines. They are widely used in densely populated urban areas, in factories, and even to supply power from the overhead posts to the consumer premises. The underground cables have several advantages over the overhead lines; they have smaller voltage drops, low chances of developing faults and have low maintenance costs. However, they are more expensive to manufacture, and their cost may vary depending on the construction as well as the voltage rating. Underground cables are prone to a wide variety of faults due to underground conditions, wear and tear, rodents etc. Diagnosing the fault source is difficult and entire cable should be taken out from the ground to check and fix faults. The project work is intended to detect the location of fault in underground cable lines from the base station in km using an ATmega328 controller. To locate a fault in the cable, the cable must be tested for faults. This prototype uses the simple concept of Ohms law. The current would vary depending upon the length of fault of the cable. In the urban areas, the electrical cables run in underground instead of overhead lines. Whenever the fault occurs in underground cable it is difficult to detect the exact location of the fault for process of repairing that particular cable. The proposed system finds the exact location of the fault. The prototype is modeled with a set of resistors representing cable length in km and fault creation is made by a set of switches at every known distance to cross check the accuracy of the same. In case of fault, the voltage across series resistors changes accordingly, which is then fed to an ADC to develop precise digital data to a programmed PIC IC that further displays fault location in distance. The fault occurring distance, phase, and time is displayed on a 16X2 LCD interfaced with the microcontroller. IOT is used to display the information over Internet using the Wi-Fi module ESP8266.

Acknowledgement

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of people, who are responsible for the completion of the project and who made it possible, because success is outcome of hard work and perseverance, but stead fast of all is encouraging guidance. So with gratitude we acknowledge all those whose guidance and encouragement served us to motivate towards the success of the project work.

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CHAPTER 1

INTRODUCTION

In underground electricity distribution systems, the cables used are placed in the ground or in some form of ducts. This makes the cables strong and the chances of faults in them are very little. Whenever there is a fault in these cables, it becomes difficult to locate and repair the fault as conductors are not visible. Needless to say, detecting these faults is a lot like finding a needle in a haystack. There are many methods to locate the faults along with new detection technology and electrical items, which makes the task easier and less time-consuming. However, do note that there is no single or a combination of methods to be considered as the "Best". There are different types of methods for different faults which make it safe and efficient to locate the faults without damaging the cable. Nevertheless, following are the electrical supply faults that occur in underground cables

Open-circuit fault

A break in the conductor of a cable is called open-circuit fault. This type of fault is checked with the help of a device called 'megger'. In this type of fault, the 3 conductors of the 3-core cable at the far end are shortened, and then connected to the ground. The megger is then used to read the resistance between each conductor and the ground. If the megger indicates 0 resistances in the circuit of the conductor, it means it is not broken. But if the megger measures infinite resistance, it means that the conductor is broken which needs to be replaced.

Short-circuit fault

When an insulator fails, it is due to the 2 conductors of a multi-core cable coming in contact with each other electrically, which indicates short-circuit failure. For this again, a megger is used. In this type, the 2 terminals of the megger are connected to any 2 conductors. Fault is indicated when the megger gives zero reading between the electricity conductors. The Same process can be repeated by taking other 2 conductors at a time.

Earth Fault

If a cable's conductor comes in contact with the earth (ground), then it is called as earth fault. In order to identify this fault, the two terminals of the megger are connected to the conductor and to the earth, respectively. Earth fault can be studied if the megger indicates zero reading. The Same procedure is applied to the cable's other conductors.

1.1 INTERNET OF THINGS

The evaluation of IoT in the electrical Power Industry transformed the way things performed in usual manner. IoT increased the use of wireless technology to connect power industry assets and infrastructure in order to lower the power consumption and cost. The applications of IoT are not limited to particular fields, but span a wide range of applications such as energy systems, homes, industries, cities, logistics, heath, agriculture and so on. Since 1881, the overall power grid system has been built up over more than 13 decades, meeting the ever increasing demand for energy. Power grids are now been considered to be one of the vital components of infrastructure on which the modern society depends. It is essential to provide uninterrupted power without outages or losses. It is quiet hard to digest the fact that power generated is not equal to the power consumed at the end point due to various losses. It is even harder to imagine the after effects without power for a minute. Power outages occur as result of short circuits. This is a costly event as it influences the industrial production, commercial activities and consumer lifestyle. Government & independent power providers are continuously exploring solutions to ensure good power quality, maximize grid uptime, reduce power consumption, increase the efficiency of grid operations and eradicate outages, power loss & theft. Most importantly, the solution should provide a real-time visibility to customers on every penny paid for their energy. There is an increasing need of a centralized management solution for more reliable, scalable, and manageable operations while also being cost effective, secure, and interoperable. In addition, the solution should enable power providers and utilities to perform effective demand forecasting and energy planning to address the growing need for uninterrupted quality power.

The goal of IoT is not just only connecting things such as machines, devices and appliances, but also allowing the things to communicate, exchanging control data and other necessary information while executing applications. It consists of IoT devices that have unique identities and are capable of performing remote sensing, monitoring and actuating tasks. These devices are capable of interacting with one another directly or indirectly. Data collection is performed locally or remotely via centralized servers or cloud based applications. These devices may be data collection devices to which various sensors are attached such as temperature, humidity, light, etc., or they may be data actuating devices to which actuators are connected, such as relays.

1.2 Brief Background of the Research

Underground cables are prone to a wide variety of faults due to underground conditions, wear and tear, rodents etc. Diagnosing fault source is difficult and entire cable should be taken out from the ground to check and fix faultsStudy of cable failures and development of accurate fault detection and location methods has been interesting research topics in the past and present. Fault tracking entails determination of the presence of a fault, while fault location detection includes the determination of the physical location of the fault. However, this fault detection and fault location detection technology for underground power distribution systems is still in developing stages.

1.3 Contribution

It is difficult to diagnose the fault source and remove the entire cable from the ground to inspect and remedy failures. This project aims to detect fault locations from the base station in underground cable lines in kilometers using an ATmega328P controller. A 16X2 LCD interfacing with the microcontroller shows the phase, and distance. IoT uses the Wi-Fi module ESP8266 to view information on the Internet. Quick repair to restore the power supply, increase system efficiency and reduce the running expenses and time for locating the errors in the field is the advantage of the precise position of the fault.

1.4 Objective of the Thesis

The project work is intended to detect the location of fault in underground cable lines from the base station in km using an ATmega328P controller. The fault occurring distance, phase, and time is displayed on a 16X2 LCD interfaced with the microcontroller. IOT is used to display the information over Internet using the Wi-Fi module ESP8266.

CHAPTER 2

LITERATURE REVIEW

M. R. Hans, Snehal C. Kor, A. S. Patil ; “Identification of underground cable fault location and development” 2017 International Conference on Data Management, Analytics and Innovation (ICDMAI) – In this paper two methods are proposed to identify and locate the faults on underground cables. One of the methods is Murray Loop method and the other one is Ohm’s Law method. Murray loop method uses the whetstone bridge to calculate exact distance of fault location from base station and sends it to the user mobile. Whereas in Ohm's law method, when any fault occurs, voltage drop will vary depending on the length of fault in cable, since the current varies.

Laxmi Goswami; “IOT Based Fault Detection of Underground Cables through Node MCU Module” 2020 International Conference on Computer Science, Engineering and Applications (ICCSEA) - In this paper IOT based technique with Google database for the fault detection with the help of Node MCU Wifi Module is used. It is totally based on IOT.

Vivek KR Verma; “UNDERGROUND CABLE FAULT DETECTION USING IoT” International Research Journal of Engineering and Technology (IRJET), July 2020 - The main aim of this paper is to find the accurate and specific location of the fault in the underground cable with the help of IoT device and by using Arduino Mega microcontroller kit. The result is shown on a web page and also the message is being sent on the mobile phone with the help of GSM.

CHAPTER 3

PROPOSED MODEL WITH THEORETICAL BACKGROUND

The basic concept of Ohm's law is found suitable in principle to develop a fault location tracking system. Based on the Ohm's Law, it is found that the resistance of the cable is proportional to its length under constant conditions of temperature and the cross section area and therefore if a low DC voltage is applied at the feeder end through a series of resistor in cable lines, the current would vary depending upon the location of fault in the cable.

Here a system is developed which consists of a microcontroller, LCD display, Fault Sensing Circuit Module, IoT Wi-Fi Module and proper power supply arrangement with regulated power output. Hence, if there is a short circuit in the form of line to ground in any phase/phases, the voltage across series resistors changes accordingly and an analog signal in the form of voltage drop is generated by the fault sensing circuit of the introduced system, which is then fed to an ADC inbuilt in already programmed microcontroller to create the exact digital data and after processing the data the output will be displayed in the connected LCD with the exact location of fault occurred in kilometres from the source station and simultaneously also indicate the corresponding R, Y, B phase where fault occurred with the exact distance. The same processed information output will appear in the webpage through connected IoT Wi-Fi Module.

In this system, ATmega328P micro controller is used. Here the current sensing of circuits made with a combination of resistors is interfaced to ATmega328 micro controller with the help of internally inbuilt ADC for providing the digital data to microcontroller. The fault sensing circuit is made with the combination of set of series resistors & the set of switches alongside each resistor. The relays are controlled by the relay driver. A 16x2 LCD display is connected to the microcontroller to display the information of phase/phases and location of fault in kilometres.

3.1 Block Diagram of proposed Model

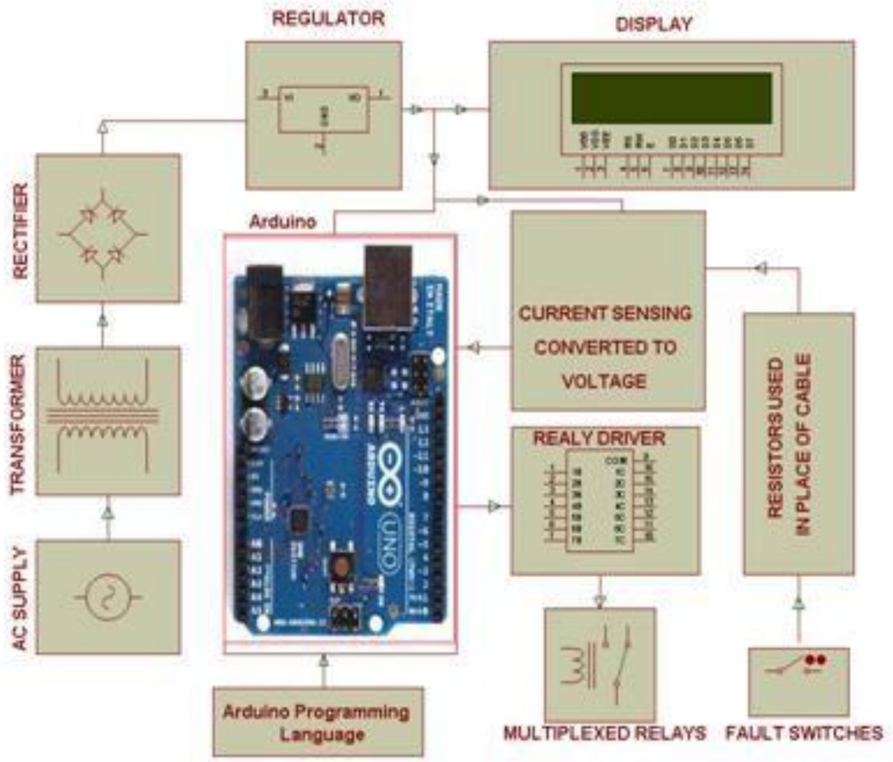

Fig 1: Block Diagram of the proposed model

1. Direct Current Power supply part: -

230V AC stepped down by transformer; a stable 4-diode bridge rectifier converts alternating current received at diagonally opposite ends to pulsating direct current which is further fed to Filter to remove any alternating current components.

2. Cable part:-

Resistors and switches create fault. Change in current is sensed by sensing voltage drop.

3. Controlling part: -

Analog to Digital Converter receives input from current sensing part, converts voltage into digital form and feeds it to the microcontroller which calculates the fault location and drives relay driver which controls the relays. Faulty section is isolated when the relay senses the fault and sends a trip signal to circuit breaker. An automatic relay, housed in control room panel, indirectly control a circuit during a change in the same or another circuit.

4. Display part: -

Liquid crystal display interfaced to the microcontroller displays the cable status or fault location of each phase R, B & Y.

CHAPTER 4

DESIGN PROCESS

4.1 Principle of Operation

The system works mainly on the principle of Ohm's Law where a low DC voltage is applied at the feeder end through fault sensing circuit.

4.2 Hardware and Software Requirements

Hardware Requirements: -

1. Resistors: Resistor is a passive component having two terminals. Resistors are connected in series which show the cables. We are using resistors of 10 kilo ohm in the project.

2. Switches: In our project we use switches to create fault in the circuit.

3. Transformer: A transformer is an important part of circuit which is used to convert electrical energy from one coil to another coil. This is mainly employed to regulate the voltage. Depending upon the behavior, there may be two types of transformers available: Step up and Step-down. We use a 230/12V step-down transformer.

4. Diode Bridge: A diode bridge is an arrangement of four (or more) diodes in a bridge circuit configuration that provides the same polarity of output for either polarity of input. When used in its most common application, for conversion of an alternating-current (AC) input into a direct-current (DC) output, it is known as a bridge rectifier.

5. Capacitors: Capacitor is a passive component having two terminals. The electrical energy is stored in the form of electric field. Electric charge is stored in it. The ripple in output of adaptor module 1 is then removed with the help of a 1000 microfarad electrolytic capacitor.

6. Voltage Regulator: Voltage regulator 7805 is used to convert the filtered output to +5V constant supply voltage.

7. Microcontroller: The ATmega328P is a single-chip microcontroller created by Atmel. ATmega328 is commonly used in many projects and autonomous systems where a simple, low-powered, low-cost micro-controller is needed. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.

8. Wi-Fi Module (ESP 8266): In this paper we are using ESP8266, a Wi-Fi module which is used for sending the data to the cloud. For sending the data first we create an account on Blynk IoT application which provides communication between the cloud and different internet connected devices.

9. Relay Driver**:** A Relay driver IC is an electro-magnetic switch that will be used whenever we want to use a low voltage circuit to switch a light bulb ON and OFF. Relays are switches that open and close circuits electromechanically or electronically.

10. LCD: LCD refers to Liquid Crystal Display, used in many devices (to display output). This is very convenient device that is used to display various information. We use a 16X2 LCD display.

Software Requirements: -

1. Arduino Software (IDE): The publicly available Arduino Software (IDE) that provides a platform to write code in simple way and send to the microcontroller. This works on Linux, Mac OS and also on Windows.

2. Proteus: Proteus is a Design Suite also known as Virtual System Modeling (VSM) offering the ability to simulate micro-controller code and also circuits. We make use of Proteus software to design and simulate our circuit.

3. BLYNK Application: This application was created for the IoT and used to manage the hardware. This app shows the data of sensor and visualizes it. This application creates an interface between the project and various widgets also responsible for the remote communication between device and the user.

4.3 Operation

1. The operation of the system states that when the current flows through the fault sensing circuit module the current would vary depending upon the length of the cable from the place of fault that occurred if there is any short circuit fault with the Single Line to ground fault, or double line to ground fault, or three phase to ground fault.

   The voltage drops across the series resistors changes accordingly and then the fault signal goes to internal ADC of the microcontroller to develop digital data. Then microcontroller will process the digital data and the output is being displayed in the LCD connected to the microcontroller in kilometres and phase as per the fault conditions. This output is also displayed in the webpage through the IoT Wi-Fi Module ESP8266 connected to the system.

2. The power supply given to the system is 230V AC supply. This 230 V supply is fed to the Adapter Module. The adaptor module converts the AC voltage to DC. The ripple in output of adaptor module is then removed with the help of a 1000 microfarad electrolytic capacitor.

   Since a constant 5V voltage source is desired for our system, because the Microcontroller (ATmega328), 16x2 LCD (Liquid Crystal Display), Relay Drivers and Relays, Fault Sensing Circuit Module, IoT Wi-Fi Module, etc. and the other components work at 5V supply, hence we are using three voltage regulators (7805). These voltage regulators convert the filtered output to 5V constant supply voltage.

   The first voltage regulator (VR1) feeds the 5 Volts supply to the microcontroller, LCD display, and the set of series resistors while the second voltage regulator VR2 feeds the relay driver IC ULN2003A and 3 three relays. The third Voltage regulator is connected to the IoT ESP8266 Wi-Fi Development Board Module which gives 5 Volts DC supply to it.

3. The project consists of three relays which are driven by a relay driver IC ULN2003A. The relays used here switches off/on the bulb loads R, Y and B to indicate the fault being occurred in corresponding phases.

4.4 Arduino Programming Code

```
#include "LiquidCrystal.h"
const int rs = 2, en = 3, d4 = 4, d5 = 5, d6 = 6, d7 = 7;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

float R1 = 10.0;
float VIN = 5.0;
float R2;
int i;
int Dist = 0;



void setup()
{
        lcd.begin (16,2);
        lcd.clear();
        pinMode(A0,INPUT);
        pinMode(9,OUTPUT);
}

void loop()
{
        float Volt = analogRead(A0);
        float VOUT = Volt/204.8;
        float R2 = ((VOUT * R1)/(VIN - VOUT));
        float i = VOUT/R2;
        int i_uA = i*1000;
        if (VOUT > 4.5){
                R2 = 0;
                i_uA = 0;
        }
```

```
else
{
        Dist = R2/10;
}

lcd.clear();
lcd.setCursor(0, 0);
lcd.print(Dist);
lcd.print(" KM");
lcd.setCursor(8, 0);
lcd.print(R2);
lcd.print(" R");
lcd.setCursor(0, 1);
lcd.print(VOUT);
lcd.print(" Volt");
lcd.setCursor(10, 1);
lcd.print(i_uA);
lcd.print(" uA");
if (R2 > 5)
{
        digitalWrite(9,HIGH);
}
Else
{
        digitalWrite(9,LOW);
}
delay(500);}
```

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 Simulation Results

The Table 1 shows the observation of resistances and currents while simulating the fault sensing circuit.

Table 1: Observation sheet for fault sensing circuit

Location of Fault	Cable Resistance During Fault Conditions, R_{DC}(in kΩ)	Total Resistance of Cable During Fault Condition, R_T (in kΩ)	Current flowing through Fault Sensing Circuit, I_F (in μA)
At 1 Km	10	20	250
At 2 km	20	30	167
At 3 km	30	40	125
At 4 km	40	50	100

A fault detecting system is developed in Proteus 8 software using microcontroller ATmega328P IC, LCD display, Relays, faultsensing circuit, etc. as shown in Fig. 2

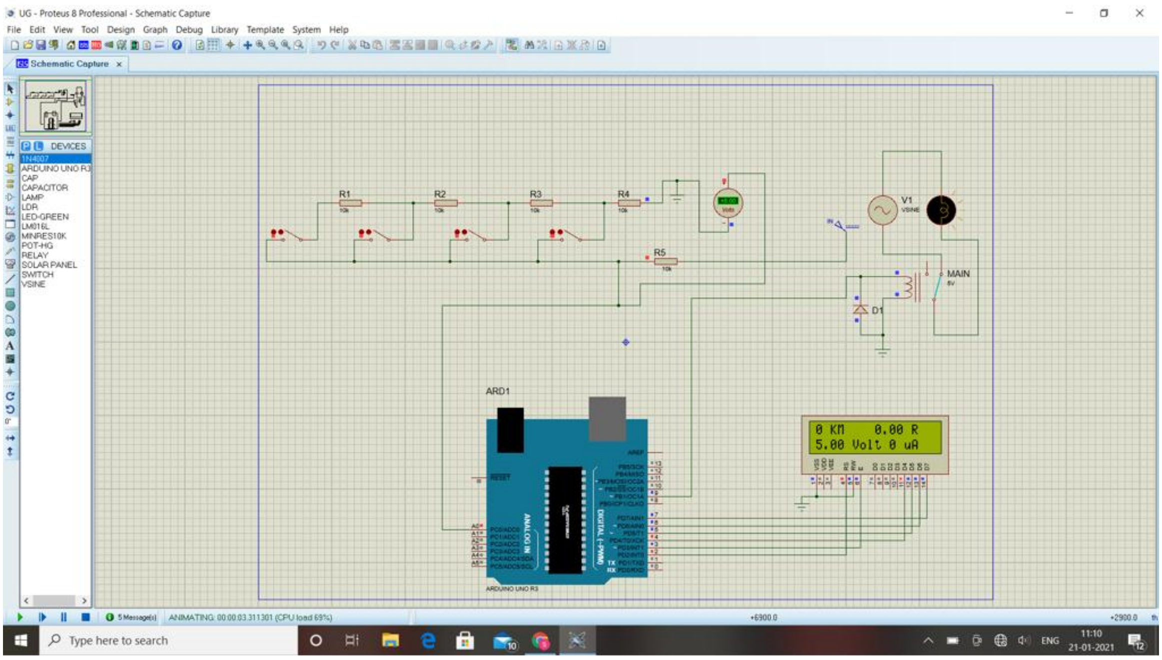

Fig 2: Simulation result for No fault condition

Table 2: Observation Sheet for basic circuit diagram

Location of Fault	**Pre-fault Voltage, V_{Ref}(in Volts)**	**Calculated Voltage Drop duringFault Conditions, V_d (in Volts): $V_d = V_{Ref} - \{I_F \times (R_T - R_{DC}\}$**	**Calculated Digital ADC Data for Microcontroller: $(V_d \times 1024)/V_{Ref}$**
At 1 Km	5	2.50	512
At 2 km	5	3.33	682
At 3 km	5	3.75	768
At 4 km	5	4.00	819

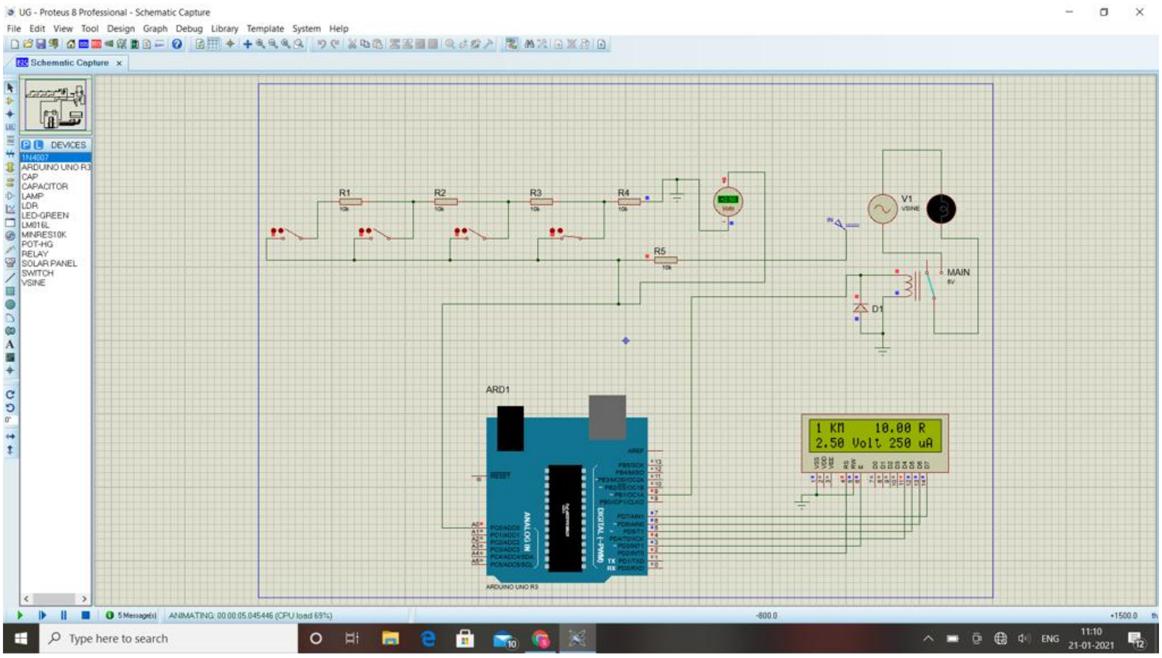

Fig 3: Simulation result for fault at 1 Km distance

In the simulation result of Fig. 3, fault is created intentionally by closing the fault switch. The corresponding voltage, current and distance values are processed by the microcontroller and are displayed on the LCD.

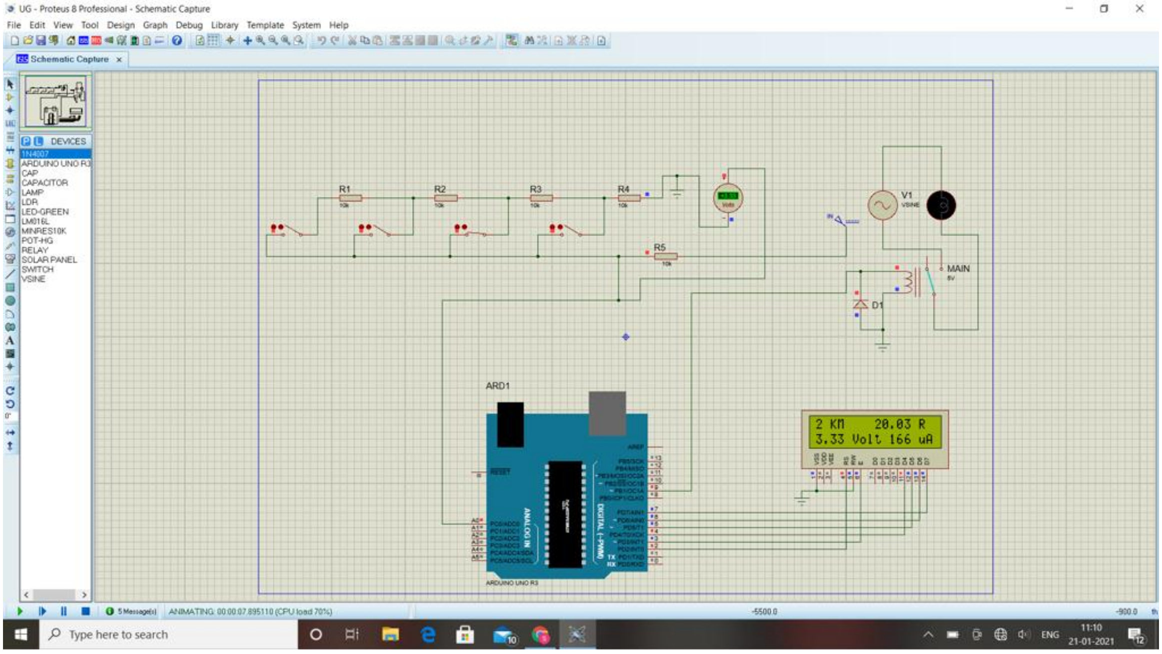

Fig 4: Simulation result for fault at 2 Km distance

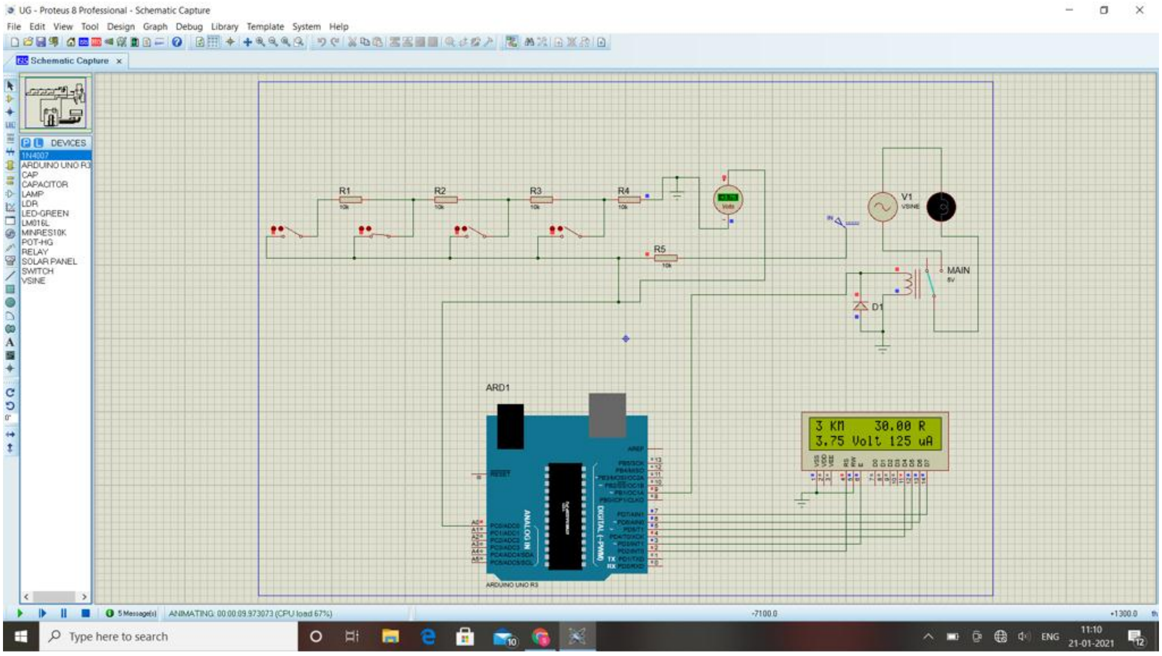

Fig 5: Simulation result for fault at 3 Km distance

5.2 Hardware Results

The hardware model shown in Fig. 6 is meant for single phase supply. The power supply is provided using step-down transformer, rectifier, and regulator. The current sensing circuit of the cable provides the magnitude of voltage drop across the resistors to the microcontroller and based on the voltage the fault distance is located.

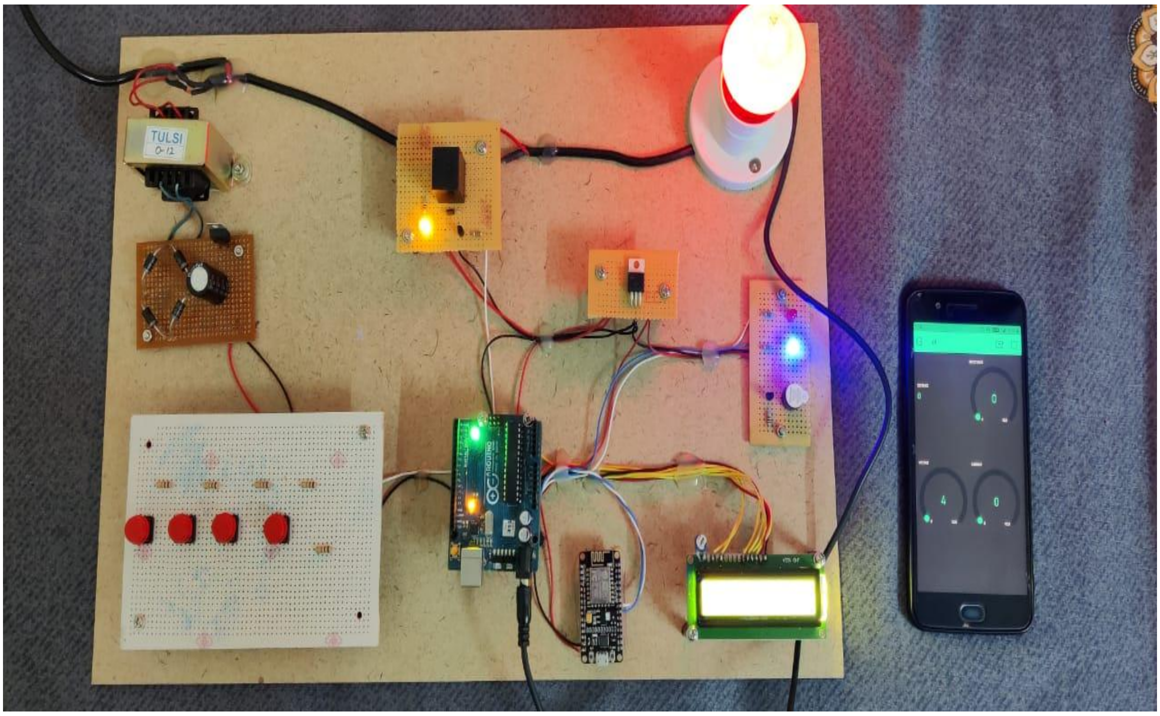

Fig 6: Hardware model of IoT Based Underground Cable Fault Distance Detection System

Figures 7, 8, 9 & 10 show the hardware results for fault locations at 1 Km, 2 Km, 3 Km & 4 Km respectively. The output is also updated onto the IoT cloud using the Blynk Application. By using this application, the operator can monitor and determine the fault location from the base station or any remote area using his/her mobile phone provided the phone is connected to the Internet.

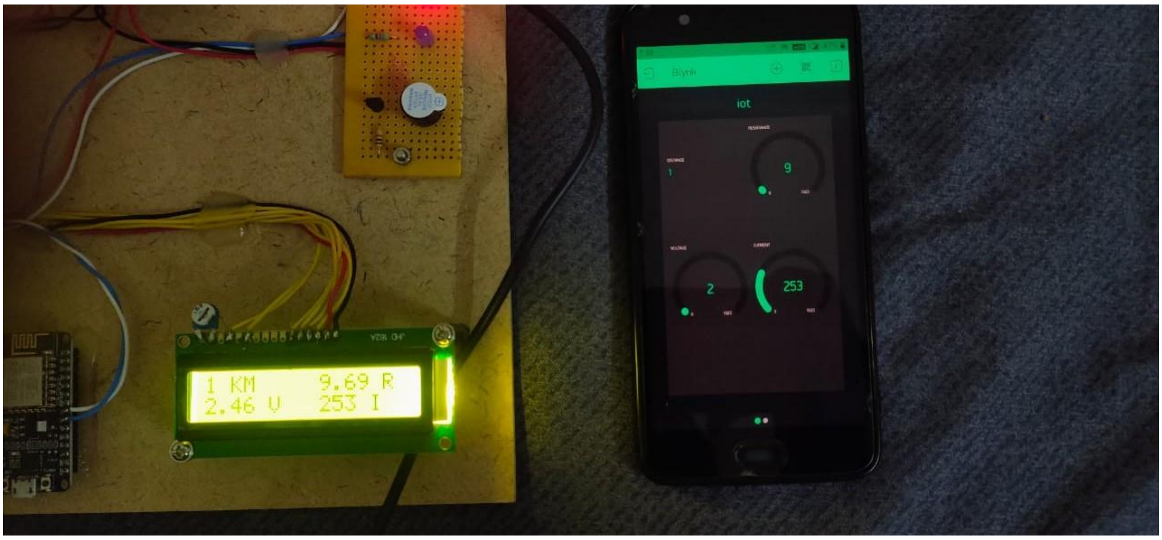

Fig 7: LCD and IoT displaying the fault at 1Km distance

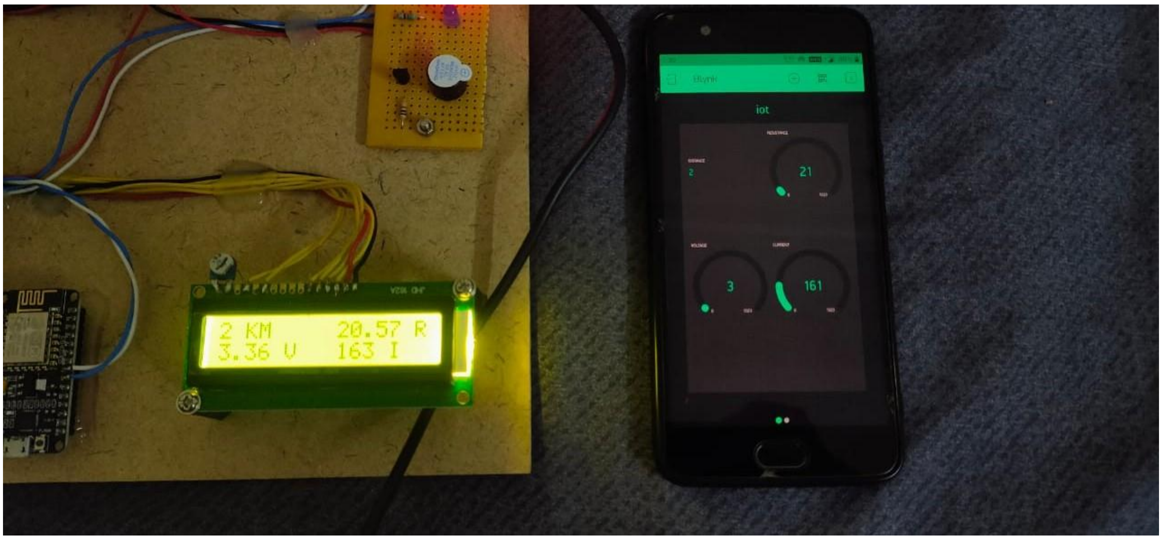

Fig 8: LCD and IoT displaying the fault at 2Km distance

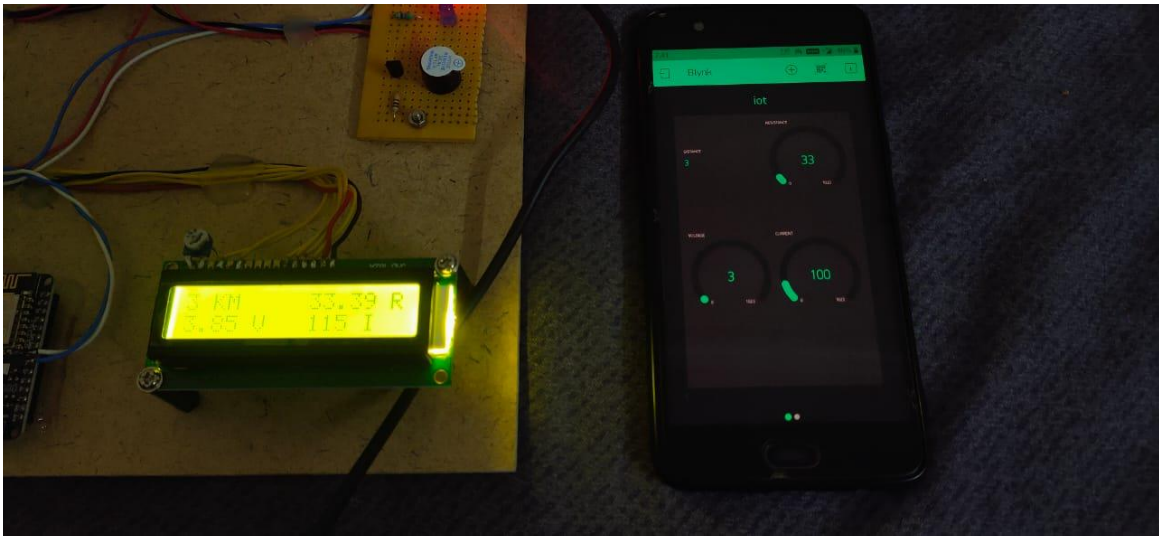

Fig 9: LCD and IoT displaying the fault at 3Km distance

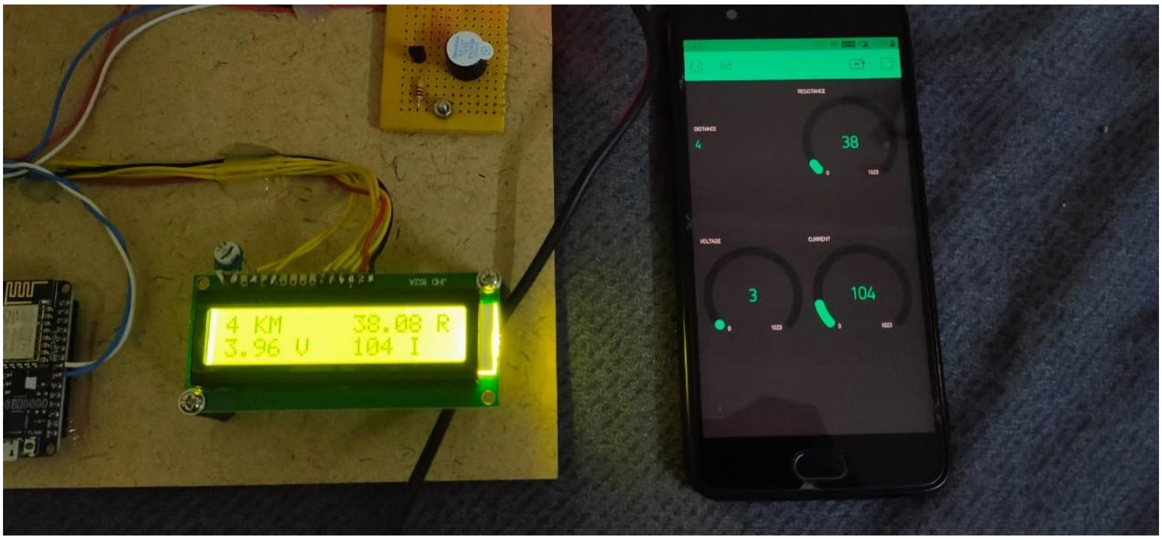

Fig 10: LCD and IoT displaying the fault at 4Km distance

5.3 IoT Application Results

The **Internet of things** (**IoT**) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, & connectivity which enable these objects to connect and exchange data.

The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention.

In our project we have used the Blynk Application Blynk is a Platform with IOS and Android apps to control Arduino, Raspberry Pi and the likes over the Internet. It's a digital dashboard where you can build a graphic interface for your project by simply dragging and dropping widgets.

Figures 11 & 12 are images of the Blynk application displaying the fault distance along with other cable parameters allowing the operator to monitor and locate the cable fault.

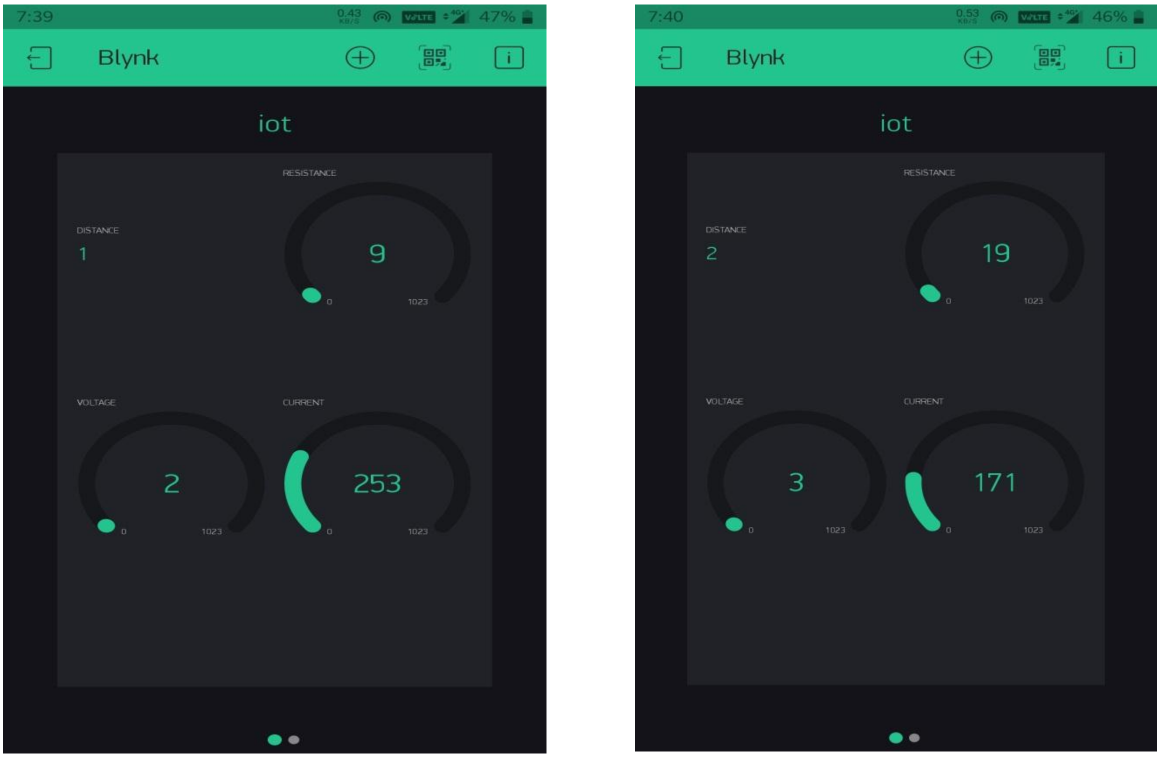

Fig 11: IoT application displaying the fault at 1Km and 2Km distance

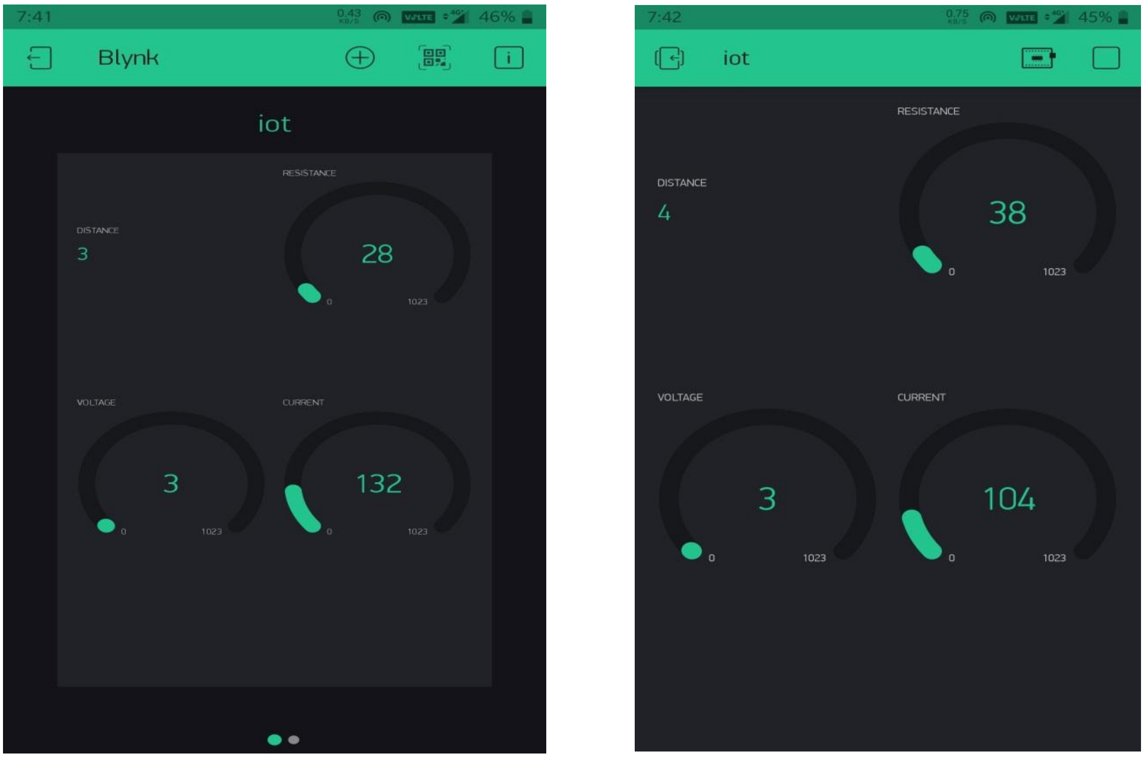

Fig 12: IoT application displaying the fault at 3Km and 4Km distance

CHAPTER 6

CONCLUSIONS AND FUTURE DIRECTIONS

This project described the IoT Technology Based Underground Cable Fault Distance Detection System Using ATmega328P Microcontroller in software and hardware simulation form and results were successful. A full-fledged prototype model had been implemented as a proof of concept to realize and understand the real time scenarios in underground cable system. Through this prototype simulation model the proposed architecture had been demonstrated that can effectively satisfy the requirement of exact fault location detection in the underground cable system and it is believed that this model can be a promising technology to solve future fault location detection problem.