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AN IOT BASED UNDERGROUND CABLE FAULT DETECTION

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Abstract*:* Underground cables are commonly used for power distribution in densely populated urban areas, factories, and to connect overhead lines to consumer premises. This is because overhead lines are often impractical, difficult, or dangerous to install in these settings. However, underground cables are susceptible to a wide range of faults caused by the underground environment, wear and tear, rodents, and other factors. Identifying the source of these faults can be challenging, as the entire length of the cable often needs to be exhumed to inspect and repair any issues. The objective of this project is to develop a node controller system that can detect and locate faults in underground cable lines from a base station, with accuracy measured in centimeters. To achieve this, the cable is modeled using a set of resistors representing the cable length in cm, and faults are simulated using switches placed at known distances. This allows the system to accurately pinpoint the location of any faults that occur. The project utilizes IoT technology, specifically the ESP8266 Wi-Fi module, to display the fault location information over the internet. This provided a convenient and accessible way to monitor and address underground cable issues remotely.

Keywords: IOT, Underground cables, fault detection, microcontroller, wi-fi module

I. 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 [1], [2].

- **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 FUNDAMENTALS OF 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 [3], [4]. 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 [5], [6], [7].

II .METHODOLOGY

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 micro controller to develop digital data. Then micro controller will process the digital data and the out put .

III. SYSTEM ANALYSIS AND DESIGN

The system is developed which consists of a micro controller, LCD display, Fault Sensing Circuit Module, IoT Wi-Fi Module and proper power supply arrangement with regulated power output [8], [9]. 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 micro controller 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 kilo meters 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 web page through connected IoT Wi-Fi module. Figure 1 depicts the architecture of the proposed system.

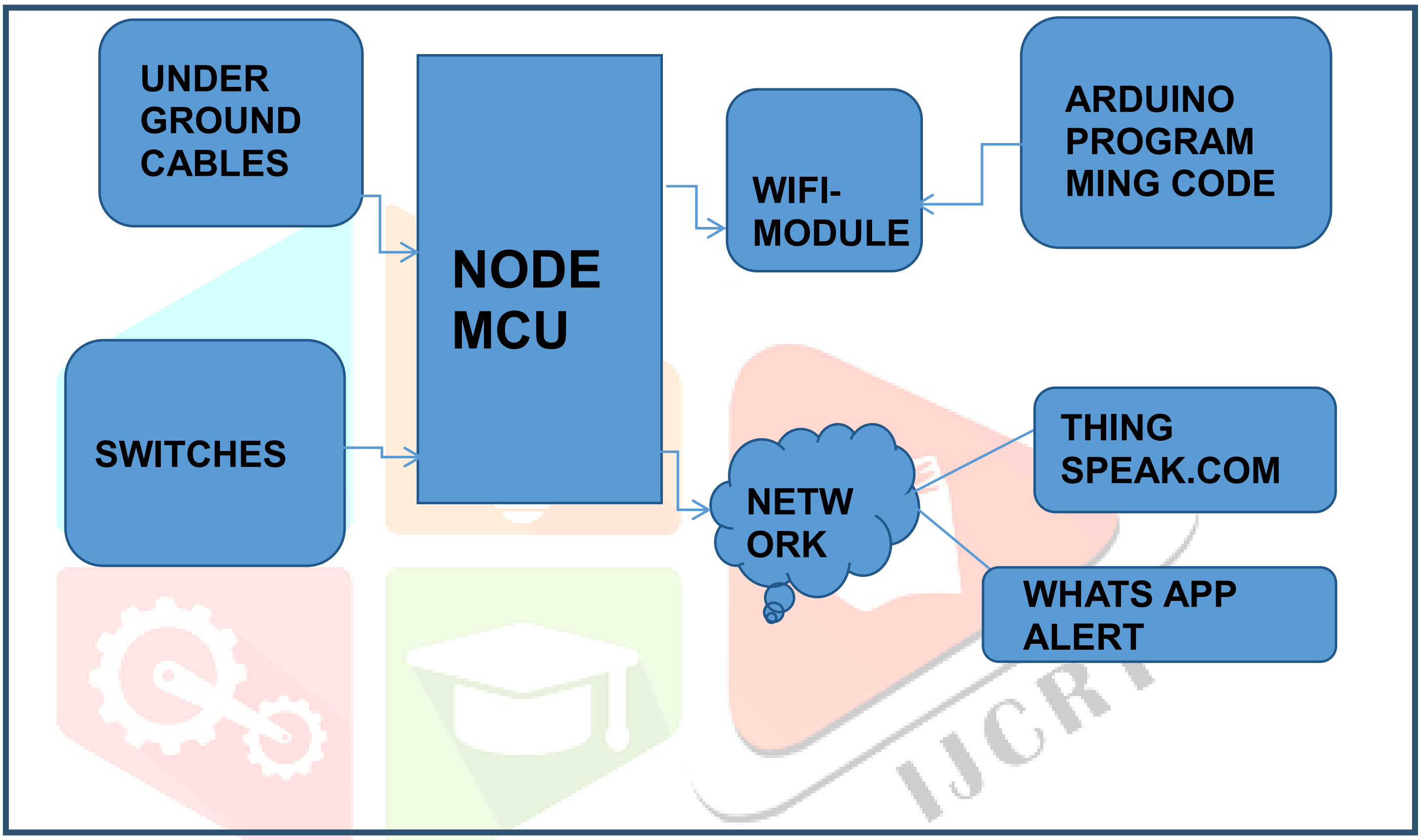

Fig 1: System architecture

3.1 EXISTING SYSTEM

A variety of technologies and tests are currently available to evaluate underground cables but there is often little relation between the diagnostic results and the actual detraction. The failures of underground power distribution cables represent a serious threat to the reliability of power infrastructure. Replacement must be done selectively since cable replacement is expensive, being estimated at no less than hundred thousand dollars per kilometre of cable in area.

Various techniques are employed for the detection of faults in underground cables. These include Cable Route Tracing, utilizing specialized equipment to trace the cable's route and locate faults; Time Domain Reflecto metry (TDR), which sends pulses down the cable and analyzes reflections for fault indications; Impulse Current Method, involving high voltage impulses to detect changes in voltage and current; Acoustic Detection, using sensors to pick up sounds produced by faults; Thermal Imaging for detecting temperature variations; Remote Monitoring Systems for continuous monitoring of parameters; Fiber Optic Distributed

Temperature Sensing (DTS) to monitor temperature changes along cables; and Electromagnetic Field Detection, which senses disruptions in the electromagnetic field around cables. Integrating these methods provides a comprehensive approach to underground cable fault detection, ensuring the reliability and safety of electrical power distribution networks.

Underground frameworks are frequently utilized in huge urban communities. In the event that a mistake happens under any condition, it is challenging to make rectifications to the circuit on the grounds that the area of the link blunder is obscure.

3.2 PROPOSED SYSTEM

The system is developed which consists of a micro controller, 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 micro controller 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 kilometers from the source station and simultaneously where fault occurred with the exact distance. The same processed information output will appear in the web page through connected IoT Wi-Fi Module.

IV . EXPERIMENTAL SET UP & WORKING

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 micro controller to develop digital data. Then micro controller will process the digital data and the output is being displayed in the LCD connected to the micro controller in kilometers and phase as per the fault conditions. This output is also displayed in the web page 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 micro farad electrolytic capacitor.

   Since a constant 5V voltage source is desired for our system, because the Micro controller (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 micro controller, 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.

4.1 ARDUINO PROGRAMMING CODE

The code was written using Embedded C language to run the proposed system. The code for the same is as follows

```
#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)

{

}

Else

{

}

digitalWrite(9,HIGH);

digitalWrite(9,LOW);

delay(500);

}
```

V .SYSTEM REQUIREMENTS

In this section the hardware and software requirements of the proposed system are illustrated.

5.1 Hardware Requirements:

1. Switches: In our project we use switches to create fault in the circuit.
2. 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.
3. Node MCU
4. Cables
5. Mother Board
6. Buzzer
7. LED Lights

5.2 Software Requirement

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

VI .IMPLEMENTATION

1. Place the node MCU (Microcontroller Unit) on the bread board.
2. The buzzer is also connected to node MCU and is placing 2 wires (white and blue) white
   wire is connected to ground and blue wire is connected to node MCU
   Do pin, The buzzer is used in order to indicate the fault has occurred by giving an alarm/sound.
3. Four switches are implemented (250v,5A AC supply), If the switch is pressed the respective LED glows indicated the occurrence of fault.
   And four LED's are also with each switch.
   LED 1 ->D6 pin of Node MCU
   LED 2 ->D7 pin of Node MCU
   LED 3 ->D8 pin of Node MCU
   LED 4 ->D1 pin of Node MCU

6.1 HARDWARE CONNECTIONS:

Each switch is having 3 terminals, The first terminal is connected with 2 wires of switch 1 is connected with 2 wires :

the first wire is connected to Node MCU ground pin.The second wire is connected to first terminal of switch2. The second terminal of switch 1 is connected to third terminal of switch 2. Second switch first terminal goes to switch 3 first terminal.

Second terminal od switch2 is connected to Node MCU D3 pin. Third terminal of switch2 is connected to 3rd terminal of switch3. First terminal f switch3 goes to first terminal of switch 4,2nd terminal of switch 3 is connected to D4 in of Node MCU.

Third terminal of is connected to 3rd terminal of switch 3. Switch 4 1st terminal is already connected to switch3 1st terminal, And it is to be noted that switch 4 1st terminal is having only one wire. Switch 4's second terminal is connected to D5 pin of Node MCU . The 3rd terminal of switch 4 is connected to switch 3 third terminal. All wires used are single standard. It is to be noted that all the 4 switches are placed on the black box which represent as it is underground. The wires connected to switches are placed in the black box. The Node MCU is also having a Wifi module ESP8266MOD in which the program code is dumped from the Arduino IDE 2.1.0 software which is installed on the PC.

1. Turn ON the pc/laptop.
2. Emulate /turn on the Wi-fi from the PC.
3. Double click ON the Arduino software.
4. Go to file click on the file option from taskbar located at the to of screen and click on "OPEN" a window appears which is having 2 options.

Objects Name:

Objects of type:

Here our program code which is written to show at what distance the putt access and at the same time send alert message to WhatsApp. Next switch 1 was pressed. As soon as switch 1 was pressed on com3 the message was displayed as cable fault at 11cm & the first LED also glows and the buzzer gave the beep sound. within a few second the SMS was send on the WhatsApp number of user that alert cable fault at 11cm.

Switch S2 -> fault at 21cms

S3 ->fault at 38cms

S4 ->fault at 54/52cms.

Then through google chrome open website thinkspeak.com. sign in by giving users email id & password. &sign in go to channel option and click on my channels & in the new channel option. click it & the new channel was created as:

1) The code shows at what distance fault comes and send alert message to the users whatsapp number by giving API key & phone number.
2) To whose mobile number the alert message is to be received is also there in ,the program code. Multiple users can also receive the information by using any program code.
3) Next the option is clocked in order to verify code for debugging.it was observed that no errors were found.
4) Next click on arrowmark option which indicates we are uploading the program code on the hide MCU wifi module.
5) Go to tools option & select /click serial monitor option.
6) Directly a new window appears (COM 3) showing a message "No cable fault occurs". "under ground cable"
7) In the program code thingsSpeak.com is also linked.
8) The graph shows at what cm put & also shows date,day, & time.

VII .INTERPRETATION OF RESULTS

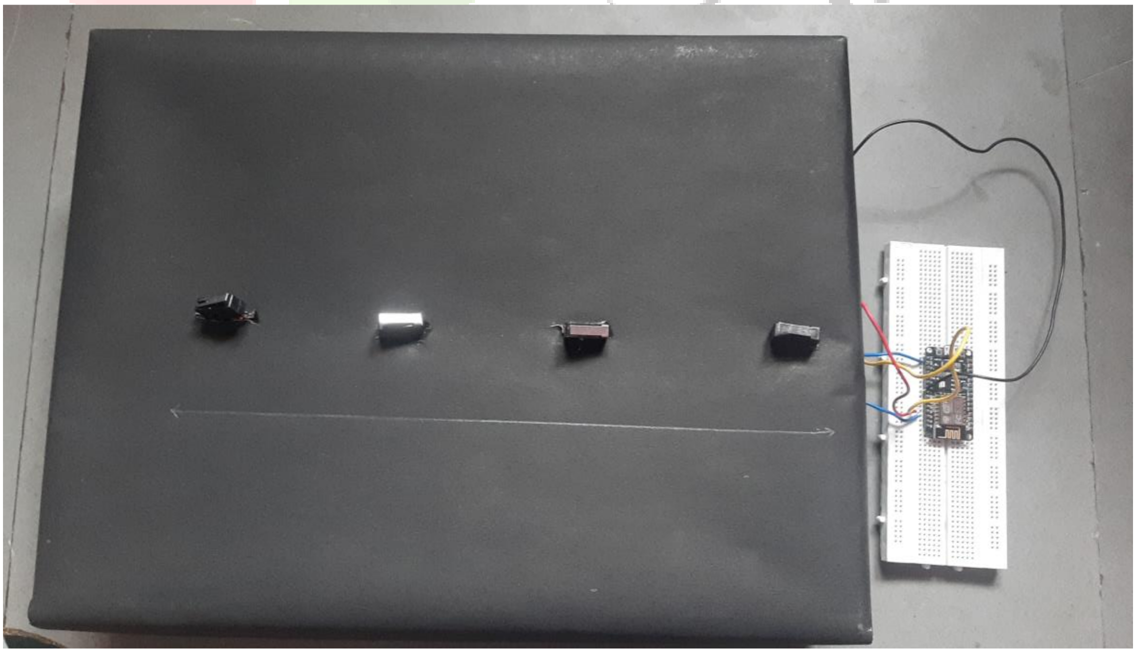

Figure 1: Connection of hardwares

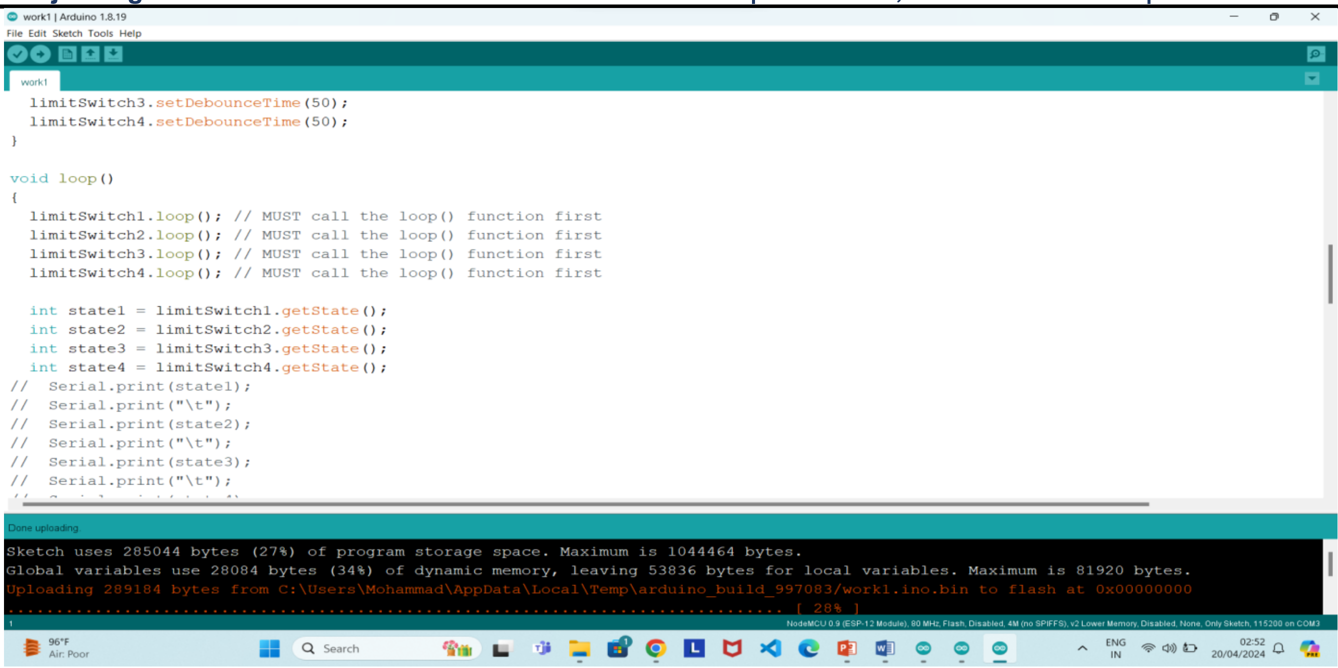

Figure 2: Verifying code

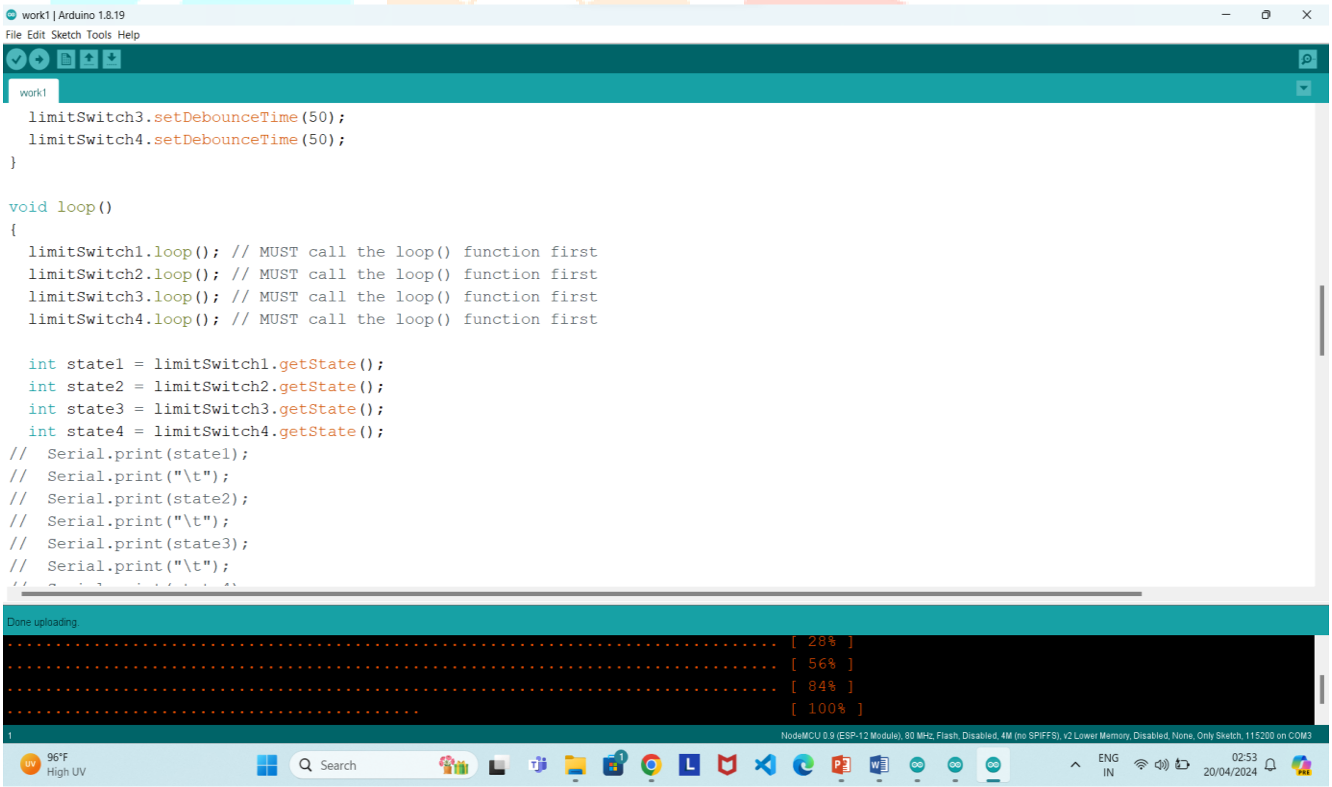

Figure 3: Uploading code

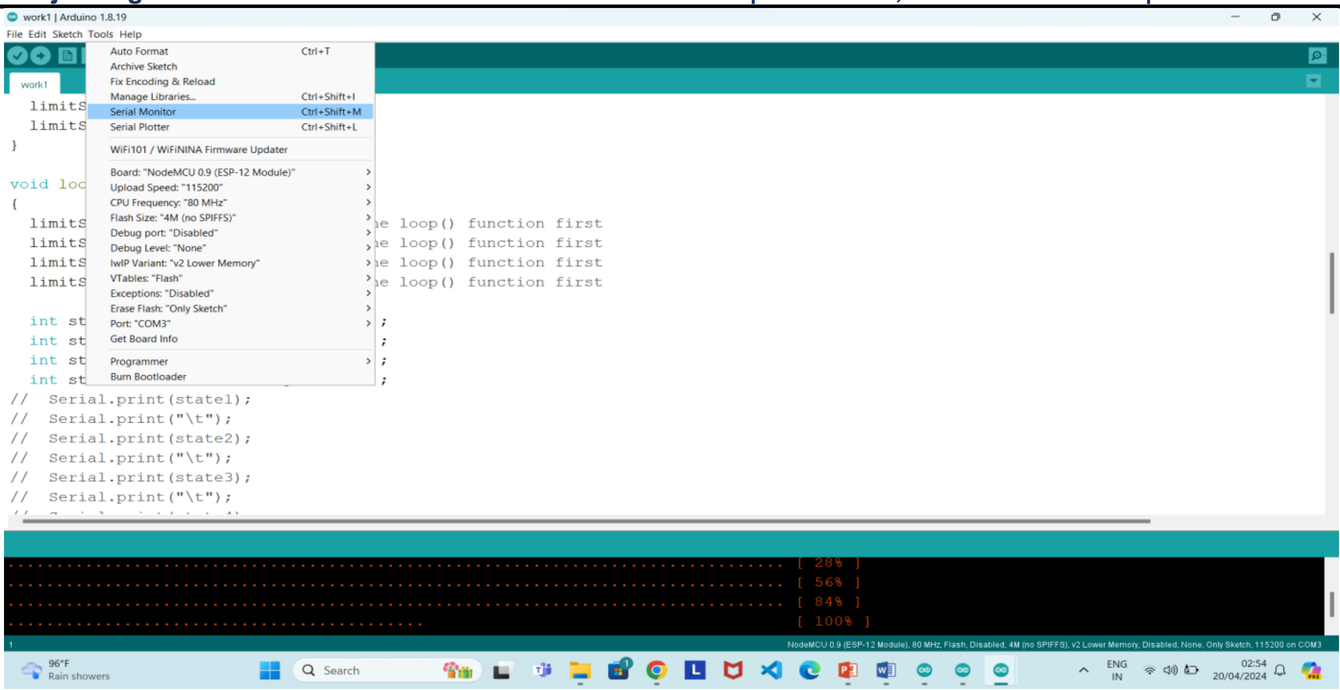

Figure 4: Serial Monitor

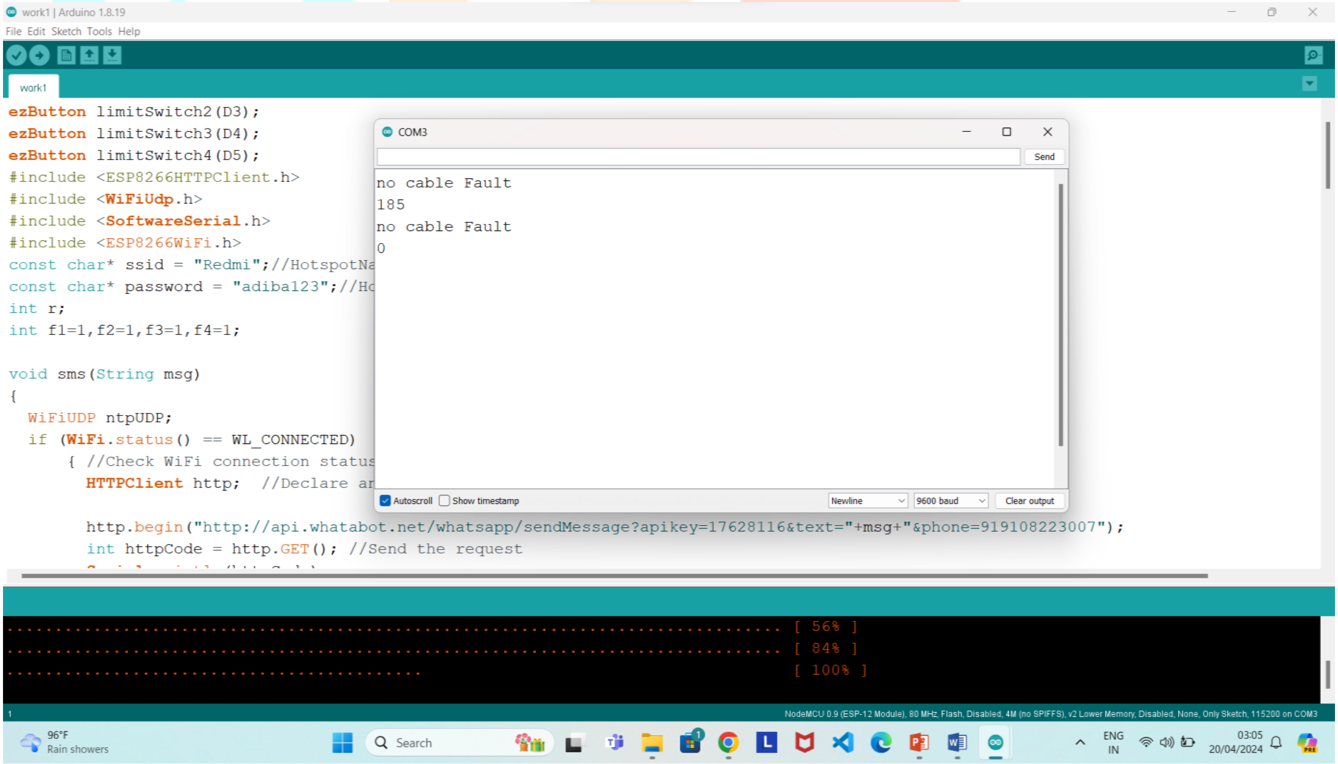

Figure 5: No cable fault

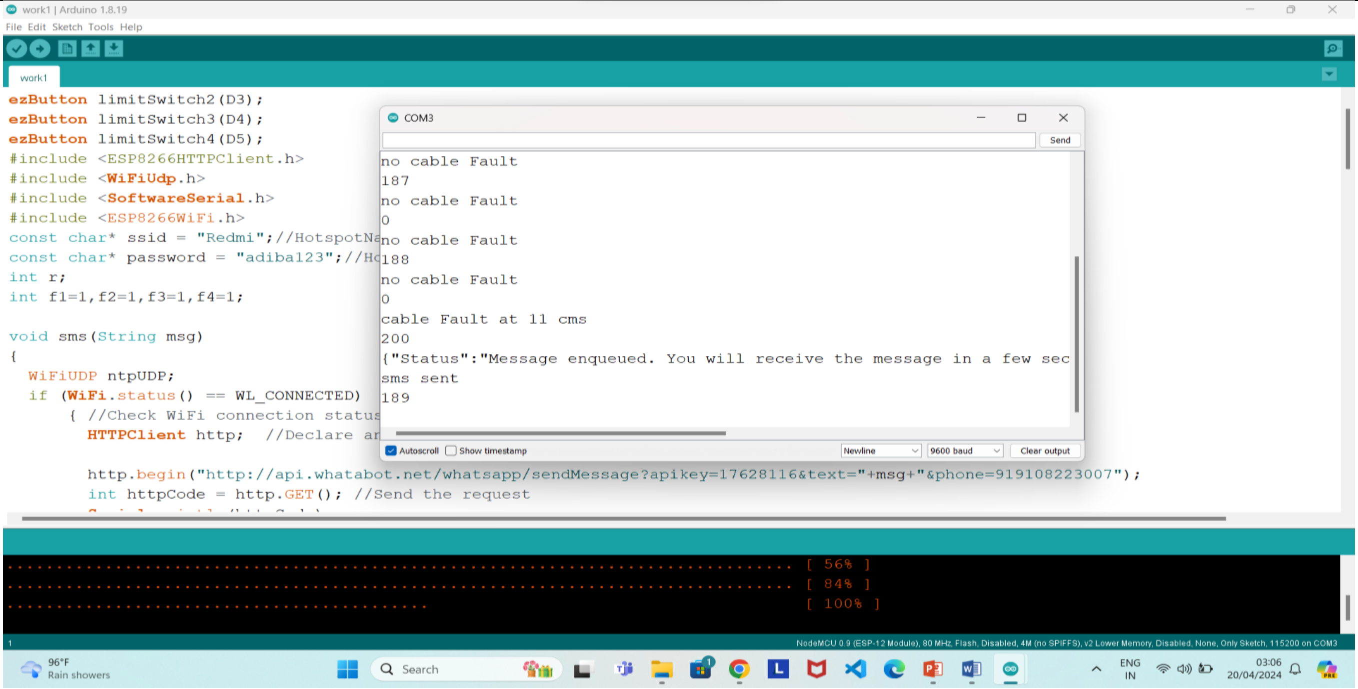

Figure 6: Cable fault occur

Figure 7: Alerting message

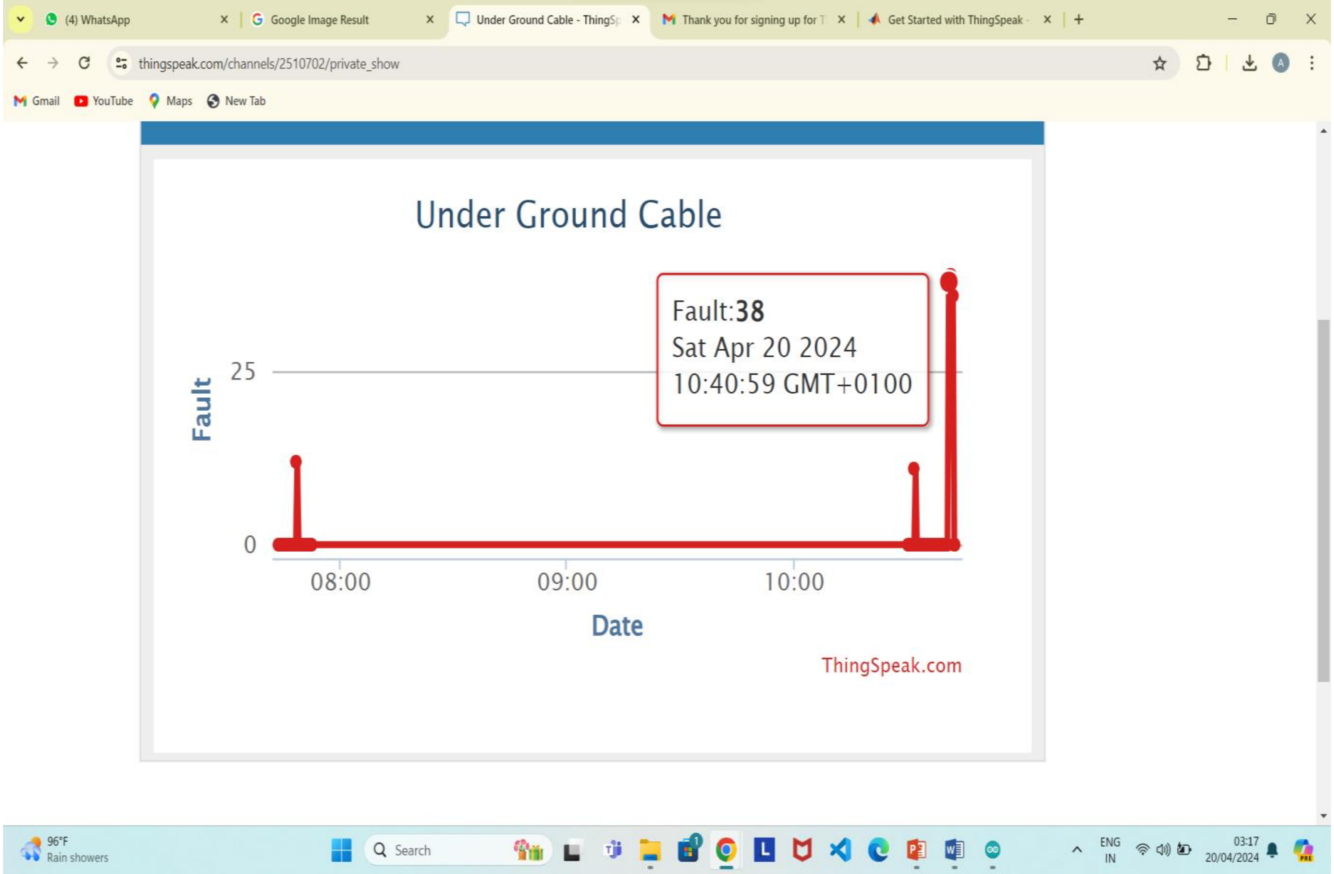

Figure 8: Graph for fault occured

VIII . CONCLUSION AND SCOPE FOR FUTURE WORK

The project described an IoT-based underground cable fault distance detection system that utilized microcontroller Node MCU. The complete system was executed in both software and hardware simulation forms, and the results obtained clearly showed how fault occurred at different instances of switch operated conditions. The distance of fault occurred was displayed on the PC screen. As soon as fault occurred, a beep sound was heard and that particular LED glowed.

Thus an efficient and complete prototype model had been developed as a proof of concept to realize and understand the real-time scenarios in the underground cable system. Through this prototype simulation model, the proposed architecture was demonstrated to effectively satisfy the requirement of precise fault location detection in the underground cable system.

It is believed that this model can be a promising technology to solve future fault location detection problems. The proposed system can be further implemented by replacing the microcontroller and Arduino unit with other possible unit.

REFERENCES

[1] Sidhu Tarlochan S, Zhihan Xu. Detection of incipient faults in distribution underground cables. IEEE Trans Power Delivery 2010;25(3):1363–71.

[2] Kojovic Ljubomir A, Williams CW. In: In 2000 Power Engineering Society Summer Meeting (Cat; 2000. p. 1175–80.

[3] Benner, C., K. B. Purry, and B. D. Russell. "Distribution fault anticipator"." EPRI, Palo Alto, CA 1001879 (2001).

[4] Terzija VV, Radojevic ZM. Numerical algorithm for adaptive autoreclosure and protection of medium-voltage overhead lines. IEEE Trans Power Delivery 2004;19 (2):554–9.

[5] Kim Charles J, Bialek Thomas O. Sub-cycle ground fault location—Formulation and preliminary results. In: In 2011 IEEE/PES Power Systems Conference and Exposition; 2011. p. 1–8.

[6] Jia Ke, Thomas David, Sumner Mark. A new single-ended fault-location scheme for utilization in an integrated power system. IEEE Trans Power Delivery 2012;28(1): 38–46.

[7] Filomena Andr´e D, Resener Mariana, Salim Rodrigo H, Bretas Arturo S. Fault location for underground distribution feeders: An extended impedance-based formulation with capacitive current compensation. Int J Electr Power Energy Syst 2009;31(9):489–96.

[8] Torres V, Guardado JL, Ruiz HF, Maximov S. Modeling and detection of high impedance faults. Int J Electr Power Energy Syst 2014;61:163–72.

[9] Kulkarni Saurabh, Santoso Surya, Short Thomas A. Incipient fault location algorithm for underground cables. IEEE Trans Smart Grid 2014;5(3):1165–74.

[10] Ghanbari Teymoor. Kalman filter based incipient fault detection method for underground cables. IET Gener Transm Distrib 2015;9(14):1988–97.

[11] Zhang Wenhai, Jing Yindi, Xiao Xianyong. Model-based general arcing fault detection in medium-voltage distribution lines. IEEE Trans Power Delivery 2016; 31(5):2231–41.

[12] Baqui Ibrahem, Zamora Inmaculada, Mazon ´ Javier, Buigues Garikoitz. High impedance fault detection methodology using wavelet transform and artificial neural networks. Electr Power Syst Res 2011;81(7):1325–33.

[13] Gautam Suresh, Brahma Sukumar M. Detection of high impedance fault in power distribution systems using mathematical morphology. IEEE Trans Power Syst 2012; 28(2):1226–34.

[14] Ebron Sonja, Lubkeman David L, White Mark. A neural network approach to the detection of incipient faults on power distribution feeders. IEEE Trans Power Delivery 1990;5(2):905–14.

[15] Faisal MF, Mohamed A, Shareef H. Prediction of incipient faults in underground power cables utilizing S-transform and support vector regression. International Journal on Electrical Engineering and Informatics 2012;4(2):186.

[16] Dong, Xiang, Yanling Yuan, Zhongqiang Gao, Chengke Zhou, Peter Wallace, Babakalli Alkali, Bojie Sheng, and Hao Zhou. "Analysis of cable failure modes and cable joint failure detection via sheath circulating current." In 2014 IEEE Electrical Insulation Conference (EIC), pp. 294-298. IEEE, 2014.